Northern Agency Tronox Mines

FINAL
Appendix B
X-Ray Fluorescence Data Evaluation Report

Response, Assessment, and Evaluation Services (RAES)

Contract No. EP-S9-17-03

Task Order 0001

October 10, 2019

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612

TETRA TECH

TABLE OF CONTENTS

Section | **Page**

ACRONYMS AND ABBREVIATIONS ix
EXECUTIVE SUMMARY ES-1
1.0 INTRODUCTION 1

1.1 PURPOSE 3
1.2 SITE SETTING 4
1.3 REPORT ORGANIZATION 9

2.0 TECHNICAL AND REGULATORY BACKGROUND 10

2.1 TECHNOLOGY OVERVIEW 10
2.2 REGULATORY AND SCIENTIFIC BACKGROUND 12
2.3 DATA QUALITY CRITERIA 13
2.4 TARGET ELEMENTS 16

3.0 METHODOLOGY 22

3.1 STUDY APPROACH 22
3.2 SAMPLE PREPARATION AND ANALYSIS METHODS 22
3.3 PRE-SURVEY PERFORMANCE EVALUATION 28
3.4 QUALITY ASSURANCE/QUALITY CONTROL METHODS 38
3.5 STATISTICAL METHODS FOR DATA EVALUATION 44
3.6 DATA QUALIFER PROCESS 48
3.7 DEVIATIONS FROM WORK PLAN 50

4.0 MODEL RESULTS 51

4.1 ARSENIC 51
4.2 IRON 67
4.3 LEAD 82
4.4 MANGANESE 99
4.5 MOLYBDENUM 114
4.6 THORIUM 131
4.7 URANIUM 149
4.8 VANADIUM 167
4.9 ZINC 183

5.0 DATA QUALITY ASSESSMENT 199

5.1 DATA QUALITY INDICATORS 199
5.2 PILOT STUDY 210
5.3 PARTICLE SIZE ANALYSIS 212

6.0 FINAL MODEL SELECTION 214

TABLE OF CONTENTS (CONTINUED)

Section **Page**

7.0 CONCLUSIONS...216
8.0 REFERENCES 217

LIST OF TABLES

Table B-1. Criteria for Characterization of Data Quality from Table 2-2 of USEPA (1998) 14
Table B-2. Summary of Data Quality Criteria According to SW-846 Method 6200 15
Table B-3. Selected Data Quality Criteria 16
Table B-4. Summary of Niton XL5 Field-Portable Instruments Used for XRF Field Survey 31
Table B-5. Summary of XRF Comparability of Standard Reference Materials (Arsenic)........... 33
Table B-6. Summary of XRF Comparability of Standard Reference Materials (Lead) 33
Table B-7. XRF Results for Standard Reference Materials at Different Filter Settings............... 34
Table B-8. Summary of XRF Measurements with and without Plastic Bag for Certified Reference Material (NIST 2709a) 36
Table B-9. Summary of XRF Measurements with and without Plastic Bag for Certified Reference Material (QC Material 180-661 RCRA1).. 36
Table B-10. XRF Confirmation Laboratory Analysis Summary.. 38
Table B-11. Niton XL5 Manufacturer Reported Method Detection Limit and Concentration Range Criteria 42
Table B-12. Summary of Categorical Ratings for XRF Accuracy 45
Table B-13. Summary of Data Pairs with Large Residuals for Arsenic in Model AS-2.............. 52
Table B-14. Summary of Parameters for Ex Situ Bulk Sample Arsenic Regression Models 53
Table B-15. Summary of Arsenic Soil Cup Linear Regression Model Parameters...................... 55
Table B-16. Method Detection Limit for Arsenic by XRF Method 58
Table B-17. Summary of Calculated Precision of XRF Method for Arsenic 59
Table B-18. Comparability for Ex Situ XRF Soil Cup Method Arsenic 60
Table B-19. Comparability for Ex Situ XRF Bulk Sample Method for Arsenic.......................... 60
Table B-20. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Arsenic Data... 62
Table B-21. Summary of Project Wide Arsenic Results by Surface Sampling Method 64
Table B-22. Summary of Parameters for Ex Situ Bulk Sample Iron Regression Models 68
Table B-23. Summary of Iron Soil Cup Linear Regression Parameters for XRF Instruments 70
Table B-24. Method Detection Limit for Iron by XRF Method 73
Table B-25. Summary of Calculated Precision of XRF Method for Iron.................................... 74
Table B-26. Comparability for Ex Situ XRF Soil Cup Method Iron... 75
Table B-27. Comparability for Ex Situ XRF Bulk Sample Method for Iron 76
Table B-28. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Iron Data... 77
Table B-29. Summary of Project Wide Iron Results by Surface Sampling Method 79
Table B-30. Summary of Parameters for Ex Situ Bulk Sample Lead Regression Models........... 83
Table B-31. Summary of Lead Soil Cup Linear Regression Model Parameters 86
Table B-32. Method Detection Limit for Lead by XRF Method.. 89
Table B-33. Summary of Calculated Precision of XRF Method for Lead 90
Table B-34. Comparability for Ex Situ XRF Soil Cup Method Lead 91
Table B-35. Comparability for Ex Situ XRF Bulk Sample Method for Lead 92
Table B-36. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Lead Data 93
Table B-37. Summary of Project Wide Lead Results by Surface Sampling Method................... 95
Table B-38. Summary of Data Pairs with Large Residuals for Manganese in Model MN-1..... 100

LIST OF TABLES (CONTINUED)

Table B-39. Summary of Parameters for Ex Situ Bulk Sample Manganese Regression Models ... 100
Table B-40. Summary of Manganese Soil Cup Linear Regression Model Parameters ... 102
Table B-41. Method Detection Limit for Manganese by XRF Method ... 105
Table B-42. Summary of Calculated Precision of XRF Method for Manganese ... 106
Table B-43. Comparability for Ex Situ XRF Soil Cup Method Manganese ... 107
Table B-44. Comparability for Ex Situ XRF Bulk Sample Method for Manganese ... 108
Table B-45. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Manganese Data ... 109
Table B-46. Summary of Project Wide Manganese Results by Surface Sampling Method ... 111
Table B-47. Summary of Data Pairs with Large Residuals for Molybdenum in Model MO-2 . 115
Table B-48. Summary of Parameters for Ex Situ Bulk Sample Molybdenum Regression Models ... 116
Table B-49. Summary of Molybdenum Soil Cup Linear Regression Model Parameters ... 118
Table B-50. Method Detection Limit for Molybdenum by XRF Method ... 122
Table B-51. Summary of Calculated Precision of XRF Method for Molybdenum ... 123
Table B-52. Comparability for Ex Situ XRF Soil Cup Method Molybdenum ... 124
Table B-53. Comparability for Ex Situ XRF Bulk Sample Method for Molybdenum ... 125
Table B-54. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Molybdenum Data ... 126
Table B-55. Summary of Project Wide Molybdenum Results by Surface Sampling Method ... 128
Table B-56. Summary of Parameters for Ex Situ Bulk Sample Thorium Regression Models ... 132
Table B-57. Summary of Thorium Soil Cup Linear Regression Model Parameters ... 135
Table B-58. Method Detection Limit for Thorium by XRF Method ... 139
Table B-59. Summary of Calculated Precision of XRF Method for Thorium ... 140
Table B-60. Comparability for Ex Situ XRF Soil Cup Method Thorium ... 141
Table B-61. Comparability for Ex Situ XRF Bulk Sample Method for Thorium ... 142
Table B-62. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Thorium Data ... 143
Table B-63. Summary of Project Wide Thorium Results by Surface Sampling Method ... 145
Table B-64. Summary of Data Pairs with Large Residuals for Uranium in Model U-1 ... 150
Table B-65. Summary of Outliers Identified in Model U-2 and Removed for Model U-2A ... 151
Table B-66. Summary of Parameters for Ex Situ Bulk Sample Uranium Regression Models .. 151
Table B-67. Summary of Uranium Soil Cup Linear Regression Model Parameters ... 154
Table B-68. Method Detection Limit for Uranium by XRF Method ... 157
Table B-69. Summary of Calculated Precision of XRF Method for Uranium ... 158
Table B-70. Comparability for Ex Situ XRF Soil Cup Method Uranium ... 159
Table B-71. Comparability for Ex Situ XRF Bulk Sample Method for Uranium ... 160
Table B-72. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Uranium Data ... 161
Table B-73. Summary of Project Wide Uranium Results by Surface Sampling Method ... 163
Table B-74. Summary of Data Pairs with Large Residuals for Vanadium in Model VA-1 ... 168
Table B-75. Summary of Parameters for Ex Situ Bulk Sample Vanadium Regression Models 168
Table B-76. Summary of Vanadium Soil Cup Linear Regression Model Parameters ... 171
Table B-77. Method Detection Limit for Vanadium by XRF Method ... 174

LIST OF TABLES (CONTINUED)

Table B-78. Summary of Calculated Precision of XRF Method for Vanadium 175
Table B-79. Comparability for Ex Situ XRF Soil Cup Method Vanadium 176
Table B-80. Comparability for Ex Situ XRF Bulk Sample Method for Vanadium 177
Table B-81. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Vanadium Data 178
Table B-82. Summary of Project Wide Vanadium Results by Surface Sampling Method 180
Table B-83. Summary of Data Pairs with Large Residuals for Zinc in Model ZN-1 184
Table B-84. Summary of Data Pairs with Large Residuals for Zinc in Model ZN-2 184
Table B-85. Summary of Parameters for Ex Situ Bulk Sample Zinc Regression Models 185
Table B-86. Summary of Zinc Soil Cup Linear Regression Model Parameters 187
Table B-87. Method Detection Limit for Zinc by XRF Method 190
Table B-88. Summary of Calculated Precision of XRF Method for Zinc 191
Table B-89. Comparability for Ex Situ XRF Soil Cup Method Zinc 192
Table B-90. Comparability for Ex Situ XRF Bulk Sample Method for Zinc 193
Table B-91. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Zinc Data 194
Table B-92. Summary of Project Wide Zinc Results by Surface Sampling Method 196
Table B-93. Summary of In Situ XRF Method Detection Limits 200
Table B-94. Summary of Ex Situ XRF Bulk Sample Method Detection Limits 200
Table B-95. Summary of Ex Situ XRF Soil Cup Method Detection Limits 201
Table B-96. Summary of Comparabilities (Uncorrected XRF Soil Cup Method) 202
Table B-97. Summary of Comparabilities (Corrected Ex Situ XRF Soil Cup Method) 202
Table B-98. Summary of Comparabilities (Uncorrected Ex Situ XRF Bulk Sample Method).. 203
Table B-99. Summary of Comparabilities (Corrected Ex Situ XRF Bulk Sample Method)...... 203
Table B-100. Summary of Precisions (In Situ XRF Method) 204
Table B-101. Summary of Precisions (Ex Situ XRF Soil Cup Method) 205
Table B-102. Summary of Precisions (Ex Situ XRF Bulk Sample Method) 205
Table B-103. Summary of Data Qualifiers in XRF Geodatabase 206
Table B-104. Results of Two Sample Hypothesis Testing of XRF Data Set and Confirmatory Data Set (Mobilization #1 – Mobilization #6) 207
Table B-105. Results of Two Sample Hypothesis Testing of XRF Data Set and Confirmatory Data Set (Mobilization #7 – Mobilization #9) 208
Table B-106. Evaluation of Prediction Limits for Target Element Regression Models............. 209
Table B-107. Summary of Corrected XRF Data Set and Laboratory Data Set for Target T12.. 211
Table B-108. Summary Statistics of Corrected XRF vs. Laboratory XRF Data Sets for Target T12 212
Table B-109. Summary of Bulk Sample and Soil Cup Sample Results for Target Elements 213
Table B-110. Summary of Final XRF Model Selection and Data Quality Criteria for Each Target Element 215

LIST OF FIGURES

Figure B-1. Regional AUM Map of the Navajo Nation 2
Figure B-2. XRF Investigation Area Map 5
Figure B-3. Tse Tah Region XRF Confirmation Soil Samples Map 6
Figure B-4. Cove Valley XRF Confirmation Soil Samples Map 7
Figure B-5. Lukachukai Mountains XRF Confirmation Soil Samples Map 8
Figure B-6. How XRF Analysis Works (from thermofisher.com) 11
Figure B-7. XRF Field Survey Process Flow Diagram 24
Figure B-8. Field Staff Taking In Situ XRF Measurements 26
Figure B-9. Prepared Soil Cups in the Laboratory 28
Figure B-10. Color Coded Equipment Bin 32
Figure B-11. Pre-Survey Instrument Comparability Study 32
Figure B-12. XRF Data Qualifier Process Flowchart 49
Figure B-13. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model AS-3 (Arsenic) 54
Figure B-14. Arsenic Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models 56
Figure B-15. Bulk Sample versus Soil Cup Arsenic Concentration 57
Figure B-16. Probability Plot of XRF Corrected Arsenic Data Set and Confirmatory Arsenic Data Set (3-Parameter Lognormal) 63
Figure B-17. Boxplot of XRF Corrected Arsenic and Laboratory Reported Arsenic 63
Figure B-18. Final Arsenic Regression Model – Unity Comparison 66
Figure B-19. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model (Iron) 69
Figure B-20. Iron Linear Regression– Ex Situ Bulk Sample vs. Ex Situ Cup Sample Models ... 71
Figure B-21. Bulk Sample versus Soil Cup Iron Concentration 72
Figure B-22. Probability Plot of XRF Corrected Iron Data Set and Confirmatory Iron Data Set (3-Parameter Lognormal) 78
Figure B-23. Boxplot of XRF Corrected Iron and Laboratory Reported Iron 78
Figure B-24. Iron Correlation – Unity Comparison 81
Figure B-25. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model PB-2A (Lead) 84
Figure B-26. Final XRF Correlation Models for Prediction of Lead using XRF Analyzer (Model PB-1A and Model PB-2A) 85
Figure B-27. Lead Linear Regression: Ex Situ Bulk Sample versus Ex Situ Soil Cup Sample Models 87
Figure B-28. Bulk Sample versus Soil Cup Lead Concentration 88
Figure B-29. Probability Plot of XRF Corrected Lead Data Set and Confirmatory Lead Data Set (3-Parameter Lognormal) 94
Figure B-30. Boxplot of XRF Corrected Lead and Laboratory Reported Lead 94
Figure B-31. Final Lead Regression Models– Unity Comparison 98
Figure B-32. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model MN-2 (Manganese) 101
Figure B-33. Manganese Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models 103
Figure B-34. Bulk Sample versus Soil Cup Manganese Concentration 104

LIST OF FIGURES (CONTINUED)

Figure B-35. Probability Plot of XRF Corrected Manganese Data Set and Confirmatory Manganese Data Set (3-Parameter Lognormal) 110
Figure B-36. Boxplot of XRF Corrected Manganese and Laboratory Reported Manganese 110
Figure B-37. Final Manganese Regression Model – Unity Comparison 113
Figure B-38. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model MO-1B (Molybdenum) 117
Figure B-39. Molybdenum Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models 120
Figure B-40. Bulk Sample versus Soil Cup Molybdenum Concentration 121
Figure B-41. Probability Plot of XRF Corrected Molybdenum Data Set and Confirmatory Molybdenum Data Set (3-Parameter Lognormal) 127
Figure B-42. Boxplot of XRF Corrected Molybdenum and Laboratory Reported Molybdenum 127
Figure B-43. Final Molybdenum Regression Model – Unity Comparison 130
Figure B-44. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model TH-2A (Thorium) 133
Figure B-45. Final XRF Correlation Models for Prediction of Thorium using XRF (Model TH-1A and Model TH-2A) 134
Figure B-46. Thorium Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models 137
Figure B-47. Bulk Sample versus Soil Cup Thorium Concentration 138
Figure B-48. Probability Plot of XRF Corrected Thorium Data Set and Confirmatory Thorium Data Set (3-Parameter Lognormal) 144
Figure B-49. Boxplot of XRF Corrected Thorium and Laboratory Reported Thorium 144
Figure B-50. Final Thorium Regression Models– Unity Comparison 147
Figure B-51. Final Selected XRF Regression Model for Thorium 148
Figure B-52. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model U-2A (Uranium) 152
Figure B-53. Final XRF Correlation Models for Prediction of Uranium using XRF (Model U1A and Model U-2A) 153
Figure B-54. Uranium Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models 155
Figure B-55. Bulk Sample versus Soil Cup Uranium Concentration 156
Figure B-56. Probability Plot of XRF Corrected Uranium Data Set and Confirmatory Uranium Data Set (Lognormal) 162
Figure B-57. Boxplot of XRF Corrected Uranium and Laboratory Reported Uranium 162
Figure B-58. Final Uranium Regression Models– Unity Comparison 166
Figure B-59. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model (Vanadium) 170
Figure B-60. Vanadium Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models 172
Figure B-61. Bulk Sample versus Soil Cup Vanadium Concentration 173
Figure B-62. Probability Plot of XRF Corrected Vanadium Data Set and Confirmatory Vanadium Data Set (3-Parameter Lognormal) 179
Figure B-63. Boxplot of XRF Corrected Vanadium and Laboratory Reported Vanadium 179

LIST OF FIGURES (CONTINUED)

Figure B-64. Final Vanadium Regression Model – Unity Comparison 182
Figure B-65. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model ZN-3 (Zinc)... 186
Figure B-66. Zinc Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models... 188
Figure B-67. Bulk Sample versus Soil Cup Zinc Concentration 189
Figure B-68. Probability Plot of XRF Corrected Zinc Data Set and Confirmatory Zinc Data Set (3-Parameter Lognormal) 195
Figure B-69. Boxplot of XRF Corrected Zinc and Laboratory Reported Zinc 195
Figure B-70. Final Zinc Regression Model – Unity Comparison.. 198

ATTACHMENTS

Attachment B1	XRF Quality Control Analysis
Attachment B2	XRF Analyzer Calibration Documentation
Attachment B3	Ex Situ Bulk Sample Regression Models
Attachment B4	Ex Situ Bulk Sample Regression Model Data
Attachment B5	Ex Situ Soil Cup Regression Models
Attachment B6	ProUCL Output for Population Tests

ACRONYMS AND ABBREVIATIONS

%D	Percent difference
AES	Atomic emission spectroscopy
ASTM	ASTM International
ATSDR	Agency for Toxic Substances and Disease Registry
AUM	Abandoned uranium mine
bgs	Below ground surface
BSA	Background study area
BTV	Background threshold value
CAMIRO	Canadian Mining Industry Research Organization Exploration Division
CFR	*Code of Federal Regulations*
COPC	Contaminant of potential concern
DQI	Data quality indicator
DQO	Data quality objective
EE/CA	Engineering Evaluation/Cost Analysis
EFR	Environmental Restoration Group
FLAA	Flame atomic absorption spectrometry
FSP	Field sampling plan
GFAA	Graphite furnace atomic absorption spectrometry
IAEA	International Atomic Energy Agency
ICP-MS	inductively coupled plasma-mass spectrometry
iiná bá	iiná bá, Inc.
Kerr-McGee	Kerr-McGee Oil Industries, Inc.
LOD	Limit of detection
m^2	Meters squared
MDL	Method detection limit
mg/kg	Milligrams per kilogram
NIST	National Institute of Standards and Technology
Niton	Niton Corporation LLC
OSWER	Office of Solid Waste and Emergency Response
ppm	Parts per million

ACRONYMS AND ABBREVIATIONS (CONTINUED)

QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
r	Pearson's correlation coefficient
R^2	Coefficient of determination
RAES	Response, Assessment, and Evaluation Services
RCRA	Resource Conservation and Recovery Act
RM	Radiation Monitoring Devices, Inc.
RPD	Relative percent difference
RSE	Removal site evaluation
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
SD	Standard deviation
SOP	Standard Operating Procedure
Tetra Tech	Tetra Tech, Inc.
UF	University of Florida
UNAT	Natural uranium
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
V	Volt
W	Watt
Weston	Weston Solutions, Inc.
XRF	X-ray fluorescence

EXECUTIVE SUMMARY

This X-ray fluorescence (XRF) Data Evaluation Report presents the methodology, results, and findings of the XRF comparability study and data evaluation to support the XRF field survey program. Tetra Tech Inc. (Tetra Tech) conducted this study on behalf of the U.S. Environmental Protection Agency (USEPA) at the Tronox abandoned uranium mine (AUM) sites and Target sites located within the Northern Agency of the Navajo Nation. The XRF field survey was a component of the removal site evaluation (RSE) field investigation that involved a 6-month multimedia sampling event at the Tronox legacy AUM sites of northeastern Arizona within the Navajo Nation. This study was the first of its kind on this scale and magnitude at uranium mines within the Navajo Nation, and included an extensive XRF field survey program involving analyses via numerous field-portable Niton XL5 XRF analyzers and collection of confirmatory soil samples submitted for laboratory analysis. The XRF field survey was designed and implemented to meet project-specific data quality objectives (DQO) identified in the RSE Work Plan (Tetra Tech 2018), and was specifically aimed to assist delineation of the spatial extent of mine-related contamination within surface soils of the Northern Agency Tronox AUM sites and Target sites. Results of this study allowed comparisons of acquired data to established background threshold values (BTV), and may be used during the risk assessment phase of the Engineering Evaluation Cost Analysis (EE/CA) of the project. XRF technology described and assessed in this report has potential to serve as a real-time screening technology during removal and/or remedial action during mine cleanup.

A total of 9,540 in-situ XRF measurements were taken across 39 AUMs and 37 Target sites within the Northern Agency Tronox Mine area region; measurements were collected within a systematic 100-square-meter (m^2) survey unit grid system at each site. The XRF field survey was conducted across extreme and treacherous terrain within the Lukachukai Mountains and across the more forgiving lower lying terrain at the base of the northwest Carrizo Mountains in the Tse Tah region of the Navajo Nation within Apache County in northeast Arizona. In addition to in situ XRF measurements, 502 confirmatory bulk soil samples were collected and evaluated via replicate ex situ XRF measurements taken directly through the plastic bags containing the bulk samples at a field office in Farmington, New Mexico. The purpose of this was to perform a comparability study by establishing a linear regression between XRF data and confirmatory data for target elements. The linear regression was used to correlate XRF and confirmatory data, and each data set was checked for data pairs that contained large residual error and whether these were outliers to be removed prior to selection of a representative model. Tetra Tech found that the ex situ XRF bulk sample measurements correlated well (Pearson's correlation coefficient [r] between 0.8 and 1.0) with concentrations in confirmatory laboratory samples that were analyzed via inductively coupled plasma-mass spectrometry (ICP-MS) according to SW-846 Method 6020A after partial digestion (Method 3050B).

XRF technology measures total concentration of an element; therefore, to achieve greatest comparability between data acquired via the XRF method and that acquired via the laboratory method, a total digestion is necessary for sample preparation (USEPA 2007). As a practical matter, however, application of a partial digestion method was selected to meet project DQOs. It was determined that correction coefficients could be applied to XRF analyzer data to predict, within acceptable levels, soil concentrations equivalent to those determined by application of the laboratory method. Through post-processing of in-situ XRF measurements using correction factors, predictions of laboratory concentrations met project DQOs for nine target elements. After post-processing, accuracy was recalculated, and inferential statistics were applied to evaluate effectiveness of the corrected XRF method—the XRF analyzer was found to measure arsenic, iron, lead, manganese, uranium, vanadium, and zinc concentrations at definitive levels as defined by Method 6200 standards, and was found to measure molybdenum and thorium concentrations at semi-quantitative levels as defined in USEPA (1998). Table B-ES-1 lists final linear regression parameters for the target elements.

In addition to acquisition of in situ XRF measurements and a comparability study of the ex situ XRF bulk sample method, a pilot study evaluated potential applicability of the ex situ XRF soil cup method; this involved more than 40 samples across the range of project-relevant constituent concentrations and use of three different XRF analyzers in succession. Aims of this study were to evaluate interchangeability of XRF analyzers and to assess a soil preparation methodology (applied in the ex situ XRF soil cup method) that resulted in a soil sample with small-sized particles. The study found very little difference in linear regression results between the two ex situ methods (slope, y-intercept, correlation coefficient). This indicated applicability of the bulk sample method as the primary tool to estimate predicted laboratory-determined concentrations of nine target elements, and to serve in risk assessments. Further, the technology should be considered for remedial or removal action surveys and/or future final status surveys if needed. Moreover, the ex situ XRF bulk sample measurement method suits field conditions, and results of comparing precision and accuracy between the two methods do not fully justify use of ex situ XRF soil cup method correction factors; that is, the ex situ XRF bulk sample method definitively measures concentrations of the same number of elements as the soil cup method. Finally, all concentrations of target elements were found to decrease with smaller particle size.

This report focuses on data analyses of various data quality indicators, including method detection limits, precision, accuracy, and comparability across different widely accepted soil preparation methods. The relatively new XRF technology was applied on a scale not previously attempted within an even more constrictive time frame. This required an extensive quality assurance (QA) and quality control (QC) program to ensure data quality suitable for use in risk assessments. All instruments used during this project had been internally calibrated by the manufacturer, and calibration checks occurred twice daily by use of standard reference materials to evaluate drift and to ensure instruments were within operating limits. Replicate measurements occurred daily when each of the types of soil preparation methods was implemented, as did evaluations of precision of each method across different concentrations. By use of this information, site-specific and method-specific detection limits were determined for all target elements (calculated per Title 40 *Code of Federal Regulations* [CFR] 136), and were compared to manufacturer-provided detection limits. Daily blank samples were scanned, and system checks occurred numerous times daily per instrument. Collection of field duplicate samples occurred at frequency (5 percent) typical for soil sampling.

Except for molybdenum (accuracy biased by very low concentrations), average relative percent difference (RPD) of results for each target element was 15 percent by application of correction factors identified during investigation of the ex situ XRF bulk sample measurement method. Lowest RPDs were evident in results for iron (12 percent), zinc (12 percent), arsenic (13 percent), manganese (13 percent), thorium (15 percent), and lead (15 percent). RPDs in results for uranium and vanadium were 22 and 27 percent, respectively. Average precisions calculated from the median relative standard deviations (RSD) in results for all target elements via the in situ XRF method, ex situ XRF bulk sample method, and ex situ soil cup method were 11, 14, and 11 percent, respectively. By application of the ex situ XRF bulk sample method, results for all target elements except molybdenum indicated a median RSD less than 20 percent—specified as acceptable in Method 6200. This report summarizes successful results of the XRF field survey program based on extensive data evaluation, and recommends continued use of this technology in the future at Northern Agency Tronox AUM sites.

Table B-ES-1. Summary of Final Ex Situ XRF Bulk Sample Method Model Parameters

Target Element	Final Model Name[1]	Correlation Coefficient (r)	Slope (m)	y-intercept (b)	Median RSD[2]	Median RPD[3]	Inferential Statistics[4]	Data Quality Criteria[5]
Arsenic (As)	Model AS-3	1.0	1.0407	-0.5494	19%	13%	Equal	Definitive
Iron (Fe)	Model FE-1	0.9	0.5179	283.36	1.5%	12%	Equal	Definitive
Lead (Pb)	Model PB-1A	0.9	0.9519	-1.476	9.7%	15%	Equal	Definitive
Manganese (Mn)	Model MN-2	0.9	0.8912	62.274	7.5%	13%	Equal	Definitive
Molybdenum (Mo)	Model MO-1B	1.0	0.7964	-1.6827	18%	44%	Equal	Quantitative Screening
Thorium (Th)	Model TH-2A	0.8	0.5189	-0.0333	14%	15%	Equal	Quantitative Screening
Uranium (U)	Model U-2A	0.9	0.8031	-2.266	13%	22%	Equal	Definitive
Vanadium (V)	Model VA-2	1.0	0.7963	-18.33	9.0%	27%	Equal	Definitive
Zinc (Zn)	Model ZN-3	0.9	0.6919	4.2593	7.4%	12%	Equal	Definitive

Notes:

1 Final models presented are primary models; lead, thorium, and uranium have two regressions based on concentration (one primary model and one high model).

2 Median RSD of the in situ XRF method for each target element.

3 Median RPD from the ex situ XRF method for each target element using corrected data.

4 Inferential statistics refers to two-sample population test Student's t-test between corrected XRF data and confirmatory data at a 99 percent level.

5 Data quality criteria refers to project-specific data quality criteria listed in Table B-3. For data quality to be definitive, the following criteria must be met: r ≥ 0.9, RSD ≤ 20 percent, RPD ≤ 30 percent, and inferential statistics are equal. For data quality to be quantitative screening, the following criteria must be met: r ≥ 0.8, RSD ≤ 20 percent, RPD ≤ 50 percent, and inferential statistics are equal.

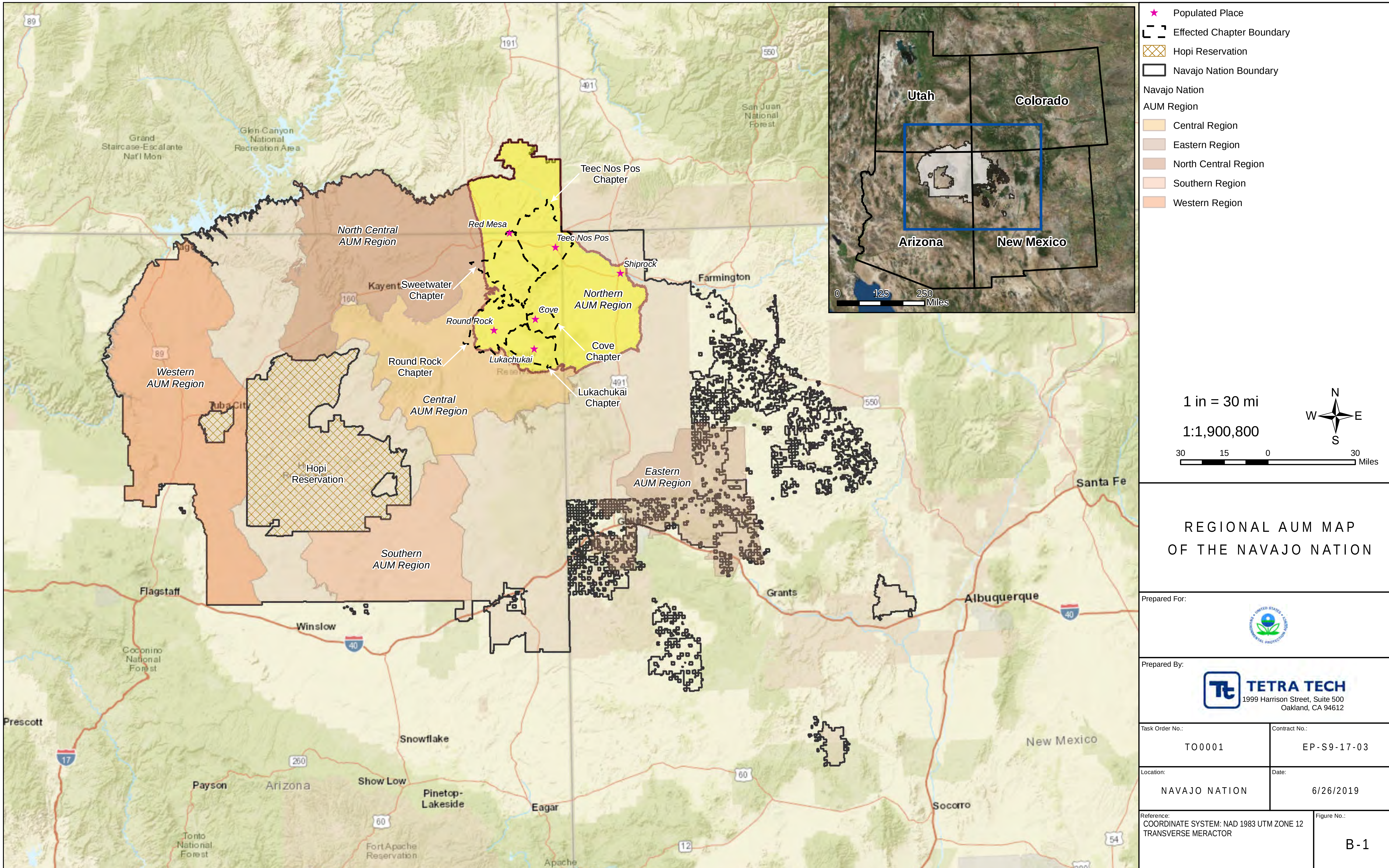
b y-intercept of ex situ XRF data versus confirmatory data regression line
m Slope of ex situ XRF data versus confirmatory data regression line
r Pearson's correlation coefficient of ex situ XRF data versus confirmatory data regression line
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.0 INTRODUCTION

This X-ray fluorescence (XRF) Data Evaluation Report is Appendix B to the Northern Agency Tronox Mines Removal Site Evaluation (RSE) Report (RSE Report). The XRF Data Evaluation Report presents the methodology and results of an XRF field survey program conducted by Tetra Tech, Inc., (Tetra Tech) within the Northern Agency Tronox Mines in support of the U.S. Environmental Protection Agency (USEPA) under Task Order 0001 of the Response, Assessment, and Evaluation Services (RAES) contract (EP-S9-17-03). The RSE Work Plan (Tetra Tech 2018) identified the need for an XRF field survey to delineate lateral extents of trace elements, specifically heavy metals associated with mining, at abandoned uranium mine (AUM) sites and Target sites of the Northern Agency Tronox Mines to satisfy project data quality objectives (DQO). Under Task Order 0001, Tetra Tech was tasked to conduct RSE field investigations at 39 AUM sites and 37 Target sites previously operated by, or likely associated with, Kerr-McGee Oil Industries, Inc. (Kerr-McGee), or its successor, Tronox (both Kerr-McGee and Tronox referred to herein as Tronox). Target sites are classified as either AUM-related sites or non-AUM Targets (see Section 1.6.1 of the Northern Agency Tronox Mines Removal Site Evaluation Work Plan [RSE Work Plan]).

Each of the AUM sites and Target sites within the Northern Agency possibly hosts mine-related contamination. Mine-related soil contamination may include radionuclides and heavy metals at concentrations above acceptable human health and/or ecological risk levels. A field-portable XRF spectrometer is a useful tool for investigating contaminated sites and guiding removal action activities (Waikato Regional Council 2015). Previously, no comprehensive investigation of heavy metals and/or other chemical constituents had occurred at AUM sites and Target sites within the Northern Agency Tronox Mines. Both aerial radiometric and ground-based, screening-level gamma surveys have occurred across some of these mines (USEPA 2015b; Weston Solutions, Inc. [Weston] 2016). Tetra Tech utilized the most advanced field-portable XRF spectrometer available during this investigation, the Thermo Fisher Scientific Niton XL5 (Niton XL5), for which factory operational specifications are available from Thermo Fisher Scientific (2016). The XRF field survey supplemented comprehensive gamma radiation surveys at each site.

All work that was part of the XRF field survey accorded with the Sampling Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) included as Appendix C to the RSE Work Plan submitted on May 14, 2018 (Tetra Tech 2018). Deviations from the RSE Work Plan are discussed in this report. AUM sites and Target sites that underwent investigation during the XRF field survey described in this report are within the Northern AUM Region, one of six AUM regions identified in the Navajo Nation. Figure B-1 is an overview map of the different AUM regions in the Navajo Nation, and highlights the Northern AUM Region area of interest within which this XRF field survey occurred. This XRF Data Evaluation Report presents the methods, results, and data evaluation of XRF field sampling efforts by the Tetra Tech team. The Tetra Tech team included Environmental Restoration Group (ERG) and iiná bá, Inc. (iiná bá) as subcontractors. Field survey efforts proceeded between April and September 2018 within the Sweetwater, Teec Nos Pos, Cove, Round Rock, and Lukachukai Chapters of the Navajo Nation, all of which are shown on Figure B-1.


Populated Place
Effected Chapter Boundary
Hopi Reservation
Navajo Nation Boundary
Navajo Nation
AUM Region
Central Region
Eastern Region
North Central Region
Southern Region
Western Region
Utah
Colorado
Arizona
New Mexico
0 125 250 Miles
1 in = 30 mi
1:1,900,800
30 15 0 30 Miles
N
W
E
S
North Central AUM Region
Western AUM Region
Central AUM Region
Southern AUM Region
Eastern AUM Region
Northern AUM Region
Hopi Reservation
Teec Nos Pos Chapter
Sweetwater Chapter
Round Rock Chapter
Cove Chapter
Lukachukai Chapter
Red Mesa
Teec Nos Pos
Shiprock
Cove
Round Rock
Lukachukai
Farmington
Flagstaff
Winslow
Grants
Albuquerque
Santa Fe
Prescott
Snowflake
Payson
Show Low
Pinetop-Lakeside
Eagar
Socorro
Tuba City
Kayenta
REGIONAL AUM MAP
OF THE NAVAJO NATION
Prepared For:
Prepared By:
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612
Task Order No.:
TO0001
Contract No.:
EP-S9-17-03
Location:
NAVAJO NATION
Date:
6/26/2019
Reference:
COORDINATE SYSTEM: NAD 1983 UTM ZONE 12
TRANSVERSE MERACTOR
Figure No.:
B-1

1.1 PURPOSE

To date, no known previous studies have occurred within the Lukachukai or Carrizo Mining districts to establish magnitudes and spatial extents of possibly present non-radiological contaminants, including inorganic constituents and heavy metals, at the complex of AUM sites within these regions. Mines in these regions of the Navajo Nation were mined for vanadium and uranium. Determined prior to field work was high potential for natural presence of non-radiological (for example., arsenic, lead, and vanadium) and radiological metals (for example, uranium and thorium) within the regions of interest. Mining may well have exacerbated spread and transport of these naturally occurring metals to result in concentrations in the environment above background levels and above ecological and human health risk screening levels. Magnitudes and extents of these mining-related contaminants in the environment were not known prior to this investigation, as indicated by the Data Gap Analysis (Appendix A to the RSE Work Plan). The Data Gap Analysis indicated need for site-specific characterization information to meet DQOs for the project. USEPA tasked Tetra Tech to undertake a comprehensive XRF field survey program as part of the 2018 RSE investigation.

A primary purpose of this report was to answer the following study question identified as part of the DQO process described in Appendix C to the RSE Work Plan, and summarized as follows:

Study Question 2: What is the lateral extent of mine-related surficial contamination at each site?

Goals of this report are to (1) present results of Tetra Tech's XRF field survey program, and (2) document suitability of XRF technology in conjunction with standard laboratory analytical sampling for the following: (a) providing cost benefits while still meeting project DQOs, (b) acquiring potentially definitive-level data to assess possibly present contamination, (c) aiding cleanup decision making, and (d) providing supplemental information useful in risk assessments. Primary objectives of the XRF field survey were as follows:

1. Utilize currently available XRF technology in the field to predict soil concentrations of selected analytes for the purpose of identifying contaminants of potential concern (COPC) at concentrations exceeding background levels.
2. Provide useful information on lateral extents of COPCs at concentrations above background levels at AUM sites and Target sites.
3. Determine whether relationships between results from field-portable XRF technology and analytical results from the laboratory justify use of XRF technology in removal action surveys and future cleanup work at AUM sites, if necessary.

The following section presents the Scope of Work for activities described within this report to achieve the objectives of this project.

1.2 SITE SETTING

The XRF field survey occurred across 39 AUM sites and 30 Target sites within the Northern AUM region of the Navajo Nation. For the purposes of the RSE investigation, the sites were grouped by geographical location into 10 distinct subarea groups referred to as Subarea Group A through Subarea Group J, as described further in the main RSE Report. These subarea groups are within three distinct investigation regions: (1) Tse Tah, (2) Cove Valley, and (3) Lukachukai Mountains. Figure B-2 shows a breakdown of the number of different types of sites within each investigation region. The XRF field survey was not conducted in drainages or background study areas. The XRF field survey did, however, include access roads to AUM sites. Results of the XRF field survey within the 39 AUM sites and select Target sites (including Cove Transfer Station, NA-0334B, and Mesa I Camp) are in Appendix H to the RSE Report. Results of the XRF field survey within each Target site are in Appendix I to the RSE Report. Across each site, in situ XRF measurements occurred within a 100-square-meter (m^2) survey unit grid system, and XRF confirmation soil samples were collected at a frequency of 1 in 20, as discussed in Section 3.3.

The Tse Tah region, shown on Figure B-2, is one of the distinct geographical regions included as part of the RSE investigation. This region includes two AUM sites and seven non-AUM Target sites within Subarea Group A and Subarea Group B. Figure B-3 is a map showing geospatial locations and distribution of XRF confirmation soil samples in this region. Maps showing in situ XRF measurement locations and XRF confirmation soil sample locations within individual AUM sites or Target sites are in the site-specific reports in Appendix H and Appendix I to the RSE Report.

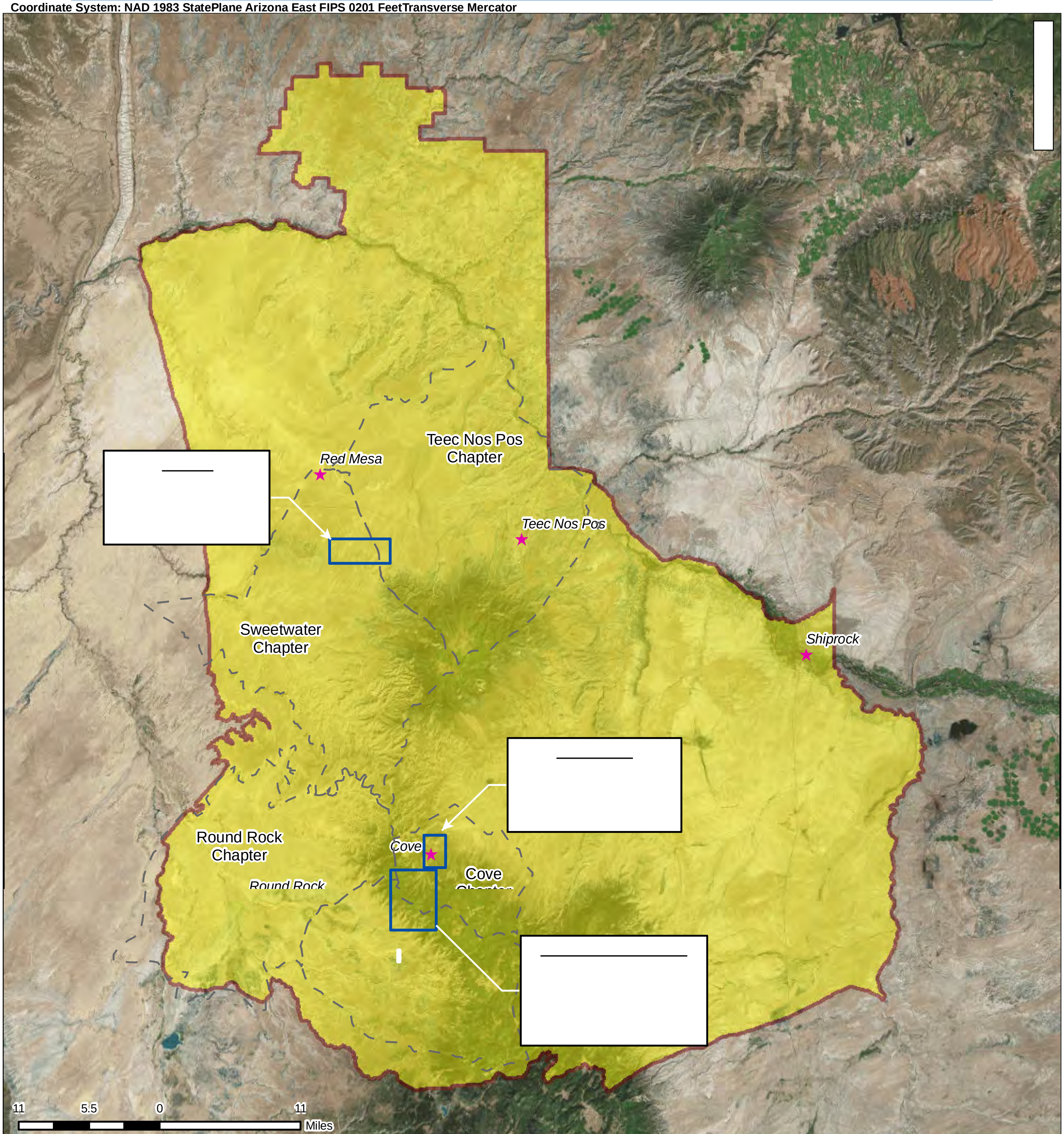
The Cove Valley region, shown on Figure B-2, is at the base of the Lukachukai Mountains and includes the Cove Transfer Station, a site that has undergone time-critical removal action and was a transfer station for shipping uranium-vanadium ore to undergo milling at Shiprock or other milling facilities. This region includes no AUM sites, one AUM-related site, and three non-AUM Target sites. This area is of extreme importance because it is the main population center of the Cove Chapter. Figure B-4 is a map showing geospatial locations and distribution of XRF confirmation soil samples in the Cove Valley region.

The Lukachukai Mountain region, shown on Figure B-2, is the largest region of investigation and includes 37 AUM sites and 19 Target sites (two AUM-related sites and 17 non-AUM Target sites). Figure B-5 is a map showing geospatial locations and distribution of XRF confirmation soil samples.

Again, Figure B-3, Figure B-4, and Figure B-5 show, respectively, confirmation soil sample locations within the Tse Tah region, the Cove Valley region, and the Lukachukai Mountain region.

Maps showing locations of in situ XRF measurements and XRF confirmation soil samples within individual AUM sites or Target sites are in the site-specific reports in Appendix H and Appendix I to the RSE Report.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



★ Populated Place

Regional Background Investigation Area

Effected Chapter Boundary

Navajo Nation Northern Abandoned Uranium Mine Region

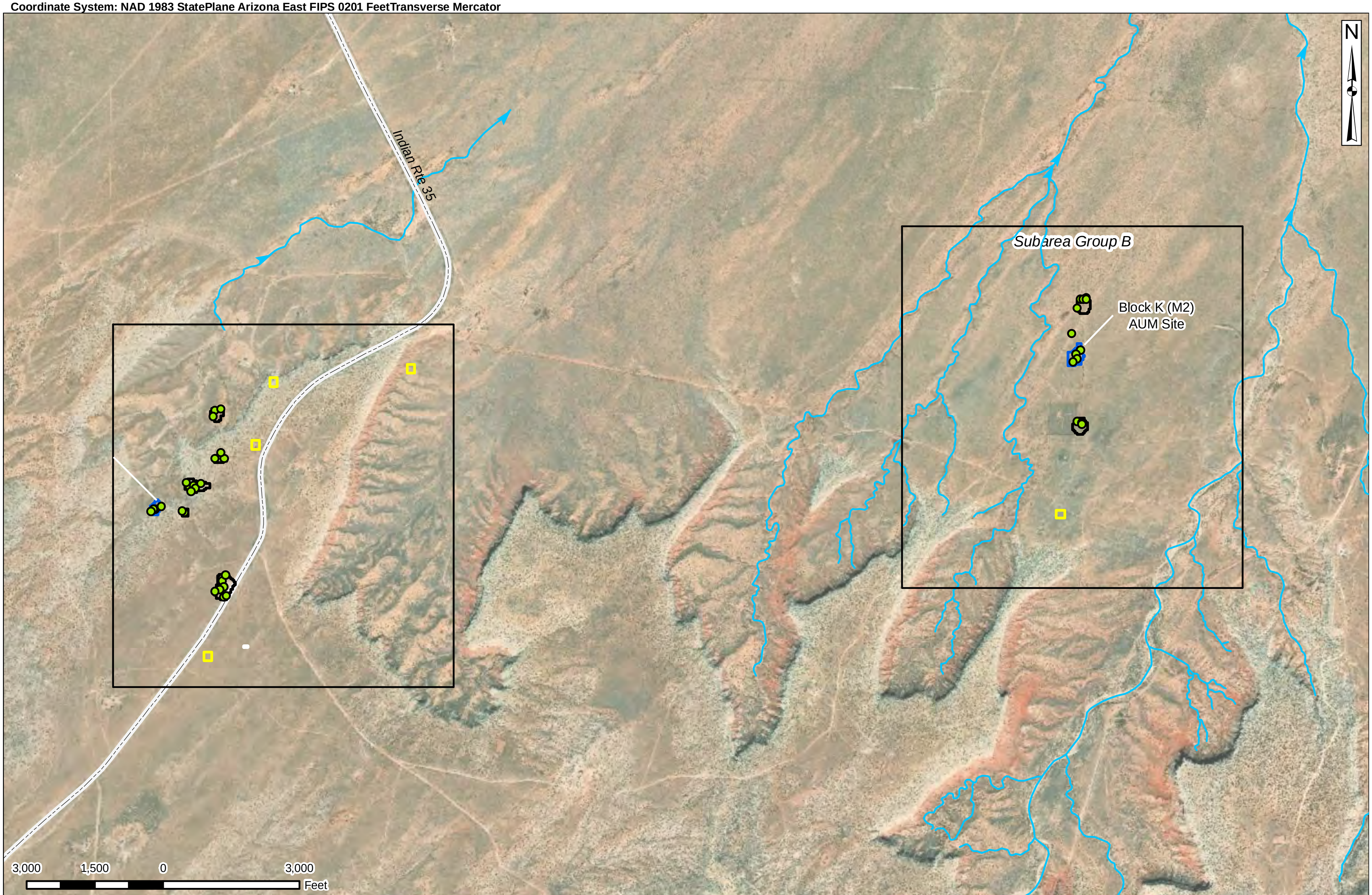
Prepared for: U.S. EPA Region 9

Prepared By: TETRA TECH

XRF INVESTIGATION AREA MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	B-2
Location: NAVAJO NATION	Date: 6/26/2019	

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



XRF Confirmation Soil Sample Location

Survey Areas

- AUM Site
- AUM Related Site
- Non-AUM Target Site
- Background Study Area
- Subarea Group
- Local Road
- Drainage*

* U.S Environmental Protection Agency, Region 9, Superfund Program, NN_Drainage_HR_AUM.shp. July, 2007.

Prepared for:

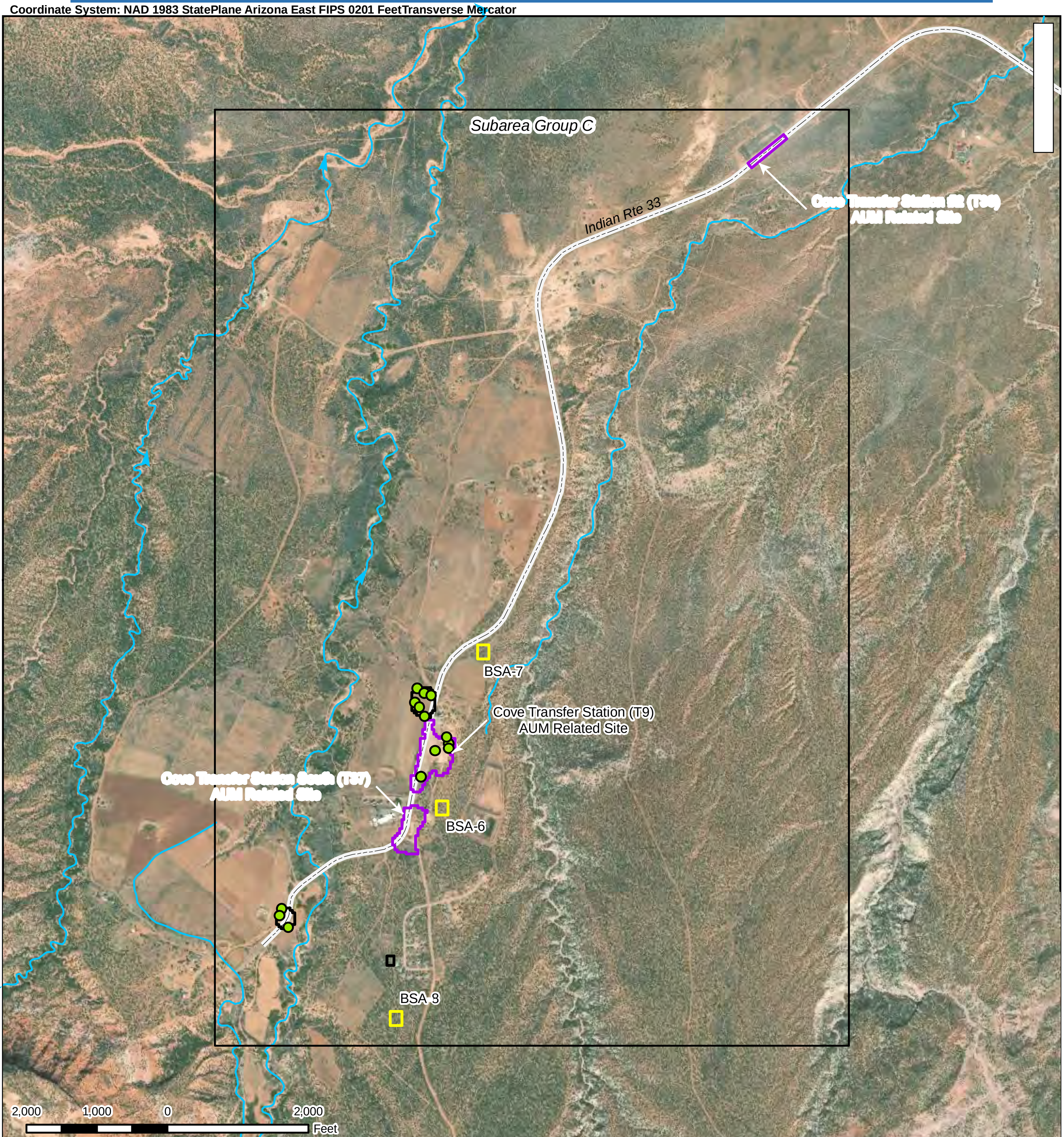
Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

TSE TAH REGION
XRF CONFIRMATION SOIL SAMPLES MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	B-3
Location: NAVAJO NATION	Date: 6/26/2019	

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



- XRF Confirmation Soil Sample Location

Survey Areas

- AUM Related Site
- Non-AUM Target Site
- Background Study Area
- Subarea Group
- Local Road
- Drainage*

* U.S Environmental Protection Agency, Region 9, Superfund Program, NN_Drainage_HR_AUM.shp. July, 2007.

Prepared for: U.S. EPA Region 9

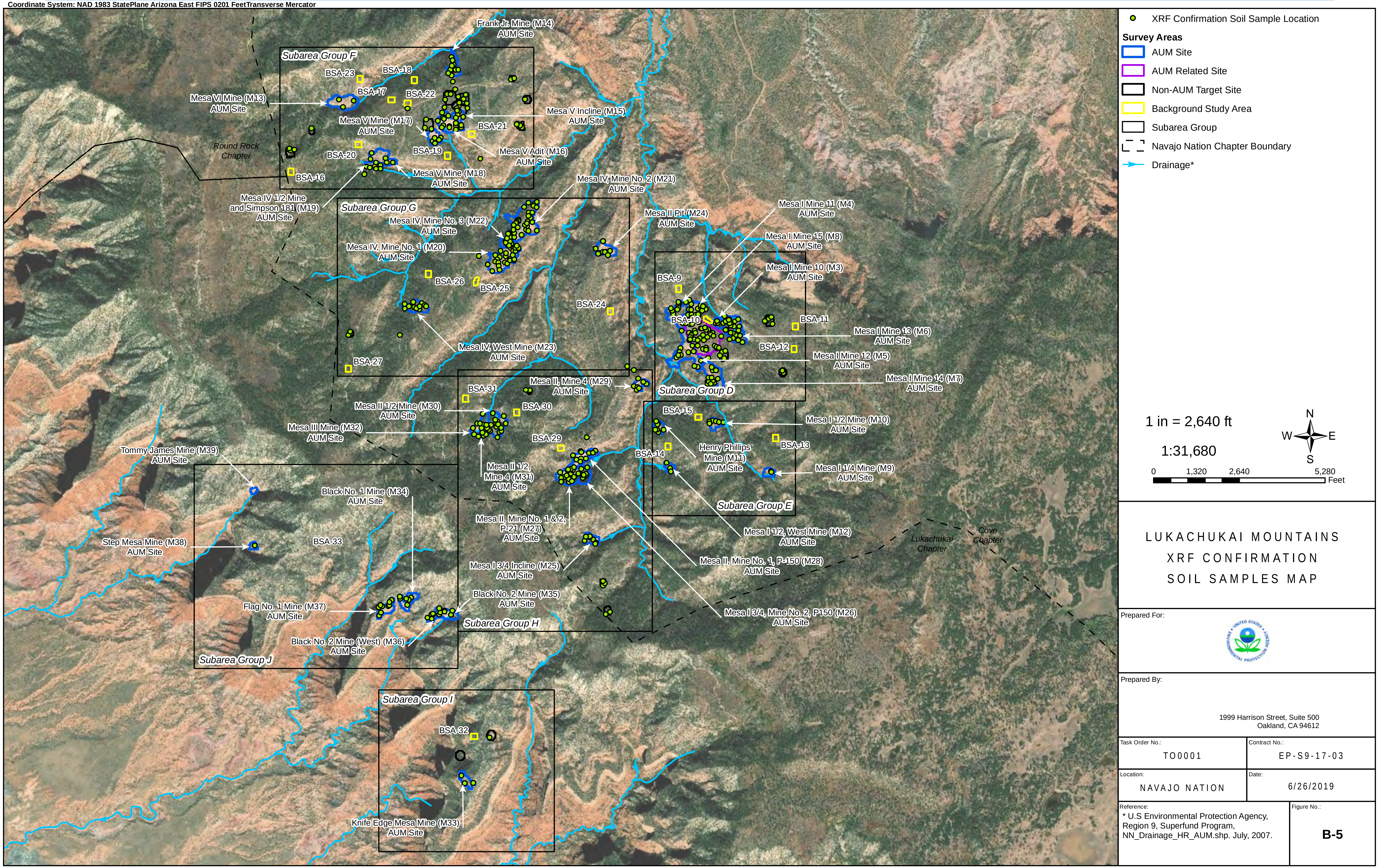
Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

COVE VALLEY XRF CONFIRMATION SOIL SAMPLES MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	B-4
Location: COVE CHAPTER NAVAJO NATION	Date: 6/26/2019	

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



1.3 REPORT ORGANIZATION

The XRF Data Evaluation Report is organized as follows:

- Section 1.0 presents background information, purpose, and site setting.
- Section 2.0 summarizes XRF technology, describes the regulatory and scientific background, specifies project-specific data quality criteria, and summarizes target elements under evaluation as part of the XRF field survey.
- Section 3.0 presents the field sampling methodology, various data evaluation procedures, and deviations to the RSE Work Plan for the XRF field survey program.
- Section 4.0 presents model results for the nine target elements.
- Section 5.0 presents a data quality assessment that includes model validation procedures, and summarizes data quality indicators for all target elements.
- Section 6.0 presents and summarizes the final model selection for each target element.
- Section 7.0 presents conclusions and offers recommendations.
- Section 8.0 lists references cited in the report.

This XRF Data Evaluation Report has a number of attachments organized as follows:

- Attachment B1 includes graphical and tabular summary of pertinent XRF quality control procedures and results.
- Attachment B2 presents XRF analyzer calibration documentation.
- Attachment B3 provides prediction report, residual report, and other graphical analyses of the various linear regression models of the ex situ XRF bulk sample method.
- Attachment B4 provides data pairs included and excluded from the final model derived from data pairs from the Baseline Study (Mobilization #1 through Mobilization #6), in both tabular and graphical format; and provides data pairs for the Site Characterization Study (Mobilization #7 through Mobilization #9).
- Attachment B5 provides a tabular summary and graphical results of the three different XRF analyzer results for the ex situ XRF soil cup method.
- Attachment B6 provides detailed raw ProUCL output data sheets for population testing between XRF and confirmatory data populations.

2.0 TECHNICAL AND REGULATORY BACKGROUND

This section summarizes XRF technology, describes the regulatory and scientific background, specifies data quality criteria, and summarizes target elements under evaluation as part of the XRF field survey.

2.1 TECHNOLOGY OVERVIEW

Selection of a robust, accurate, and cost-effective measurement tool was critical for successful characterization of lateral extent of mine waste at the Northern Agency Tronox Mines. After careful consideration, the field portable Niton XL5 model XRF analyzer was selected as the instrument for use in the XRF field survey program. This model of XRF analyzer is still relatively new, and Niton still performs research on the instrument and advances many aspects of the technology. USEPA has not issued a Technology Verification Report on the Niton XL5, and this report can serve as a basis for future evaluations of this technology.

The Niton XL5 has different modes of analysis depending on the application, including precious metals mode, coatings mode, mining mode, soils mode, consumer goods mode, and general metals mode. The soils mode was used for this project because of its design for detection and remediation of environmental contaminants from mining operations. The Niton XL5 was selected because of its higher sensitivity and ability to rapidly analyze soil samples in situ while providing information on heavy metal contaminants. In the instrument's soils mode, one can easily detect all Resource Conservation Recovery Act (RCRA) metals, priority pollutants, and USEPA target analytes with near-instant and legally defensible results. One consideration in selection of this instrument is its ability to detect uranium and vanadium at lower levels than other types of field-portable XRF analyzers available commercially.

Typically, field-portable XRF technology uses a radiation source from one or more radioisotopes or from an electrically excited x-ray tube to induce characteristic X-ray emissions from elements in a sample (USEPA 2007). Each source emits a specific set of primary X-rays or gamma rays that excite one or more elements within a sample to emit characteristic X-rays at respectively lower energies. When more than one source can induce emissions of X-rays from the element of interest, the source is selected according to its excitation efficiency for the element of interest (USEPA 2007). The Niton XL5 uses a proprietary large area drift detector and a dynamic current adjustment feature ensuring optimum sensitivity for each measurement. The Niton XL5 utilizes a 5-watt (W) X-ray tube with a silver anode with dynamically adjustable current for optimal sensitivity. The instrument has three distinct filter modes: Main, High, and Low. Count time is user programmed with a maximum of 60 seconds for each mode. Section 3.1.3 summarizes how optimal count times and filter modes were selected for this project. The analyzer has a 12-volt (V) lithium-ion battery with a 3.6-W power supply, and allows the user to change the battery in the field without need to turn off the unit. Tetra Tech rented the unit from a rental company, and accompanying equipment included test stands, soil guards, and standard reference materials for calibration checks. Figure B-6 overviews the technology and how the Niton XL5 performs XRF analysis.

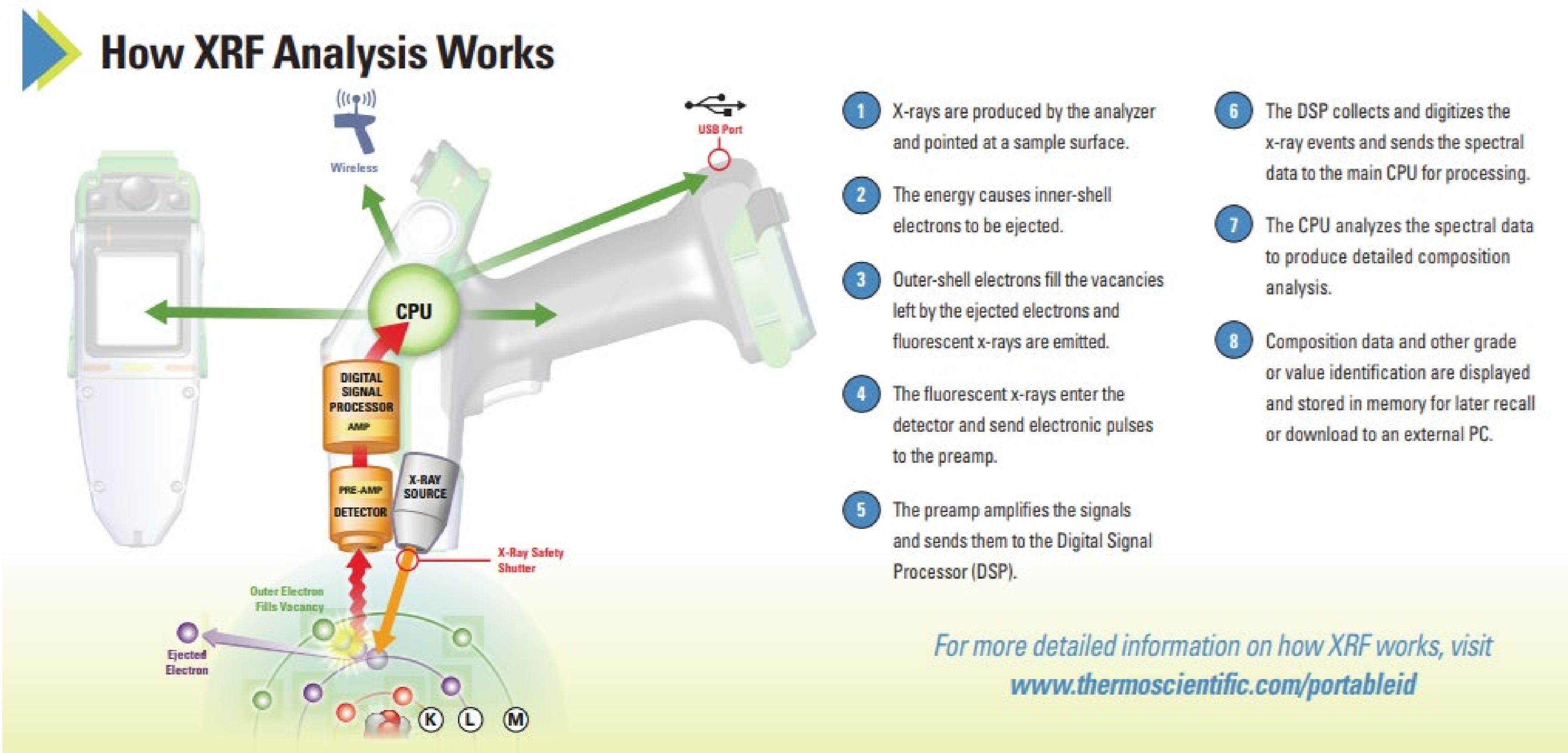


Figure B-6. How XRF Analysis Works (from thermofisher.com)

2.2 REGULATORY AND SCIENTIFIC BACKGROUND

Application of portable XRF instruments to analyze soil samples for metals began in earnest in the 1980s. Up to the mid-1990s, application of portable XRF spectrometers for this purpose under rugged field conditions was somewhat difficult because of instrumental bulkiness and especially the need for a cord to connect the mobile probe to a battery and the analysis unit. Successful use of hand-held XRF spectrometers with all components of the instrument enclosed within a small volume occurred first in the mid-to-late 1990s in the United States, stimulated by an effort to detect and measure lead concentrations in paint, a pressing environmental issue in the United States. Niton Corporation LLC (Niton) and Radiation Monitoring Devices, Inc. (RMD)—both in the Boston, Massachusetts area—followed different approaches to determine lead concentration in paint via XRF, and emerged by verdict of the market as the two leading vendors of hand-held XRF instruments for that purpose. By the latter 1990s, Niton had successfully applied hand-held XRF technology to analyses of soil samples (DeKosky 2009).

Advantages of field-portable (hand-held) XRF technology include rapidity and inexpensiveness in its quantitative detections of trace elements in soil and sediments. In the United States, widespread commercial acceptance in the late 1990s of this technology was also a result of successful technology verification and evaluation programs and publication of Innovative Technology Verification Reports led by USEPA beginning in 1998 (USEPA 1998) and again in 2005 (USEPA 2006a, 2006b, 2006c, 2006d). These reports summarized programs that evaluated different commercially available technologies for measuring trace elements in soil and sediment. These programs contributed to the most recent update of USEPA SW-846 Method 6200 in 2007 (USEPA 2007). Since 2007, even more recent technological improvements in the industry have led to widespread adoption of this technology by government agencies, environmental consultancies, and research institutions across the world (Parsons and others 2012). However, at the time this report was written, the most recent guidance published on field-portable XRF methods in the United States was still Method 6200, which provides guidance for conducting in situ and intrusive XRF studies, and was developed following the extensive programs funded by USEPA described above.

Notably, other developed nations have adopted similar policies and guidance, and several international scientific research papers have been published wherein Method 6200 is consistently referenced. For this project, Method 6200 is the primary guidance document for performing field work, laboratory work, and data evaluation of XRF methods presented herein. However, significant literature outside of Method 6200 is also consistently referenced and followed throughout this report. For instance, other countries have developed guidance programs based on Method 6200 including New Zealand's Guidance for Analysis of Soil Contamination Using Portable XRF Spectrometer (Waikato Regional Council 2015). Similarly, other international government institutions such as the Canadian Mining Industry Research Organization (CAMIRO) Exploration Division have conducted large-scale quality control assessments such as CAMIRO's Quality Control Assessment of Portable XRF Analyzers: Development of Standard Operating Procedures, Performance on Variable Media and Recommended Uses (CAMIRO Exploration Division 2013). Kalnicky and Singhvi (2001) researched comparisons of bench-top and portable XRF instrumental performances and performances of different models of portable XRFs—the most cited and definitive non-governmental guidance for application of field-portable XRF technology. Other frequently cited reference documents include Melquiades and Appoloni (2004) and Radu and Diamond (2009). In addition to these research publications are other publications referenced in this report, including Shefsky (1997), Wu and others (2012), University of Florida [UF] (2013), Parsons and others (2012), Guitouni (2016), and Mamatha and others (2016).

2.3 DATA QUALITY CRITERIA

One objective of this study was to evaluate data quality indicators for XRF analysis (including precision, accuracy, and comparability) in relation to a confirmatory method, and to use that information to characterize quality of data obtained via use of XRF technology. Data that meet certain criteria can be used for risk assessment purposes. "Comparability" in this study refers to how well XRF-acquired data compare to data resulting from application of a standard laboratory technique, and regression analysis is most commonly applied to conduct this comparison (USEPA 2008). A linear regression least squares analysis occurred to determine whether a linear relationship exists between XRF data and confirmatory data for each target element for each soil preparation technique. As discussed later, the laboratory confirmation method selected for this project did not involve a total acid digestion, and therefore expectation was that alterations in XRF-generated data would have to occur via application of "correction" factors to render XRF data "comparable" to laboratory analytical data. This study develops corresponding element-specific correction factors. These correction factors could then be applied to in situ XRF measurements to predict laboratory concentrations of target elements quantitatively, depending on how data quality would be characterized for each target element.

An underlying goal of the large-scale XRF field survey was to utilize quantitative, field-acquired XRF data to characterize sites hosting analyte concentrations ranging from near background to future cleanup levels with a high level of certainty. The definition of "quantitative" XRF analysis depends, to a large extent, on the application and intended use of the data (Kalnicky and Singhvi 2001). Typically, XRF instruments can perform in situ or intrusive (that is, ex situ) analyses. Because of limitations on precision and accuracy, in situ analysis yields qualitative results and ex situ analysis can provide semi-quantitative or quantitative results depending on how the soil sample is prepared prior to analysis. End uses of the data include background comparisons for RSE investigations and, more importantly, potential future use in risk assessments and for quantitative screening during future removal/remedial action surveys and/or final status surveys.

Determining how best to characterize XRF analysis data with respect to quality criteria is only briefly mentioned in the most recent guidance (Method 6200), which provides a limited explanation of how XRF data can be considered "definitive" or "screening." Previous reports such as USEPA (1998) and earlier versions of that have presented a slightly more detailed framework for characterizing data quality criteria for XRF data, but some of those recommendations were not carried into the most updated 2007 version of Method 6200. For example, USEPA (1998) recommends that for data to meet definitive level requirements, the median relative standard deviation (RSD) must be less than 10 percent; however, Method 6200 recommends a requirement of a median RSD of less than 20 percent, and notes that precision by itself does not suffice to characterize data quality—that is, as long as the median RSD is less than 20 percent. For the purposes of this report, data quality criteria conveyed in both documents (USEPA 1998 and 2007) appear in the following two subsections.

2.3.1 USEPA 1998 Data Quality Criteria

At the time USEPA (1998) was written, an approved USEPA method for field-portable XRF spectrometers did not exist. Therefore, the 1998 USEPA Technology Verification Report regarding field XRF analyzers (USEPA 1998) was written to categorize the data based on one of the following three data quality levels: (1) definitive, (2) quantitative screening, and (3) qualitative screening. The first two levels are defined in USEPA (1993). Qualitative screening level criteria were defined in a demonstration plan (PRC Environmental Management, Inc. 1995) to further differentiate screening level data. Definitive level is considered the highest level quality, and data in this category are usually generated by application of rigorous analytical methods that conform to approved USEPA or ASTM International (ASTM) standards. Definitive level data are considered analyte-specific with a high degree of quantitative accuracy. Quantitative screening data provide confirmed analyte identification and quantification although the quantification may be relatively imprecise. The Quality Assurance/Quality Control Guidance for Removal Activities (USEPA 1990) recommends verification of screening level data in a minimum of 10 percent of collected samples via a USEPA-approved method according to QA/QC criteria associated with definitive data. Notably, Method 6200 specifies a verification frequency involving a minimum 5 percent of collected samples subjected to a USEPA-approved method. The term "data type" refers to the general level of data quality, based on ultimate use of data. For example, qualitative screening level data indicate presence or absence of contaminants in a sample matrix, but do not provide reliable concentration estimates with any degree of certainty. Data may be compound-specific or specific to classes of contaminants. Table B-1 summarizes criteria for characterizing data quality in USEPA (1998).

Table B-1. Criteria for Characterization of Data Quality from Table 2-2 of USEPA (1998)

XRF Data Quality Criteria	Correlation Coefficient Criteria	Inferential Statistics Required?[1]	Precision Requirements	Accuracy Requirements
Definitive	r^2 = 0.85 to 1.0	Yes	RSD ≤ 10 percent	None
Quantitative Screening	r^2 = 0.70 to 1.0	No	RSD ≤ 20 percent	None
Qualitative Screening	r^2 = 0.70 to 1.0	No, but data should have less than 10 percent false negative	RSD > 20 percent	None

Notes:

1 Inferential statistics must indicate that the two data sets are statistically similar.

r^2 Coefficient of determination (sometimes referred to as R^2)

RSD Relative standard deviation

USEPA U.S. Environmental Protection Agency

XRF X-ray fluorescence

2.3.2 Method 6200 Data Quality Criteria

Section 9.7 of Method 6200 provides some guidance for characterizing data quality criteria for XRF analysis as "screening" or "definitive level" according to the criteria summarized in Table B-2. This is the most current approved USEPA guidance for use of field-portable XRF analyzers to determine concentrations of metals in soils and sediment. These two data levels are defined in the Uniform Federal Policy for Quality Assurance Project Plans: Part 2B QA/QC Compendium (USEPA 2005) as the following:

- **Screening data** can support an intermediate or preliminary decision but should eventually be supported by definitive data before completion of a project.
- **Definitive data** should be suitable for final decision-making (at the appropriate level of precision and accuracy, as well as legally defensible).

Table B-2. Summary of Data Quality Criteria According to SW-846 Method 6200

XRF Data Quality Criteria	Correlation Coefficient Criteria	Inferential Statistics Required?[1]	Precision Requirements	Accuracy Requirements
Definitive	r ≥ 0.9	Yes	RSD < 20 percent	None
Screening	r ≥ 0.7	No	RSD < 20 percent	None

Notes:

1 No method is suggested regarding inferential statistics, but a specified criterion is that XRF and confirmatory data be statistically equivalent at a 99 percent confidence level.

r Pearson's correlation coefficient

RSD Relative standard deviation

XRF X-ray fluorescence

2.3.3 Selected Data Quality Criteria

Various approaches to characterize data quality criteria for field-portable XRF measurements have been developed. USEPA (1998) defines three data quality levels and specifies a slightly more robust approach more weighted on precision, while Method 6200 defines two data quality levels with a criterion solely weighted on comparability requirements via correlation coefficient and inferential statistics. USEPA (1998 and 2008) discuss a process to transform XRF data based on results of a regression analysis between XRF and confirmatory data; however, Method 6200 does not mention data transformation, data conversion, or correction factors—nor does it provide guidance on such topics. In considering data quality criteria for this project, Method 6200 was the priority reference; however, integrating elements of data quality criteria from USEPA (1998) and maintaining Method 6200 requirements results in a more conservative and robust approach to characterize data quality. The method proposed for this project to characterize quality criteria of XRF analysis methods is presented in Table B-3 below. This approach meets the definitive level requirements specified in Method 6200, and introduces a second tier of quality criteria referred to as quantitative screening (or semi-quantitative), which can still be used for risk assessment purposes. Quantitative screening is defined in USEPA (1993) and presented in USEPA (1998).

Table B-3. Selected Data Quality Criteria

XRF Data Quality Criteria	Correlation Coefficient Criteria[1]	Inferential Statistics Required?[2]	Precision Requirements	Accuracy Requirements[3]	Can be Used for Risk Assessment?
Definitive	r ≥ 0.9	Yes	RSD ≤ 20 percent	RPD ≤ 30 percent	Yes
Quantitative Screening	r ≥ 0.8	Yes	RSD ≤ 20 percent	RPD ≤ 50 percent	Yes
Qualitative Screening	r ≥ 0.7	No	RSD ≤ 30 percent	RPD ≤ 50 percent	No

Notes:

1 This is interpreted as having one significant figure; that is, an r of 0.89 would round up to 0.9.

2 No method is suggested regarding inferential statistics, but a specified criterion is that XRF and confirmatory data be statistically equivalent at a 99 percent confidence level.

3 RPD is for field duplicates of soil (USEPA 2014b); median RPD is referred to in this table.

r Pearson's correlation coefficient
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

The proposed data quality criteria above meet Method 6200 requirements for definitive level data quality, and application of the proposed quantitative screening criterion would be appropriate for risk assessment but would require confirmatory analysis to support decisions. The proposed method also specifies accuracy requirements (via median relative percent difference [RPD] of all concentrations) of uncorrected or corrected XRF data. What this means is that if an alternate method is selected for the confirmatory method (such as a partial digestion method), a factor can be used to "correct" the XRF data, and then respective RPDs between individual data pairs can be assessed. Uncorrected and corrected results should always be compared. For inferential statistics, paired t-test or nonparametric test shall be applied to compare population means between XRF data (uncorrected and corrected) and confirmatory soil sample data sets at a 99 percent confidence level.

2.4 TARGET ELEMENTS

This project involves an XRF field survey to detect and measure concentrations of a series of inorganic elements in soil, including heavy metals. Target elements identified during the study are arsenic, iron, lead, manganese, molybdenum, thorium, uranium, vanadium, and zinc. XRF field surveys have been used for decades to characterize soils and solid media at a wide variety of sites (USEPA 1998). Typically, XRF analyzers can be used to measure concentrations of elements with atomic numbers exceeding 16 (USEPA 2008). However, spectral interferences among elements often prevent an XRF unit's measurements of concentrations of all elements with atomic numbers exceeding 16 that would be considered acceptable or useful for environmental applications. However, a hand-held XRF spectrometer can satisfactorily determine concentrations of the nine target elements in this study—all with atomic numbers exceeding 16. The following subsections discuss each target element.

2.4.1 Arsenic

Arsenic is a primary analyte of interest in the RSE investigations because it is likely mining related and was identified as a COPC above background at numerous sites during the RSE investigation. The atomic number of arsenic is 33, and the crustal abundance of arsenic is approximately 1.5 to 2.0 milligrams per kilogram (mg/kg) (U.S. Geological Survey [USGS] 2017). Concentrations of naturally occurring arsenic in surface soils can range from 1 to 50 mg/kg (USEPA 2006a).

Previously reported detection limits for arsenic by use of field-portable XRF analyzers range from 10 to 20 mg/kg (USEPA 2006a, 2007). The manufacturer (Thermo Fisher Scientific) of the Niton XL5 analyzer used in this study reports a detection limit of approximately 2.0 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for arsenic are conveyed in the method detection limit (MDL) evaluation in Section 4.1.3. As reported in Appendix A to the RSE Report, at background study areas (BSA), arsenic concentrations ranged from 0.35 to 68 mg/kg, with an average of 2.3 mg/kg. Risk-based soil screening levels for arsenic are typically greater than 2.0 mg/kg (USEPA 2019). Because the arsenic detection limit is 2.0 mg/kg with use of the Niton XL5 analyzer, this is a useful tool to evaluate soil concentrations with reference to background concentrations and risk-based soil screening levels.

Arsenic is successfully analyzed via inductively coupled plasma-mass spectrometry (ICP-MS); however, spectral interferences between arsenic and lead peaks can affect detection limits and accuracy in XRF analysis when the ratio of lead to arsenic is 10 to 1 or greater (USEPA 2006a). The average ratio of lead to arsenic in XRF confirmation samples and surficial soil samples combined is 3.0; therefore, spectral interferences from lead are not expected to present a problem in this study's assessment of arsenic data.

2.4.2 Iron

Iron is a secondary analyte of interest in the RSE investigations, meaning it is generally less likely to be associated with uranium-vanadium mining activities, and is less hazardous to the environment and human health than primary analytes. The atomic number of iron is 26, and the average crustal abundance is approximately 50,000 mg/kg (USEPA 1995). Concentrations of naturally occurring iron in surface soils typically range from 7,000 to 550,000 mg/kg, with the iron content originating primarily from parent rock (USEPA 2006a). Although iron is not a primary analyte, it is important for this study because of spectral interferences between iron and other target elements. Additionally, iron is often used as a standard reference element in XRF analysis.

Previously reported detection limits of iron by use of field-portable XRF analyzers range from 10 to 60 mg/kg (USEPA 2006a, 2007). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of approximately 9 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for iron are conveyed in the MDL evaluation in Section 4.2.3. Iron concentrations among BSAs presented in Appendix A to the RSE Report range from 1,100 to 16,000 mg/kg, with an average of 5,136 mg/kg. Because the iron detection limit is 9 mg/kg by use of the Niton XL5 analyzer, this is a useful tool to evaluate soil concentrations with reference to background concentrations and risk-based soil screening levels.

ICP-MS and XRF analytical methods both provide dependable measures of iron concentration. However, high or low concentrations of iron in the soil matrix can induce respective differences in analytical results for other elements from applications of both ICP-MS and XRF methods. Nevertheless, the maximum iron concentration detected via ICP-MS in surface soils is 24,000 mg/kg, and thus interference by iron with analytical results for other elements is not expected to be a significant issue.

2.4.3 Lead

Lead is a primary analyte of interest in the RSE investigations. The atomic number of lead is 82, and the average crustal abundance is approximately 20 mg/kg (USEPA 1995). Concentrations of naturally occurring lead in surface soils typically range from 2 to 200 mg/kg (USEPA 2006a).

Previously reported detection limits for lead by use of field-portable XRF analyzers range from 10 to 20 mg/kg (USEPA 2006a, 2007). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of 1 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for lead are conveyed in the MDL evaluation in Section 4.3.3. Lead concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 1.2 to 19 mg/kg, with an average of 5.6 mg/kg. Because the lead detection limit is 1 mg/kg by use of the Niton XL5 analyzer, this is a useful tool to evaluate soil concentrations with reference to background concentrations and risk-based soil screening levels.

ICP-MS and XRF analytical methods both provide dependable measures of lead concentration. However, spectral interferences between arsenic and lead may result in differences between lead concentrations measured via XRF and ICP-MS (USEPA 2006a). Nevertheless, as discussed in Section 2.4.1, ratios of lead to arsenic in most of the study area are not expected to cause spectral interferences.

2.4.4 Manganese

Manganese is a secondary analyte of interest in the RSE investigations. Although manganese is not a primary analyte, it is important for this study because manganese can be associated with vanadium, which is a primary analyte (USEPA 2006a). The atomic number of manganese is 25, and the average crustal abundance is approximately 850 mg/kg (USEPA 1995). Concentrations of naturally occurring manganese in surface soils typically range from 100 to 4,000 mg/kg (USEPA 1995).

Previous studies reported a detection limit of 30 mg/kg for manganese by use of field-portable XRF analyzers (International Atomic Energy Agency [IAEA] 2005). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of approximately 13 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for manganese are presented in the MDL evaluation in Section 4.4.3. Manganese concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 24 to 1,100 mg/kg, with an average of 210 mg/kg. Risk-based soil screening levels for manganese typically exceed 1,000 mg/kg (UESPA 2019). Because the manganese detection limit is 13 mg/kg by use of the Niton XL5 analyzer, this is a useful tool to evaluate soil concentrations with reference to background concentrations and risk-based soil screening levels.

ICP-MS and XRF analytical methods both provide dependable measures of manganese concentration. Manganese does not cause spectral interferences with other target elements.

2.4.5 Molybdenum

Molybdenum is a primary analyte of interest in the RSE investigations. The atomic number of molybdenum is 42, and the average crustal abundance is approximately 1.5 mg/kg (USGS 2017). Naturally occurring molybdenum in surface soils ranges from less than 1 mg/kg to 115 mg/kg in uranium roll-front deposits (Bullock and Parnell 2017).

The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of 1 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for molybdenum are presented in the MDL evaluation in Section 4.5.3. Molybdenum concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 0.027 to 4.9 mg/kg, with an average of 0.20 mg/kg. Risk-based soil screening levels for molybdenum are typically greater than 1 mg/kg (UESPA 2019). Because background soil concentrations of molybdenum reported in this study are often below or close to the detection limit, the XRF spectrometer is not as useful for evaluating low concentrations of molybdenum as it is for other target elements. However, the XRF spectrometer is effective for determining higher concentrations of molybdenum associated with uranium deposits, and for comparing soil concentrations to risk-based screening levels.

ICP-MS and XRF analytical methods both provide dependable measures of molybdenum concentration. Molybdenum is not expected to cause spectral interference with other target analytes.

2.4.6 Thorium

Thorium is a primary analyte of interest in the RSE investigations, and is a naturally occurring radioactive metal. The atomic number of thorium is 90, and the average crustal abundance is approximately 4.5 mg/kg (Lambert and Heir 1968). Thorium exists primarily as thorium-232 (99.98 percent by mass) with a small amount of thorium-230 (0.02 percent). thorium-232 decays slowly via alpha decay with a half-life on the order of the age of the universe (14 billion years). Thorium occurs naturally in soils at average concentrations of 2-12 mg/kg (Agency for Toxic Substances and Disease Registry [ATSDR] 1990).

Previous studies reported a detection limit of 10 mg/kg for thorium by use of field-portable XRF analyzers (USEPA 2007). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of 1 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for thorium are presented in the MDL evaluation in Section 4.6.3. Thorium concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 0.52 to 27 mg/kg, with an average of 2.7 mg/kg. USEPA does not provide regional screening levels for thorium. Because the background soil concentrations of thorium reported in this study are often close to the detection limit, the XRF spectrometer is not as useful for evaluating low concentrations of thorium as it is for other target elements. However, the XRF spectrometer is effective for determining higher concentrations of thorium and for comparing soil concentrations to risk-based screening levels.

Measurement and detection of thorium can be made directly via techniques such as alpha spectroscopy, liquid scintillation counting, gamma spectroscopy, ICP-MS, and XRF. Thorium is not expected to cause spectral interference with other target analytes.

2.4.7 Uranium

Uranium is a primary analyte of interest in the RSE investigations, and is a naturally occurring radioactive metal. The atomic number of uranium is 92, and the average crustal abundance is 2 to 4 mg/kg (ASTDR 2013). In nature, uranium is found as uranium-238, uranium-235, and uranium-234. Almost all uranium found in nature is uranium-238 (>99.27 percent by mass) with small amounts of uranium-235 (0.7 percent) and uranium-234 (0.006 percent).

Previous studies reported a detection limit of 2 to 4 mg/kg for uranium by use of field-portable XRF analyzers (CAMIRO 2013). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of 2 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for uranium are presented in the MDL evaluation in Section 4.7.3. Uranium concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 0.09 to 22 mg/kg, with an average of 1.1 mg/kg. Risk-based soil screening levels for uranium are typically greater than 1 mg/kg. Because background soil concentrations of uranium reported in this study are often close to the detection limit, the XRF spectrometer is not as useful for evaluating low concentrations of uranium as it is for other target elements. However, the XRF spectrometer is effective tool in determining higher concentrations of uranium associated with AUM sites, and in comparing soil concentrations to risk-based screening levels.

Uranium is not included as an analyte in Method 6200; however, field-portable XRF spectrometers have been applied successfully to other sites for soil characterization of total uranium—including Rattlesnake Creek (Johnson and others 2005) and Riley Pass Abandoned Uranium Mines (Tetra Tech 2015). Measurement and detection of uranium can occur directly via techniques such as alpha spectroscopy, liquid scintillation counting, gamma spectroscopy, ICP-MS, and XRF.

2.4.8 Vanadium

Vanadium is a primary analyte of interest in the RSE investigations. The atomic number of vanadium is 23, and the average crustal abundance is approximately 100 mg/kg. Concentrations of naturally occurring vanadium in surface soils typically range from 20 to 500 mg/kg (USEPA 2006a).

Previously reported detection limits for vanadium by use of field-portable XRF instruments range from 10 to 50 mg/kg (USEPA 2006a, 2007). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of 3 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for vanadium are presented in the MDL evaluation in Section 4.8.3. Vanadium concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 3.2 to 330 mg/kg, with an average of 13 mg/kg. Risk-based soil screening levels for vanadium are typically greater than 50 mg/kg (UESPA 2019). Because the vanadium detection limit is 3 mg/kg by use of the Niton XL5 analyzer, this is a useful tool to evaluate soil concentrations with reference to background concentrations and risk-based soil screening levels.

ICP-MS and XRF analytical methods both provide dependable measures of vanadium concentration. Vanadium causes little spectral interferences with other target elements (USEPA 2006a).

2.4.9 Zinc

Zinc is a secondary analyte of interest in the RSE investigations. The atomic number of zinc is 30, and the average crustal abundance is approximately 75 mg/kg. Concentrations of naturally occurring zinc in surface soils typically range from 10 to 300 mg/kg (USEPA 1995).

Method 6200 reports the lower limit of detection in quartz sand for zinc at 50 mg/kg (USEPA 2007). The manufacturer of the Niton XL5 analyzer used in this study reports a detection limit of approximately 2 mg/kg in silica sand when the instrument is in soils mode; method-specific detection limits for zinc are presented in the MDL evaluation in Section 4.9.3. Zinc concentrations among the BSAs presented in Appendix A to the RSE Report ranged from 4.8 to 290 mg/kg, with an average of 16 mg/kg. Risk-based soil screening levels for zinc compounds are typically greater than 100 mg/kg (UESPA 2019). Because the zinc detection limit is 2 mg/kg by use of the Niton XL5 analyzer, this is a useful tool to evaluate soil concentrations with reference to background concentrations and risk-based soil screening levels.

ICP-MS and XRF analytical methods both provide dependable measures of zinc concentration. However, spectral interferences between copper and zinc peaks may impact the limit of detection for zinc. The range of copper observed at the site and the results of the XRF data evaluation of zinc for this project, indicate that no spectral interference affected the results of the zinc data collected using the XRF analyzer. The MDL evaluation regarding zinc is provided in Section 4.9.3 and further indicates that copper did not adversely affect the MDL of zinc because the MDL of zinc was close to the factory reported MDL.

3.0 METHODOLOGY

This section presents the methodology to implement XRF field survey sampling, including study approach, sample preparation techniques, pre-survey performance evaluation, QA/QC methods including the variety of ways to monitor analytical quality, and statistical methods for determining accuracy and comparability of the various techniques. This section also specifies the data qualifier process and summarizes any deviations from the RSE Work Plan. All results related to field QC methods are in Attachment B1.

3.1 STUDY APPROACH

Tetra Tech followed a robust approach applying different methods of conducting an XRF field survey for determination of elemental concentrations in surface soils at the project areas shown in Section 1.2. The XRF field survey involved use of a newer hand-held XRF spectrometer and conformance to the most current regulatory guidance and/or scientific literature available on the subject, as described in Section 2.2. Figure B-7 is a process flow diagram of the XRF field survey program. More detailed descriptions of the three types of XRF preparation method appear in Section 3.2.1 through Section 3.2.3.

3.2 SAMPLE PREPARATION AND ANALYSIS METHODS

Sampling and sample preparation procedures are the most crucial steps in all analytical techniques, including XRF analysis (IAEA 1997). The most recent version of Method 6200 provides guidance for quantifying detections of inorganic analytes by use of a field-portable, energy-dispersive XRF fluorescence spectrometer.

Note: The term “energy-dispersive” denotes a process in which the instrument’s detector receives all x-rays from the sample and discriminates x-rays of different energies, allowing measures of intensities at those respective energies; this contrasts with “wavelength-dispersive” XRF instruments with significantly different architecture that measure intensity of a very narrow range of energies. Wavelength-dispersive XRF instruments are bulky and cannot be used portably. All XRF instrumentation referenced in this report is energy-dispersive. For a good comparison of advantages and disadvantages of wavelength-dispersive and energy-dispersive XRF instrumentation, see pages 356-360 of what remains the major treatise on the subject of XRF analysis by Bertin (1975).

Method 6200 describes two primary methods for use of field-portable XRF spectrometers: in situ and intrusive. During in situ XRF measurements, which occur in the field, the probe window is placed in direct contact with the surface of soil to be analyzed.

Two applications of the intrusive method are viable, both ex situ. Both require collection of a sample of soil or sediment. In the “soil cup sample” method (Section 2.2 of Method 6200), the sample is dried, homogenized, and sent through a sieve to 60 mesh; then a portion of it is placed in a sample cup [soil cup]. The sample cup may be placed on top of the probe window inside a shielded XRF stand for analysis. In the “bulk bag sample” method (Section 11.4 of Method 6200), a larger sample (bulk sample) is dried, homogenized, and undergoes removal of debris/rocks; then it is placed in a bulk bag with placements of the probe directly onto the sample bag at multiple locations across the bag for analysis. USEPA (2007) recommends the soil cup method to achieve increased data quality. During this project, both methods were evaluated. For the purposes of this report, intrusive XRF methods can be categorized into (1) ex situ bulk sample XRF method, and (2) ex situ soil cup XRF method.

Each approach to soil preparation and measurement has advantages and disadvantages. In situ XRF measurements can proceed much more quickly than ex situ measurements but can be less representative of the target population and provide limited ability to optimize conditions of the sample medium for analysis. On the other hand, ex situ measurements require more time and effort, but this sampling approach can be adjusted to increase representativeness of the target population, and sample conditions can more easily be adjusted to optimize XRF measurements. This report evaluates precision and accuracy attainable by use of the current technology via each of these XRF methods. Figure B-7 is a process flow diagram of the XRF field survey program.

Intrusive sampling (ex situ) was used in a correlation study comparing an XRF dataset to a confirmatory laboratory analytical dataset, as described in Section 4.1.1.5 of the QAPP (Appendix C to the RSE Work Plan). Results indicated a successful correlation for several analytes; however, a correlation factor was deemed necessary to correct XRF data to be more representative of predicted data from the laboratory. Section 4.0 evaluates results of the correlation study to determine whether a statistically sound relationship can be expected between XRF and laboratory analytical datasets.

Uncorrected XRF measurement results are reported by the instrument in parts per million (ppm), while laboratory analytical results from soil samples are reported in mg/kg. Throughout this report, XRF results converted to predicted laboratory-determined concentrations are reported in mg/kg units. These units are comparable in the context of this study because all sample results derive from dry weight soil samples, whereby 1 ppm equals 1 mg/kg.

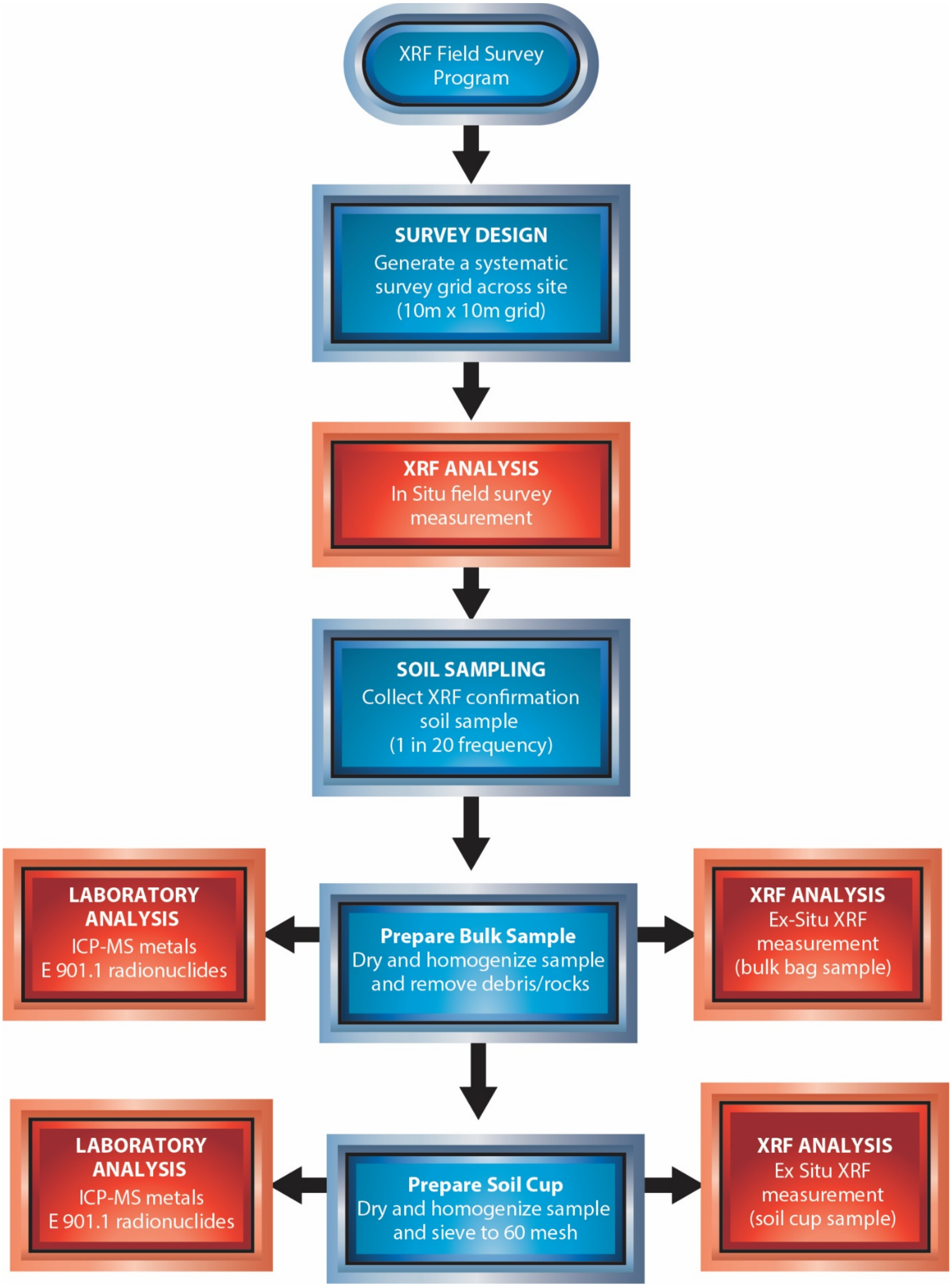


Figure B-7. XRF Field Survey Process Flow Diagram

3.2.1 In Situ XRF Method

In situ XRF measurements evaluate metals concentrations only within the top few millimeters of exposed soil because of the relatively shallow penetrative ability of the XRF analyzer; however, this measurement approach provides a very rapid, cost-effective means to take measurements relatively representative of the target population in areas where lateral and vertical distributions of metals are expected to be homogenous.

The XRF field survey utilized discrete measurements to represent grid-based sample units, referred to as survey units. Specifically, the survey area within each site was divided into a series of 10- by 10-meter (100 m^2) survey units. The field-portable XRF analyzer was placed at the approximate center of each survey unit and activated for analysis ("in situ XRF measurement"). Figure B-8 below shows photographs of the field crew taking in situ XRF field measurements (in ppm). As described in Section 4.1.1.4 of the QAPP (Appendix C to the RSE Work Plan [Tetra Tech 2018]), Tetra Tech performed a pilot study to evaluate effectiveness of an adjusted in situ XRF measurement. This approach was deemed unwarranted, and a semi-adjusted procedure was preferred. In situ XRF measurements proceeded in accordance with USEPA SW-846 Method 6200 and Standard Operating Procedure (SOP) 004 of the QAPP in Appendix C to the RSE Work Plan (Tetra Tech 2018).

At each location designated for an in situ XRF measurement (see Section 4.2.1.4 of the QAPP [Appendix C to the RSE Work Plan]), the soil within approximately 0 to 3 inches below ground surface (bgs) within in an approximately 6-inch-square area was cleared of surface debris, and if necessary, thoroughly homogenized in place by use of a stainless steel hand trowel or similar. The homogenized soil was visually assessed for signs of moisture, and then patted down in place by use of the stainless-steel hand trowel or a gloved hand to provide a uniform surface for the XRF analysis. The XRF analyzer was then placed directly against the homogenized soil for measurement. A single XRF measurement was taken at each location within the optimal scan times (30 second main filter, 15 second high filter, and 15 second low filter) discussed in Section 3.3.3. A minimum of one measurement occurred at each location; however, wherever an XRF confirmation sample was collected (at frequency of 5 percent), an additional in situ measurement occurred without lifting the probe off the surface of the soil, resulting in two measurements at each of those locations. The second sample is referred to as the in situ XRF field duplicate (or simply XRF field duplicate). An analysis to evaluate precision agreement between the primary measurement and the XRF field duplicate measurement for each instrument is in Attachment B1. In addition to XRF field duplicates, a series of replicate measurements occurred once per day per instrument as described in Section 3.4.6—seven replicate in situ XRF measurements at a randomly selected survey unit without lifting the XRF analyzer off the ground surface between measurements.

Figure B-8. Field Staff Taking In Situ XRF Measurements

3.2.2 Ex Situ Bulk Sample XRF Method

In areas where distribution of metals is expected to be relatively heterogeneous, the intrusive sampling approach can typically provide results more representative of the target population because of ability to incorporate composite sampling, aggressive homogenization, and multiple analyses of each sample via that approach. Intrusive sampling often involves collection of soil within the full depth profile under evaluation, and thorough mixing of this soil in an external container to homogenize it. Intrusive samples can be dried more easily if this is necessary to increase accuracy of XRF measurement, and multiple measurements of a single sample volume are easier, thus allowing determination of an average concentration within a single sample volume.

At approximately 5 percent of in situ XRF measurement locations, XRF confirmation soil samples were collected within 0 to 3 inches bgs to attain definitive analytical results (via laboratory analysis) at the site, and to develop a correlation as described in the previous section. Each XRF confirmation soil sample was collected immediately after in situ XRF field duplicate measurement. The soil collected was placed into resealable plastic bag. The samples were taken to a secure field laboratory in Farmington, New Mexico, for further preparation. Most bulk soil samples collected at AUM sites and Target sites were relatively dry and homogenous, so little further preparation of these samples was required prior to ex situ XRF analysis. However, some samples had to be dried, and from certain soil samples, organic debris or large rocks were removed prior to analysis. Once a sample had been homogenized, dried, and (relatively) freed of debris, it was placed back into the bag and XRF analysis occurred. A minimum of six replicate XRF measurements were taken, three on each side of the bag at equally spaced locations across the bag (ex situ XRF bulk sample measurements). These measurements were used in a correlation study comparing the XRF dataset (presumed fallible) to the analytical dataset from the laboratory (presumed definitive).

3.2.3 Ex Situ Soil Cup Sample XRF Method

Objectives of the third XRF method, the ex situ XRF soil cup method, were to (1) quantify comparability of arsenic determinations by multiple XRF analyzers; (2) assess, via regression models, comparability of results from application of the more intrusive method involving soil cups and the less intrusive method involving bulk samples; and (3) evaluate concentrations of target analytes based on particle size. This commonly applied method is described in Method 6200. The bulk sample preparation method discussed in the previous section represents the entire particle size distribution, which better indicates actual field conditions during collection of in situ XRF measurements, while the soil cup preparation method involves well-homogenized, finer soil particles (less than 60 mesh sieve). Approximately 5 percent of bulk samples were handpicked based on the range of metals concentrations, and were retrieved from the laboratory for further preparation. The samples were dried again, ground with mortar and pestle, and mechanically sieved through a 60 mesh sieve into a powder form and placed into soil cups. The soil cups were then analyzed by three different XRF analyzers over the same count time as applied in the other XRF methods. Six replicate measurements were taken to maintain consistency with the ex situ XRF bulk sample method. Prepared soil in each soil cup had the same physical characteristics, and particle size similar to the standard reference materials used (see Figure B-9).

Figure B-9. Prepared Soil Cups in the Laboratory

3.3 PRE-SURVEY PERFORMANCE EVALUATION

Each operator of a hand-held XRF spectrometer should become familiar with performance of the instrument before taking it to the field (CAMIRO 2013). Niton XL5 technology is essentially brand new, and few if any publications regarding it are available; moreover, at the time of the survey of Niton XL5 technology, no known publications of USEPA-sponsored technological verification reports had occurred. A number of USEPA-sponsored technology verification programs have addressed older models of Niton XRF analyzers, including the Niton Xli analyzer (USEPA 1998) and the Niton 700 Xli and 700 XLt analyzers (USEPA 2006a, b). Therefore, before entering the field, Tetra Tech spent time to understand and evaluate performance of this relatively new technology—reviewing manuals and available informational sheets, and directly communicating with Thermo Fisher Scientific technical support staff.

Before implementation of the XRF field survey program, the following required further investigation: (1) potential sources of interference, (2) comparability and repeatability among different XRF instruments for eventual interchangeability, (3) selection of optimal filter reading scan times, (4) evaluation of thin film and/or plastic bag interference, and (5) selection of laboratory confirmatory method. Resolving all of these issues was extremely important to success of the XRF field survey program, and each required careful consideration before entry to the field. The following subsections address considerations of performance evaluation issues regarding the XRF field survey program.

3.3.1 Potential Sources of Interference

Field-portable XRF technology is sensitive to spectral interferences, as well as to physical and chemical matrix effects that can decrease precision and accuracy (Parsons and others 2012). Physical matrix effects result from variations in the physical character of the sample (USEPA 2007). Extent of these variations depends on the sample preparation method. With intent to mitigate potential physical matrix effects during this project, different soil preparation techniques were applied and evaluated in the respective XRF analytical methods of (1) in situ XRF measurement, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method.

Some physical matrix effects are universal regardless of sample preparation technique (for example, moisture content). Even in relatively dry soils, soil moisture dramatically affects analytical performance of XRF analyzers (for example, a signal loss of 27 percent for arsenic at 20 percent moisture content by weight) (Parsons and others 2012). Given the semi-arid environment of the project setting, moisture content of soils was usually between 2 and 5 percent. However, during the monsoon season, potential for extreme weather events increased, and all XRF field operations halted during periods of extensive rainfall. Furthermore, both intrusive sampling techniques included drying of soils prior to any ex situ XRF analysis.

Finally demanding attention are potential for spectral interferences from elevated concentrations of certain elements and effects of this on determinations of concentrations of other elements. Spectral interferences can render some elemental analyses difficult (Kalnicky and Singhvi 2001); higher iron content can induce high background for manganese, and lead can severely interfere with arsenic determination. As described in Section 2.4, concentration ratios of particular elements and concentrations of other elements that could induce potential spectral interferences are not present at any sites evaluated as part of this study.

3.3.2 Instrument Comparability Analysis

In previous large-scale QC assessment programs conducted by different organizations, particularly the CAMIRO study in 2013, inconsistencies were discovered in performance from one instrument to another, and (less frequently) among XRF analyzers from the same manufacturer (CAMRIO 2013). Nine field-portable Niton XL5 analyzers were used in the XRF field survey program. Because these instruments were used interchangeably, it had been important for the team to evaluate instrument comparability before initiation of the XRF field survey.

To alleviate any concerns, the Tetra Tech team conducted an initial pre-survey evaluation to establish and quantify performances of the many instruments to be used during this project by conducting a cross comparison analysis of instrumental performances in analyzing standard reference materials for specific target elements. Each instrument was color coded to distinguish it from the others. The color coding scheme allowed for daily assignments of field personnel to correspond to a team color (corresponding to the color of an XRF analyzer), site location, and tasks for the day. Table B-4 lists the color codes of the different instruments involved, and the manufacturer-provided serial number of each instrument. Each team had a distinct, color-coded storage bin to contain decontaminated sampling materials pertinent to daily work. Figure B-10 is a photograph of the different color-coded bins used during the project.

Before any instrument was used during the project, it was inspected for any physical signs of damage, and a pre-survey calibration check protocol was followed to ensure that the XRF analyzer met pre-established QC limits for the project. Prior to use of each XRF analyzer in the field, factory calibration documentation was reviewed to ensure the instrument had been calibrated by the factory within manufacturer-recommended limits and had passed all factory-required QC checks. A cross-XRF analyzer comparability study occurred, as illustrated on Figure B-11, weeks before entry to the field. Attachment B2 includes scanned copies of available calibration documentation for each instrument.

Because of project size, many samples were required to meet project DQOs; therefore, many instruments were required for use in both the field (in situ) and in the field laboratory (ex situ). The project team was aware that data from the XRF analyzer could require site-specific correlations to determine correction factors for the XRF analyzer so that conversions to predicted laboratory-determined concentrations of different target elements could occur. Therefore, it was important to establish whether the instruments were interchangeable or if these would require instrument-specific calibration factors. The pre-survey instrument comparability study involved evaluation of all nine XRF analyzers. Each was tested via analysis of a set of three standards containing detectable quantities of respectively different concentrations of arsenic and lead (two potential COPCs and primary analytes of interest identified during the DQO process). The data sets from nine measurements of each standard were then evaluated by calculating the RSD and the percent difference (%D) among the mean XRF results and known concentrations of the reference standards.

A Niton-provided XRF test stand was used for the cross-comparison analysis. A series of three different certified reference material soil cups, including two from the National Institute of Standards and Technology (NIST), were placed over the analyzer probe, and a series of seven replicate measurements by each analyzer occurred in sequence at a 60-second count rate on the main filter. The three standard references sets (NIST, RCRA, and UNAT) containing differing levels of metal concentrations listed in order from low to high concentrations included NIST (arsenic = 11 mg/kg, lead = 17 mg/kg), natural uranium (UNAT) (arsenic = 77 mg/kg, lead = 52 mg/kg), and RCRA (arsenic = 500 mg/kg, lead = 500 mg/kg). Table B-5 lists instrument comparability results for arsenic. Table B-6 lists instrument comparability results for lead. The RSD was less than 5 percent for arsenic and less than 12 percent for lead—both well within the 20 percent recommended by Method 6200. The %D was within the ± 20 percent recommended by Method 6200 for arsenic at all standard concentrations but not for lead at the lowest concentration. Based on data acquired across the multiple analyzers, it was determined that precision and accuracy of arsenic and lead measurements were good, and thus the instruments could be interchangeable over the duration of the project. An additional analysis also occurred to evaluate cross-comparison capabilities to determine concentrations of all target elements by use of site-specific soil cups, as described in Section 3.3.

Table B-4. Summary of Niton XL5 Field-Portable Instruments Used for XRF Field Survey

Color Code for Niton XL5 Portable XRF Analyzer	XRF Serial Number[1]
Black	X500674
Blue	X500939
Green	X500870
Orange	X500872
Pink	X500940
Purple	X500530
Red	X500875
White	X500946
Yellow	X500941

Notes:

[1] Serial Number provided by manufacturer

XRF X-ray fluorescence

Figure B-10. Color Coded Equipment Bin

Figure B-11. Pre-Survey Instrument Comparability Study

Table B-5. Summary of XRF Comparability of Standard Reference Materials (Arsenic)

Arsenic		XRF ID (Color) and Arsenic Concentration (ppm)									Statistics			
Source	**Reference Value (ppm)**	**Yellow**	**Orange**	**Blue**	**Green**	**Pink**	**Purple**	**Black**	**Red**	**White**	**XRF Average (ppm)**	**SD (ppm)**	**RSD**	**%D**
NIST[1]	11	11	11	10	11	10.6	10	10	10	11	10.4	0.39	3.8%	-0.8%
UNAT[2]	77	81	84	76	87	88	85	84	89	88	85	4.1	4.8%	9.2%
RCRA[3]	500	478	498	489	474	489	508	484	497	493	490	11	2.2%	-2.0%

Notes:

1 The material from NIST is an approved Niton standard reference material referred to as "CRM 180-649 NIST 2709a."
2 UNAT is a reference material created by Tetra Tech and ALS, and was tested by two laboratories; this is not an approved Niton standard reference.
3 The RCRA material is an approved Niton standard reference material referred to as "QC Material 180-661 RCRA1."

%D Percent difference
NIST National Institute of Standards and Technology
ppm Parts per million
RCRA Resource Conservation and Recovery Act
RSD Relative standard deviation
SD Standard deviation
UNAT Natural uranium
XRF X-ray fluorescence

Table B-6. Summary of XRF Comparability of Standard Reference Materials (Lead)

Lead		XRF ID (Color) and Lead Concentration (ppm)									Statistics			
Source	**Reference Value (ppm)**	**Yellow**	**Orange**	**Blue**	**Green**	**Pink**	**Purple**	**Black**	**Red**	**White**	**XRF Average (ppm)**	**SD (ppm)**	**RSD**	**%D**
NIST[1]	17	13	13	14	12	13	16	13	14	14	13	1.1	8.4%	-25%
UNAT[2]	52	52	58	50	57	61	74	59	62	61	59	6.8	12%	13%
RCRA[3]	500	457	451	463	433	454	543	454	463	483	467	32	6.8%	-6.9%

Notes:

1 The material from NIST is an approved Niton standard reference material referred to as "CRM 180-649 NIST 2709a"
2 UNAT is a reference material created by Tetra Tech and ALS, and was tested by two laboratories; this is not an approved Niton standard reference.
3 The RCRA material is an approved Niton standard reference material referred to as "QC Material 180-661 RCRA1"

%D Percent difference
ICP-MS Inductively coupled plasma-mass spectrometry
ppm Parts per million
RSD Relative standard deviation
SD Standard deviation
XRF X-ray fluorescence

3.3.3 Analysis of Optimal Scan Times

The field-portable Niton XL5 XRF analyzer has different measurement modes and filter options. "Soils" mode was selected because of its environmental application for heavy metals risk assessment and site modeling. The three primary filter settings for the XL5 are: (1) main filter, (2) low filter, and (3) high filter. The minimum filter time is 0 seconds and ranges to 60 seconds. The maximum scan time would be 180 seconds total with 60 seconds each filter (that is, 60 seconds on main filter, 60 seconds on low filter, and 60 seconds on high filter). Typically, it is not necessary to run the instrument at the maximum scan time to achieve desired detection limits. In some cases, shorter scan times may be enough to reach desired detection limits for a given analyte of interest. Purposes of the XRF investigation were to reduce cost and increase coverage area; therefore, an optimal scan time of 60 seconds was deemed reasonable to reduce cost without compromising detection limits. Prior to field work in the Northern Agency Tronox Mines, an evaluation occurred to determine optimal filter settings for the Niton XL5 via measurement of a number of elements at different concentrations under two different options/scenarios. The first scenario was a 60-second scan time on only the main filter. The second scenario was a 30-second scan time on the main filter, 15-second scan time on the high filter, and 15-second scan time on the low filter. Table B-7 lists results of the filter scan analysis.

Table B-7. XRF Results for Standard Reference Materials at Different Filter Settings

Mode			60s 0s 0s[1]		30s 15s 15s[2]	
			XRF (ppm)			
Element	Standard Source	Reference Concentration (ppm)	Concentration (ppm)	%D	Concentration (ppm)	%D
Lead (Pb)	RCRA[3]	500	454	-9.6%	466	-7.0%
Arsenic (As)	RCRA	500	484	-3.3%	489	-2.2%
Thorium (Th)	NIST[4]	10.9	10.6	-2.6%	10.7	-1.9%
Lead (Pb)	NIST	17.3	12.4	-33%	13.3	-26%
Arsenic (As)	NIST	10.5	10.4	-1.2%	10.3	-2.2%
Zinc (Zn)	NIST	103	81.9	-22%	85.5	-19%
Iron (Fe)	NIST	33,600	33,278	-1.0%	32,303	-3.9%
Manganese (Mn)	NIST	529	442	-17%	437	-19%
Vanadium (V)	NIST	110	104	-5.2%	106	-3.4%

Notes:
1 60s 0s 0s refers to 60 seconds on Main filter only.
2 30s 15s 15s refers to 30 seconds on Main filter, 15 seconds on Low filter, and 15 seconds on High filter.
3 Quality Control Material 180-661 RCRA1.
4 Certified Reference Material 180-649 NIST 2709a.

RCRA Resource Conservation Recovery Act
NIST National Institute of Standards Materials
%D Percent difference
ppm Parts per million
XRF X-ray fluorescence

Results of the filter scan analysis are listed in Table B-7, which compares concentrations in ppm of the certified reference materials to concentrations in ppm determined by the XRF analyzer under both scenarios described above. Evaluation of the results indicated an increase in accuracy (that is, a decrease in %D) for six of the nine XRF analyzers under the second scenario (30 seconds, 15 seconds, 15 seconds). For the other three elements (arsenic, iron, and manganese) (no improved accuracy under the second scenario), differences in RPDs between the two scenarios were minor. Because of these findings, the second scenario was selected for the entire project.

3.3.4 Evaluation of Bag Interference

Lighter elements such as potassium and calcium, which emit lower energy radiation upon excitation, are more susceptible to attenuation effects during analysis through protective layers such as plastic bags (Parsons and others 2012). One of the soil preparation techniques described in Section 3.2, the ex situ XRF bulk sample method, involves collection of a bulk soil sample in a plastic Ziplock bag followed by transfer to a field laboratory where the XRF instrument is applied to measure concentration(s) of target element(s) in the soil sample through the plastic Ziploc bag. Therefore, it was important to quantify potential interference of the bag. An evaluation of bag interference occurred via seven replicate measurements of the certified reference material soil cups provided by Niton, through a plastic bag. Two reference materials were used: (1) NIST 2709a containing lower concentrations of target elements and (2) QC Material 180-661 RCRA1 containing higher concentrations of target elements.

Table B-8 and Table B-9 below compare results of analyzing, respectively, a certified reference material containing analytes at higher concentrations and another certified reference material containing those same analytes at lower concentrations—without and with the plastic bag over those materials. Results from the certified reference material containing analytes at lower concentrations indicated RPDs between concentrations returned with and without plastic bag cover ranging from 1.6 to 14 percent (molybdenum was nondetect and was not included). Under this scenario, returned concentrations of all analytes except lead and uranium decreased slightly with presence of the bag. Results from the certified reference material containing analytes at higher concentrations indicated RPDs between concentrations returned with and without plastic bag cover ranging from 4.1 to 22 percent (molybdenum was nondetect and was not included). Under this scenario, returned concentrations of all analytes except uranium decreased slightly with presence of the bag. Generally, the results indicate that presence of a bag during ex situ XRF analysis does tend to interfere with data for certain lighter elements; however, in general and based on this limited study, these effects are limited and not detrimental to most uses of XRF data.

Table B-8. Summary of XRF Measurements with and without Plastic Bag for Certified Reference Material (NIST 2709a)

Target Element	Soil Cup without Bag		Soil Cup with Bag		RPD
	Average XRF Measurement (ppm)	RSD	Average XRF Measurement (ppm)	RSD	
Arsenic	10	8.5%	9.4	9.1%	8.7%
Iron	33,341	2.1%	30,561	1.1%	8.7%
Manganese	427	3.4%	381	4.3%	12%
Molybdenum	-	-	-	-	-
Lead	12	8.3%	12	6.2%	1.6%
Thorium	10	10%	9.8	8.1%	6.4%
Uranium	4.8	30%	5.5	21%	14%
Vanadium	107	7.3%	99	5.4%	8.1%
Zinc	81	3.2%	75	2.7%	7.8%

Notes:

- \- Not evaluated as the concentration was less than the limit of detection
- NIST National Institute of Standards Materials
- ppm Parts per million
- RPD Relative percent difference
- RSD Relative standard deviation
- XRF X-ray fluorescence

Table B-9. Summary of XRF Measurements with and without Plastic Bag for Certified Reference Material (QC Material 180-661 RCRA1)

Target Element	Soil Cup without Bag		Soil Cup with Bag		RPD
	Average XRF Measurement (ppm)	RSD	Average XRF Measurement (ppm)	RSD	
Arsenic	493	1.6%	467	2.0%	5.3%
Iron	18,103	1.2%	16,766	1.4%	7.7%
Manganese	77	16%	62	18%	22%
Molybdenum	-	-	-	-	-
Lead	453	1.1%	434	1.6%	4.1%
Thorium	10	11%	9.4	15%	8.2%
Uranium	2.6	65%	2.7	58%	6.7%
Vanadium	85	7.3%	81	9.4%	5.3%
Zinc	38	6.3%	36	5.1%	5.0%

Notes:

- \- Not evaluated as the concentration was less than the limit of detection
- ppm Parts per million
- QC Quality control
- RCRA Resource Conservation and Recovery Act
- RPD Relative percent difference
- RSD Relative standard deviation
- XRF X-ray fluorescence

3.3.5 Laboratory Confirmation Method

Methods for analysis of elements in environmental samples, including soil and sediments, are well established in the environmental laboratory industry (USEPA 2006a). Analytical methods appropriate for soil and sediment samples have been promulgated by USEPA in the compendium of methods: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) (USEPA 1997). Currently, several laboratory methods can detect heavy metals in soil and sediments using the following methods (USEPA 2006a, 2007): (1) ICP-atomic emission spectroscopy (AES), (2) flame atomic absorption spectrometry (FLAA), (3) graphite furnace atomic absorption spectrometry (GFAA), and (4) ICP-MS. Under SW-846, several acid digestion methods also are required prior to elemental analysis, including Method 3050 (a partial digestion method) or Method 3052 (a total digestion method). The confirmatory laboratory method selected should meet project-specific DQOs (USEPA 2007).

Method 6020A (ICP-MS) was selected for the target elements of interest for this project based on cost, the method's demonstrated accuracy and precision, and other reasons. ICP-MS is a technique for determining concentrations of trace elements that requires serial dilutions to mitigate effects of higher concentrations of interfering ions or other matrix interferences (USEPA 2006a). Quantification of trace elements close to the detection limit is essential for background comparison, which is a DQO of the project. Additionally, background and site sampling for this project utilized ICP-MS for analysis for heavy metals and other inorganic compounds; therefore, it is important to maintain consistency among method selections. Method 6200 does not include Method 6020A as one of the reference methods for analysis for metals for evaluation of comparability but rather uses Method 6010, another method of analysis by inductively coupled plasma. The XRF analyzer measures total concentration of an element; therefore, to achieve greatest comparability of this method with the reference method, a total digestion method (that is, Method 3052) should be part of sample preparation (USEPA 2007). However, the confirmatory method in application of Method 6200 was Method 3050 (partial digestion), and the XRF data compared very well, with the regression correlation coefficient (r) often exceeding 0.95 (USEPA 2007). The critical factor is that the digestion procedure and analytical reference method applied should meet project DQOs.

To summarize, EPA SW-846 Method 3050B/6020A was applied for all target analytes evaluated for the XRF comparability study. Because Method 3050B is not a total digestion method, data returned by the XRF analyzer is not expected to replicate data from application of the laboratory method for every target analyte, and a correction factor for XRF data may be calculated for each target element for application during the phase of post-processing the in situ XRF measurement database. Table B-10 summarizes XRF confirmation laboratory analyses for this project. The following section presents QA/QC methods.

Table B-10. XRF Confirmation Laboratory Analysis Summary

Analyte	Analytical Method	Percentage of Samples Analyzed
Metals	USEPA SW-846 Method 6020	100
Mercury	USEPA SW-846 Method 7471	10
Radium-226	USEPA Method 901.1	100
Radium-228	USEPA Method 901.1 (via Actinium-228)	100
Potassium-40	USEPA Method 901.1	100
Lead-210	Eichrom Method (PAI 726 Rev 10)[1]	10
Uranium-238	USEPA Method 901.1 (via Thorium-234)	10
Thorium-232	USEPA Method 901.1 (via Actinium-228)	10
Isotopic thorium	ASTM D3972 Modified	10

Notes:
1 Provided as a laboratory preparation standard operating procedure by the laboratory in RSE Work Plan.
ASTM ASTM International
SW-846 Test Methods for Evaluating Solid Waste/Chemical Methods (USEPA 1997)
USEPA U.S. Environmental Protection Agency

3.4 QUALITY ASSURANCE/QUALITY CONTROL METHODS

The following sections address methods of QA and QC.

3.4.1 Overview

Analytical quality of XRF results was monitored in a variety of ways, including use of standard reference materials, analyses of blanks, analyses of in situ XRF field duplicates, and repeated measurements of selected samples (replicate samples). A number of QA/QC procedures were followed to ensure proper system performance within the manufacturer-intended operation parameters of all XRF analyzers utilized over the course of this project. Section 4.4.1.2 of the QAPP (Appendix C to the RSE Work Plan [Tetra Tech 2018]) discusses QA/QC protocols for field QC. Generally followed during this project was SOP No. 0004 (Field-Portable X-Ray Fluorescence Analyzed Measurement), included as Attachment C-1 to the QAPP. Cases of deviation in procedure from that specified in the RSE Work Plan are summarized in Section 3.7. The following subsections present the various procedures followed as part of QA/QC protocol during the XRF field survey. Tabular and graphical summaries of primary QA/QC results during the XRF field survey program are in Attachment B1.

3.4.2 Calibration

Prior to use of all instruments in the XRF field survey, these were checked to ensure they had been factory-calibrated within the limits set by the manufacturer. Scanned copies of available calibration documents are in Attachment B2.

3.4.3 Blanks

Daily or more frequently, each XRF instrument used in the field and/or in the laboratory setting analyzed blank samples in the test stand. The blank samples were from a clean quartz matrix, free of any analytes at concentrations above established lower limits of detection. These blank samples were used to monitor for cross-contamination and laboratory-induced contamination or interferences (USEPA 2007). Typically, blanks are used to assess potential laboratory contamination and/or some forms of calibration problems. Data from the blanks were reviewed by a chemist regularly, and no issue arose with any instrument used during this project.

3.4.4 System Checks

Internal energy calibration checks, referred to as “system checks,” occurred multiple times per day per instrument, as recommended by the manufacturer and by Method 6200 (USEPA 2007). A system check is a test of an instrument to determine whether it is operating within resolution and stability tolerances. Daily system checks are recommended by the instrument manufacturer and are considered a best management practice for use of a field-portable XRF analyzer. These checks are intrinsic to the system, and could be set so the instrument would require the user to perform automatic system checks periodically. However, the internal protocol was to perform calibration checks at a minimum of once daily and after the instrument had been turned off and then turned back on.

3.4.5 Calibration Checks

Analysis of prepared standards containing known concentrations allows monitoring of system calibration over time (Johnson and others 2005). Certified standard reference materials were obtained from the manufacturer (Thermo Scientific), as well as from the laboratory. These materials were analyzed by each instrument throughout the project as a QC procedure to ensure no occurrence of drift and to maintain instrument comparability. If anomalous readings were detected, the XRF instrument was retested; if the problem persisted, the unit was sent back to the manufacturer, and data acquired by use of that instrument were removed from the project database. These calibration checks focused on the project’s primary target elements at different concentrations. Control charts were developed to ensure that measurements did not fall outside of QC limits. Attachment B1 summarizes all control charts for daily checks of target elements.

3.4.6 Precision Samples

Repeated analyses are important because these allow estimates of analytical precision (Johnson and others 2005), and the resulting data can also be used to estimate method detection limits for the XRF analyzer. XRF precision measurements occurred as specified in Section 4.4.1.2 of the QAPP (Appendix C to the RSE Work Plan [Tetra Tech 2018]), and in accordance with Method 6200. Precision of the XRF method is monitored by analyzing samples with low, moderate, or high concentrations of target analytes; frequency of precision measurements depends on DQOs for the data (USEPA 2007). Method 6200 recommends, minimally, a sequence of repetitive analyses of one precision sample per day of instrument use.

USEPA recommends analysis of each precision sample seven times in replicate. In this report, the term "replicate sample" is used interchangeably with "precision sample." For this project, every instrument used in the field performed in situ XRF replicate analyses of a precision sample minimally once per day. Evaluation of precision of data returned from XRF instruments used in the laboratory could occur via standard reference material checks, as well as ex situ XRF bulk sample measurements, which are discussed later.

Method 6200 also recommends evaluation of precision measurements for the different types of XRF sampling occurring during a project (that is, in situ XRF measurements and intrusive XRF measurements). Precision of in situ XRF measurements and intrusive XRF measurements can be measured. Intrusive XRF measurements for this project were of two forms: (1) ex situ XRF bulk sample measurements, and (2) ex situ XRF soil cup measurements. Preparations for both in situ XRF measurements and intrusive XRF measurements are discussed in Section 3.3. Notably, only six replicate measurements from intrusive bulk replicate samples occurred rather than seven replicate measurements from the quality control samples. This was because three measurements were collected on each side of the bag at an evenly spaced spatial distribution. Precision can be measured by calculating the RSD, defined as:

$$RSD\ (\%) = \frac{\sigma}{\mu}$$

Where σ is the standard deviation of the replicate measurements in ppm and μ is the mean of replicate measurements in ppm. The higher the RSD, the lower the precision, and the lower the RSD, the higher the precision. An evaluation occurred of precision of data returned by all XRF instrumentation for all of the different target analytes at differing concentrations (that is, low, medium, and high) from application of each soil preparation technique (that is, in situ XRF method, ex situ XRF bulk sample method, ex situ XRF soil cup method). The information acquired from this evaluation helped determine appropriate recommendations for data quality and data usability of the XRF analyzer used during this project. A guideline of less than 20 percent RSD for the target analytes is ideal for the data to be considered of high data quality for use in risk assessments (USEPA 2007).

The RSD helps provide understanding of precision of an XRF instrument. Attachment B1 summarizes measurement of precision of data acquired by each instrument used at any time during the course of the project.

3.4.7 Field Duplicate Samples

In situ XRF duplicate measurements involve analyzing the same sample twice without lifting the XRF instrument from the ground. Duplicate measurements occurred at a frequency of one duplicate for every 20 situ XRF measurements taken in the field. In most cases, the field duplicate measurement was taken at the same location of collection of an XRF confirmation soil sample. A frequency of 5 percent follows Method 6200 Section 9.7 recommendations. Field duplicate measurements for the project should have RPDs less than 30 percent. Attachment B1 summarizes RPDs of all of field duplicate measurements.

An RPD is calculated as follows:

$$RPD = \frac{[XRF_{Primary} - XRF_{Duplicate}]}{(XRF_{Primary} + XRF_{Duplicate})/_2}$$

3.4.8 Method Detection Limits

Another objective of this study was to calculate detection limits of the XRF analyzer in its application to each XRF method during the XRF field survey. The MDL is defined as the minimum concentration of an analyte that can be measured and reported, with 99 percent confidence that concentration of the analyte is greater than zero; this MDL is determined via analysis of a sample in a given matrix containing the analyte (Title 40 CFR Part 136, Appendix B, Revision 1.11). Detection limits for XRF analysis are both element- and matrix-dependent, and most elements are detectable below typical site action levels (Kalnicky and Singhvi 2001). The MDL depends on several factors, including the analyte of interest, type of detector used, type of excitation source, strength of excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences (USEPA 2007). Detection limits are affected by concentration of the analyte in the sample—that is, analytes at high concentrations tend to have higher apparent detection limits than those at lower concentrations (Kalnicky and Singhvi 2001). This highlights the necessity to use a sample with analyte concentrations as close to the MDL as possible (Kalnicky and Singhvi 2001). MDLs of actual site data tend to be somewhat higher, reflecting instrument use over several months during the project.

Table B-11 lists manufacturer-reported MDLs for the target elements of this project. This table also lists concentration range criteria for very low, low, medium, and high analyte concentrations. These are arbitrary criteria selected for calculating precision and accuracy over a variety of concentration ranges, which is a specification of Method 6200. Concentration ranges listed in Table B-11 are used throughout this report.

While Table B-11 lists MDLs for the Niton XL5 as calculated by the manufacturer, it is more appropriate to determine the MDL for a specific project (Kalnicky and Singhvi 2001). The manufacturer-reported MDLs were developed following 40 CFR Appendix B to Part 136, and were calculated by use of a 60-second analysis time for each of the three filters (total analysis time of 180 seconds). The MDL lowers as analysis time increases. For this project, a 60-second analysis time, partitioned across the different filters as described in Section 3.3.3, was implemented for all instruments used in the field or in the laboratory. Therefore, MDLs calculated for this project account for this, and were expected to be higher than the manufacturer-reported MDLs.

Table B-11. Niton XL5 Manufacturer Reported Method Detection Limit and Concentration Range Criteria

Target Element	Niton MDL (ppm)	*Concentration Range Criteria (ppm)*			
		Very Low	Low	Medium	High
		< 2x MDL	2x - 5x MDL	5x - 10x MDL	≥ 10x MDL
Arsenic	2	<4.0	≥4.0 and <10	≥10 and <20	≥20
Iron	9	<18	≥18 and <45	≥45 and <90	≥90
Lead	1	<2.0	≥2.0 and <5.0	≥5.0 and <10	≥10
Manganese	13	<26	≥26 and <65	≥65 and <130	≥130
Molybdenum	1	<2.0	≥2.0 and <5.0	≥5.0 and <10	≥10
Thorium	1	<2.0	≥2.0 and <5.0	≥5.0 and <10	≥10
Uranium	2	<4.0	≥4.0 and <10	≥10 and <20	≥20
Vanadium	3	<6.0	≥6.0 and <15	≥15 and <30	≥30
Zinc	2	<4.0	≥4.0 and <10	≥10 and <20	≥20

Notes:

[1] From Thermo Fisher Scientific Niton XL5 Analyzer: Limits of Detection - Mining & Soils (Thermo Fisher Scientific 2017).

MDL Method detection limit

ppm Parts per million

Section 9.6 of Method 6200 states that the lower limit of detection should be established from actual measured performance, and sensitivity should be established as the lowest point of detection based on acceptable target analyte recovery in the desired sample matrix. Based on a literature review, several approaches are followed for calculating MDL for XRF analyzers; however, the most common and seemingly accepted approach is to follow Title 40 CFR Part 136, Appendix B, Revision 1.11. The manufacturer generally followed this approach to determine instrument-specific MDLs for target elements in silica, as did USEPA in a number of technology verification studies (USEPA 1998, 2006a). Therefore, for this project, site-specific and method-specific MDLs were all calculated via this approach. Following this approach, the lower limit of detection is calculated as the concentration equivalent to three standard counting errors (σ) of a set of measurements of background intensity (Kalnicky and Singhvi 2001; Bertin 1975; Jenkins and Gilfrich 1992). Thus, the standard deviation for the replicate analyses is used to estimate the MDL for the analytes of concern. Use of site soil samples near background concentrations represents site conditions in terms of general composition, particle size distribution, and moisture content. Typically, site background soils may be used for determination of MDLs with good success (Kalnicky and Singhvi 2001). More than 500 XRF confirmation soil samples were collected across all concentrations ranges of the different target elements, which allowed accumulation of a robust data set to calculate MDLs for most target elements.

Use of samples with analyte concentrations in the range of background was ideal for determining site-specific MDLs for the XRF analyzer. This was accomplished by utilizing data in the very low and low ranges (any sample containing analytes at concentrations less than or equal to five times predicted respective MDLs) as listed in Table B-11. For this project, three types of sample matrices were evaluated, and the method of matrix evaluation differed for each type. Therefore, sensitivity was established for each method and was useful for qualifying the in situ XRF measurement database discussed later in Section 3.6.

Replicate samples were collected for all three XRF methods discussed in Section 3.3 and used in the XRF field survey. The in situ XRF replicate sampling consisted of seven replicate measurements at a random site location at frequency of once per day per instrument. Analyte concentrations at these sample locations ranged from below the limit of detection to high concentrations depending on where the sample was collected at a given site. To calculate the MDL for an analyte for the in situ XRF method, precision data sets for all instruments were combined, and first any reported data below the limit of detection for the instrument were removed from the data set. The samples were then sorted by very low, low, medium, and high to evaluate the statistics, including precision (via RSD) across the different concentration ranges. The in situ XRF method MDL for each analyte was calculated by averaging, from replicate measurements, all reported uncorrected XRF measurement concentrations less than five times the manufacturer-reported MDL. This approach was followed because often, not enough laboratory analytical data were available pertaining to a given sample location where a replicate sample was collected. For analytes (such as iron) present in no samples at concentrations in the very low to low range, the MDL was calculated by averaging the lowest 10 concentrations detected in samples. This occurred for some elements and for different XRF methods. The MDL for a given sample location was the standard deviation of the replicate measurements times 3. MDLs were easily calculated for the majority of target elements because of low concentrations of these in numerous samples collected at various sites. The MDL was calculated according to procedures specified in Title 40 CFR Part 136, Appendix B, Revision 1.11. Equation 1 can be used for calculating the MDL:

Equation 1: $$MDL = t_{(n-1,1-\alpha=0.99)}\sigma$$

Where,

MDL	=	method detection limit
n	=	number of samples
σ	=	standard deviation of concentrations detected in replicate samples
t	=	Student's t value for 99 percent confidence level and a standard deviation estimate with n-1 degrees of freedom (a consistent value of 3 was used during this project regardless of sample size)

MDLs of analytes also were calculated, and in a similar manner, for the two different intrusive XRF methods (ex situ XRF bulk sample measurements and ex situ XRF soil cup sample measurements). For each bulk sample, the XRF analyzer took six replicate measurements, with each measurement non-consecutive (that is, the XRF analyzer was physically lifted off the surface between measurements). The six measurements were taken at different locations on the surface of the plastic bag holding the sample. Three readings were taken on each side of the sample bag, and the unit was lifted between readings. The MDL for each analyte was calculated as the average of concentrations reported from bulk soil sample results that were less than five times the manufacturer-reported MDL of that analyte. This procedure involved the 264 soil samples collected during Mobilization #1 through Mobilization #6.

A similar approach was followed for calculating MDLs of analytes for the ex situ XRF soil cup measurement method; however, fewer soil samples were available for the analysis. This approach was expected to yield the lowest limits of detection for a number of reasons, but primarily because the soil samples were more homogenized, particle size was uniform, the sample was dried in the oven, and the XRF test stand was used. Soil cups were prepared and analyzed as described in Section 3.3. Determination of the MDL for each target element was based on results from replicate samples that contained the target element at concentrations near the detection limit (that is, very low and low as defined in Table B-11), if possible. The MDL for each analyte was calculated by averaging concentrations of that analyte (reported from replicate measurements) less than five times the manufacturer-reported MDL for that analyte.

3.5 STATISTICAL METHODS FOR DATA EVALUATION

Another objective of this study was to evaluate comparability of XRF-determined concentrations of all target elements to concentrations of those elements measured by application of confirmatory laboratory methods, in contexts of the different sample preparation methods and measurement techniques.

3.5.1 Relative Percent Difference

Comparability of two results from the same sample can be evaluated by the quantitative parameter referred to as RPD. The RPD can help determine how well the XRF-reported measurement corresponds to the laboratory-reported concentration for a given data pair for each target element. An RPD of 0 percent would indicate a perfect match between the XRF measurement and the laboratory-reported concentration. Because the XRF analyzer measures total elemental concentration and the selected laboratory method involves a partial digestion method, it is not always likely the RPD will be low between the data pairs, and a correction factor will be determined via linear regression. Once a correction factor is determined, it can be applied to the XRF data set and the RPD can then be recalculated. These respective data sets are referred to as "uncorrected' and "corrected." Reported for this project are accuracies of both corrected and uncorrected XRF datasets from applications of the two primary methods for which such comparisons can occur. Notably, the median RPD is recommended to assess accuracy of a method. The RPD can be calculated as the absolute value of the difference between the XRF-determined concentration of an element in a sample and the laboratory-determined concentration of that element in the same sample, divided by the average of these two values.

Previous evaluation studies have used a categorical rating system to identify how well an XRF method achieves accuracy (USEPA 1998, 2006a). Table B-12 conveys the categorical system previously used. Later in the report, a performance evaluation is presented to show which target elements fall into which categorical ratings for accuracy of the different XRF methods.

Table B-12. Summary of Categorical Ratings for XRF Accuracy

Value of XRF Accuracy[1]	Rating[2]
RPD ≤ 10 percent	Excellent
10 percent < RPD < 25 percent	Good
25 percent ≤ RPD ≥ 50 percent	Fair
RPD > 50 percent	Poor

Notes:

1 Refers to the accuracy of the XRF method for each target element, based on median RPD.

2 Table generated from USEPA Technology Verification Reports (USEPA 1998, 2006a).

ICP-MS Inductively coupled plasma-mass spectrometer
RPD Relative percent difference
USEPA U.S. Environmental Protection Agency
XRF X-ray fluorescence

3.5.2 Linear Regression

Several statistical analysis methods may be applied to evaluate and compare XRF and confirmatory data (Kalnicky and Singhvi 2001). Comparability is a qualitative parameter that expresses how closely one data set matches another. It is recognized that direct comparison of the reference laboratory data (derived from ICP-MS after partial acid digestion) to XRF measurements may result in discrepancies because of differences in sample preparation and measurement techniques; however, comparisons of laboratory data to XRF measurements are expected to accord well enough to meet project objectives. The two primary types of statistical methods applied to evaluate comparability of XRF and confirmatory data for this project are: (1) linear regression and correlation analysis between data pairs, and (2) inferential statistics to evaluate populations of the two data sets.

Linear regression is the primary method for evaluating comparability of XRF data and confirmatory data. The linear regression least squares method is applied to determine if a linear relationship between the data pairs exists. A number of parameters are used to assess this relationship, to determine if the XRF spectrometer is an appropriate tool for risk assessment purposes, and to assess potential uses of the instrument in the future for remedial action purposes, if necessary. The Pearson's correlation coefficient (r) and the coefficient of determination (R^2) are the correlation parameters of interest. Other important parameters include the slope (m) and y-intercept (b) of the least squares fit. These parameters help determine if application of a correction factor to the XRF data is necessary to better represent laboratory-reported concentrations, especially because the laboratory analytical technique utilizes a partial digestion method, and because of elemental or matrix effects, full recovery of one or more analytes may not be possible (contrary to the XRF unit, which measures total elemental concentration[s]). Laboratory analytical techniques selected for the project are discussed in Section 3.3.5.

Data correction is recommended when using XRF technology for site characterization or remediation monitoring (USEPA 1998). A percentage (5 percent) of samples were collected for reference laboratory analysis aimed at providing a basis for determining a correction factor. A minimum of one sample for each 20 (5 percent) in situ XRF measurements should be submitted for confirmatory analysis, as recommended in Section 9.7 of Method 6200. Other documents (USEPA 1998, 2006a) recommend 10 percent or 20 percent, but Method 6200 was the primary guidance followed. An eight-step correction method, involving a log-transformed method, is presented in USEPA (1998) in order to reduce relative bias and increase accuracy to acceptable levels. A similar approach was followed in this study, but a non-log transformed linear regression is applied here for all correlations performed.

Numerous correlations were developed using linear regression least squares between field-portable XRF measurements and laboratory analytical results for the nine target elements (arsenic, iron, lead, manganese, molybdenum, thorium, uranium, vanadium, and zinc). Each regression model resulted in calculation of a correlation coefficient (r), coefficient of determination (r^2), slope (m), and y-intercept (b). Additional analysis was performed to evaluate the standardized residuals for further statistical evaluation. The standardized residual equals the value of a residual divided by an estimate of its standard deviation. Standardized residuals greater than 2 and less than -2 are usually considered large and Minitab identifies these observations in the table of unusual observations and the table of fits and residuals. All of these statistical features are important for evaluating and determining appropriate models for each target element and for choosing how to apply correction factors to improve accuracy in application of XRF methods.

For this project, the regression models were selected only from the 264 data pairs generated from the Baseline Study, which primarily occurred during Mobilization #1 through Mobilization #6. A data pair includes, for each target element, the average value of replicate ex situ XRF measurements pertaining to that element from a given bulk sample (independent variable, x-axis) and laboratory-reported concentration of that element (response or dependent variable, y-axis) in the same bulk sample.

Several statistical analysis methods may be applied to evaluate and compare XRF and confirmatory data (Kalnicky and Singhvi 2001). The first statistical requirement for confirmation samples is regression analysis to evaluate if a linear relationship exists between the independent variable (XRF data) and the dependent variable (confirmatory laboratory data). Regression results were plotted as a visual aid to determine the significance of the linear model and to identify potential outliers (Kalnicky and Singhvi 2001). Potential outliers were identified by visual analysis of the linear regression model, normal histograms of standardized residuals, and normal probability plot as well as statistically by evaluation of Minitab output indicating unusual observations based on the analysis of standardized residuals greater than 2 or less than -2.

Correlation analysis is related to regression analysis. Correlation analysis determines the degree of linearity between two sets of data. A correlation coefficient (r) is generated in the analysis, and ranges in value from -1.0 (a perfect negative linear relationship) to 1.0 (a perfect positive linear relationship). If a strong linear relationship exists, linear regression analysis should be used to evaluate the data sets (Kalnicky and Singhvi 2001). A correlation analysis was first performed to determine for which analytes a strong linear relationship between XRF data and laboratory data resulted, and this is how the nine target elements were determined in the first place. A criterion of $r > 0.7$ was established, as specified in numerous publications regarding XRF (USEPA 1998, 2006a, 2007; Kalnicky and Singhvi 2001).

Graphical presentation of the regression model facilitates an intuitive feel for the data and provides better understanding of the model. A wide range of values induced plots of the data on different scales to indicate the possible impact of high or low values on the model (Kalnicky and Singhvi 2001). For several elements (uranium, lead, thorium) use of multiple models was deemed beneficial to represent the data based on concentration levels in order to more accurately account for bias from higher concentrations on the lower values. The standardized residuals of the regression model were examined for outliers by use of a statistical software package (Minitab 18). Residuals are differences between predicted dependent values and actual dependent values. A plot of residuals versus dependent values should be a random scattering of points about the zero residual line (Kalnicky and Singhvi 2001). Residuals were also plotted on a probability curve to evaluate for normality. Spread of the standardized residuals was evaluated for identifying data pairs exhibiting unusually large error.

Following the approaches just described, anomalies or outliers are usually apparent. If any outliers are apparent, the regression analysis should be performed with and without these values to determine their impact on the model (Kalnicky and Singhvi 2001). Because sample size was so large in this project, avoiding removal of data points was not necessary; moreover, the condition for residual normality was less important based on the central limit theorem. Once outliers were identified, further evaluation of those specific data pairs occurred, and only outliers that could be justified by explanation were then removed from the final regression analysis.

Possible reasons for presence of outliers in a dataset include instrumental error (deficiency of the XRF analyzer), but this is rare because of the stringent QC checks that occur. Another possible reason is laboratory error whereby the laboratory reports concentrations are an order of magnitude off because of a technician calculation error or dilution factor error. During this study, that circumstance was apparent, and a number of samples were sent for reanalysis and found to contain the expected concentrations upon reanalysis. Finally, the "nugget" effect is a possibility, whereby the laboratory sample (typically only 1 gram) may contain a small "nugget" of analyte, resulting in a higher or lower laboratory result than expected based on the ex situ XRF measurement (Kalnicky and Singhvi 2001). Nonetheless, the most meaningful regression analysis for evaluating XRF performance is one free of outliers, free of nondetects, and within the appropriate concentration range of interest. The concentration range of interest includes a range near background levels to future cleanup or action levels.

Notably, the additional data pairs acquired in Mobilization #7 through Mobilization #9 were not utilized in the primary regression analysis but were used to compare data populations and to fit with the prediction limits of the primary model. These data from the last three mobilization surveys were used to determine how well the data fell within the prediction limits of the established correlation for each model.

Ideally, the complete data set (Mobilization #1 through Mobilization #6) would have been utilized for development of the correlation model. However, as described previously, some primary steps had been taken with the data pairs prior to development of an established final regression model. In all cases, the original data set—with and without outliers—was always retained and is presented in the attachments to this report.

The following steps were taken prior to development of a correlation:

1. Data pairs were identified as "nondetect" and removed from all future analyses if either a minimum of one replicate ex situ XRF measurement was reported at less than the limit of detection (LOD) of the instrument, or a laboratory confirmatory sample concentration was reported as nondetect ("U" or "UJ") following data validation. Nondetect data pairs were flagged and removed from the regression analysis because either circumstance described in the previous sentence indicated that the data would not accurately reflect the true concentrations in the sample. All nondetect data are listed in the data tables in Attachment B4 to this report.
2. Outliers were removed from the regression models and identified for retesting following identification of these via visual inspection and evaluation of standardized residuals. Regression model reports and results with inclusion and exclusion of outliers are conveyed in Attachment B3 to this report.

In some cases, the spread of data was large and expanded across multiple magnitudes (that is, 1, 10, 100, or 1,000); in certain cases, it was determined that a separate correlation for the lower levels and higher levels was required to better characterize these ranges. For example, a correlation for lead was developed for XRF lead measurements less than 30 ppm, and another correlation was selected for XRF lead measurements exceeding 30 ppm. Similar circumstances with uranium and thorium were recognized whereby certain higher concentrations biased prediction of lower concentrations, and two linear regression models were warranted.

A process similar to that described in this section was followed for the soil cup study as well. Section 4.0 presents linear regression model results for both the bulk sample and soil cup studies and describes the process for identifying outliers in data sets pertaining to each of the target elements. The following section discusses the process for determining appropriate data qualifiers used in this project.

3.6 DATA QUALIFER PROCESS

Neither EPA Method 6200 nor any other source in the extensive scientific literature reviewed provides guidance for qualifying in situ XRF measurement data. Therefore, Tetra Tech applied an approach designed to qualify in situ XRF measurement data to identify COPCs and to qualify estimates of data to be used for risk assessment purposes. The three primary data qualifiers used with this approach are as follows:

- "QU" is a qualifier for data points that are not detected. Nondetects can be identified directly when the XRF analyzer reports a concentration below the LOD; or as data reported by the XRF analyzer, when corrected, become negative concentrations; or, during application of the in situ method, when the XRF reports data at values less than the calculated XRF detection limit.
- "QH" – are detected data outside the upper limits of the prediction model.
- "QL" – are detected data outside the lower limits of the prediction model.

Figure B-12 is a process flow diagram for qualifying the in situ XRF measurement database.

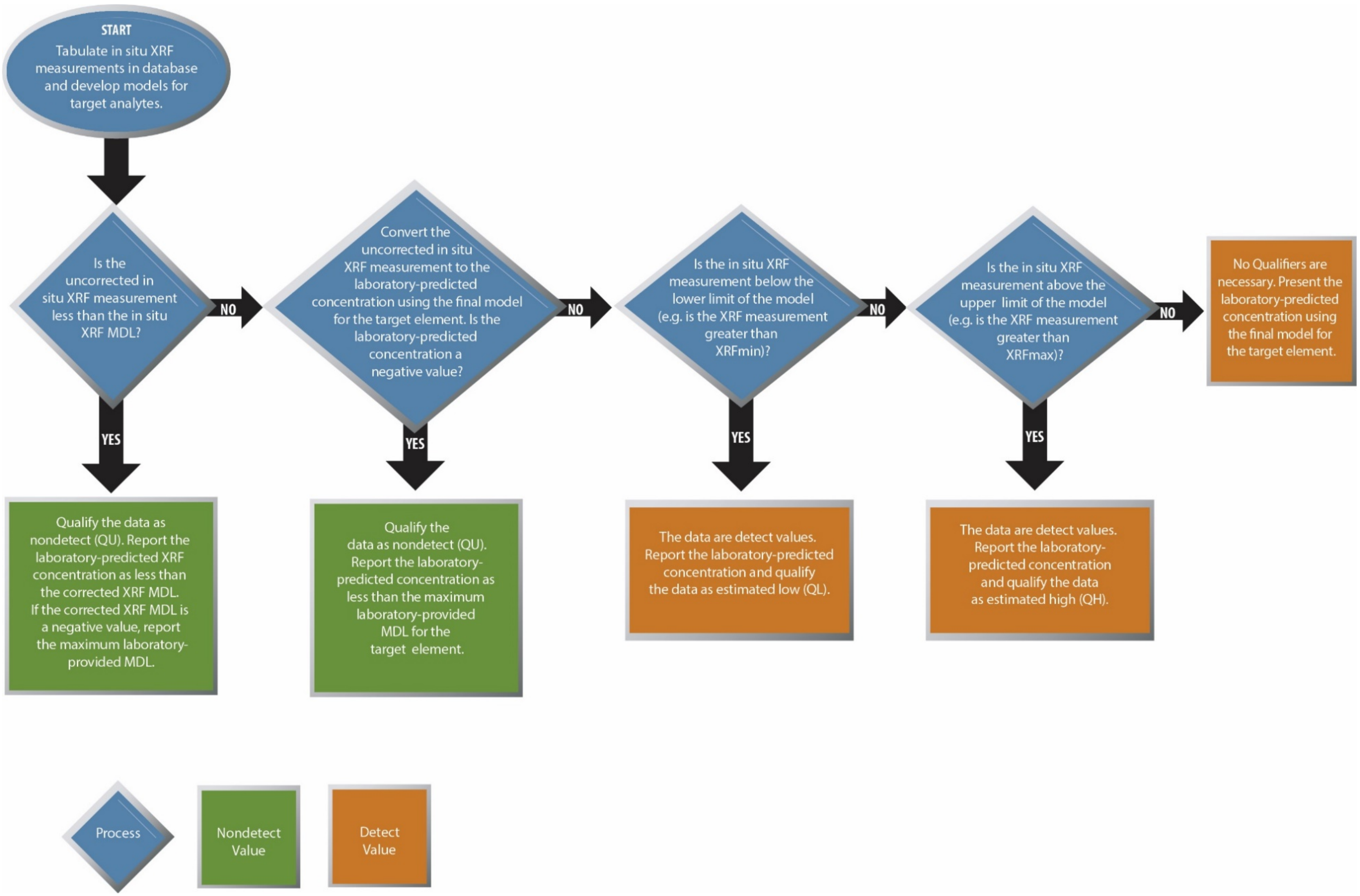


Figure B-12. XRF Data Qualifier Process Flowchart

3.7 DEVIATIONS FROM WORK PLAN

Some deviations from the RSE Work Plan occurred (Tetra Tech 2018). The XRF field survey during this project was the first of its kind for AUMs within the Navajo Nation. Decisions made based on lessons learned during the project, previous experience, and prudent field judgement ensured achievement of DQOs. In all cases, decisions were documented, discussed with the USEPA, and presented within this report. The deviations from the RSE Work Plan are as follows:

- A comparability study using soil cups occurred; this had not been proposed in the RSE Work Plan. This was added to add further assurance with instrument comparability as well as evaluating particle size concentrations.
- System checks were initially performed once per day, but frequency later increased to a minimum of twice per day and whenever the instrument was powered on and off. The increase was following discussions with Niton technicians on how to increase accuracy of the instrument.
- Section 4.1.1.7 of the QAPP (Appendix C to the RSE Work Plan [Tetra Tech 2018]) specified that XRF measurements were to be taken within the survey grids of the selected project background locations. Prior to field work, but after approval of the RSE Work Plan, a decision was made to collect soil samples only for laboratory analysis, and not to take XRF measurements within the background study areas.
- Specific locations for in situ XRF field survey measurements were proposed in the Field Sampling Plan (FSP) for each site, as described in Appendix F to the RSE Work Plan. However, many planned data acquisition locations were changed based on field conditions; these are summarized in site-specific RSE Reports in Appendix H and Target site reports in Appendix I to the main RSE Report.

4.0 MODEL RESULTS

This section presents model results for each target element evaluated as part of the XRF comparability study. The results include a detailed description of the process for developing regression models and correlation analyses of XRF data sets and confirmatory data sets for the two primary soil preparation methods discussed in Section 3.2. This section also includes an evaluation of analytical quality (precision, accuracy, detection limits) of the in situ XRF method, ex situ XRF bulk sample method, and ex situ XRF soil cup method. Additional information includes a summary of final model selection for each target element, and an evaluation of how XRF data compare to laboratory analytical data across the different target elements in the project.

4.1 ARSENIC

4.1.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 arsenic data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the arsenic comparability study. The samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis but, instead, were used for inferential statistics and model validation purposes. A total of 131 of 264 data pairs contained nondetects and were therefore removed from the dataset prior to the initial linear regression least squares analysis. All 131 nondetect arsenic data pairs were removed because of issues with XRF instrument detection capabilities and not because of issues with laboratory detection limits (that is, data from all confirmatory samples were detected results). Laboratory-reported arsenic concentrations from bulk soil samples in the removed dataset ranged from 0.5 to 10 mg/kg, with an average standard deviation of 1.8 mg/kg and a standard deviation of 1.1 mg/kg, respectively. Following removal of these data pairs, a linear regression least squares analysis was applied on the remaining 133 arsenic data pairs. For these remaining data pairs, laboratory-reported arsenic concentrations from the data set ranged from 1.5 to 74 mg/kg, with an average of 8.5 mg/kg.

An analysis to identify potential outliers and to evaluate the potential effects of influential outliers (that is, a data pair that significant effects the slope of the regression line) that were outside of concentration levels near background or at future cleanup or action levels was performed (that is, to bracket levels of interest). Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted using regression analysis tools in the Minitab statistical software. Additionally, an evaluation occurred to assess effects of the different bracketed concentration ranges, which involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the arsenic data set, conclusion was that the range of arsenic data pairs observed warranted a single model with one scale. Several different regression scenarios were evaluated and documented for this report as described below.

Model AS-1 is the first of a series of models that involved linear regression least squares analysis. This model included the entire arsenic dataset (without nondetects), totaling 133 data pairs. Through visual inspection of a fitted line plot, an influential outlier was flagged (sample M24-XS128-01-061118). This extreme outlier had an average ex situ XRF arsenic measurement of 3.6 ppm with a relative standard deviation of 20 percent, indicating a relatively homogenous sample from which acquired data indicated an MDL less than two times the factory-reported MDL for the XRF instrument (MDL = 2 ppm). However, the laboratory-reported arsenic concentration of this sample was 91 mg/kg, resulting in an RPD of 185 percent between data from the two samples. Because the average RPD between all the Model AS-1 arsenic data pairs, excluding this sample, was 15 percent, the higher RPD from this data pair warranted further investigation. Tetra Tech suspects either a laboratory error occurred because of dilution or a small aliquot taken for ICP-MS analysis contained an elevated concentration from a small mineralized soil particle(s) with a high arsenic concentration (referred to as the "nugget effect"). Either way, the sample was removed from the comparability study prior to evaluation of any further models. Also, and notably, the laboratory was asked to check for mistakes and then, if no errors were noted during their review, to reanalyze M24-XS128-01-061118. No errors were found; upon reanalysis, the laboratory reported an arsenic concentration of 2.8 mg/kg, thus reducing the RPD to 26 percent between XRF and laboratory data. A full diagnostic report regarding Model AS-1 from the statistical software is in Attachment B3; this model still includes sample M24-XS128-01-061118, identified as an outlier.

The second model, referred to as Model AS-2, contained the exact dataset as Model AS-1 excluding the single outlier discussed earlier (M24-XS128-01-061118). An improvement of the correlation coefficients from Model AS-1 (r = 0.77) to Model AS-2 (r = 0.96) occurred by removal of the outlier, further confirming that sample M24-XS128-01-061118 was an outlier. A similar approach was again followed to identify potential outliers by visual inspection and by statistical evaluation of the standardized residuals from Model AS-2. Six data pairs with large residuals were identified by use of the statistical software, requiring further inspection. Table B-13 summarizes the data pairs identified as having large residuals through the Minitab regression statistical package.

Table B-13. Summary of Data Pairs with Large Residuals for Arsenic in Model AS-2

Sample ID	Average Ex Situ XRF Arsenic Value (ppm)[1]	RSD of Ex Situ XRF Arsenic Values[2]	Laboratory Arsenic Result (ppm)[3]	RPD of Data Pairs
M15-XS93-01-052118	48	7.6%	42	13%
M21-XS126-01-060818	31	11%	25	22%
M22-XS14-01-060418	26	21%	16	47%
M28-XS43-01-062018	44	7.6%	53	19%
M33-XS22-01-071218	53	13%	74	34%
M21-XS290-01-060918	12	18%	25	73%

Notes:
1 Average of six ex situ XRF arsenic measurements taken from the bulk sample.
2 RSDs of the six ex situ XRF arsenic measurements taken from the bulk sample.
3 Laboratory-reported arsenic concentration by partial digestion (3050B) and ICP-MS (6020A).

ICP-MS Inductively coupled plasma-mass spectrometer
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

RSDs of the data pairs listed in Table B-13 were all less than 21 percent, indicating that the samples were relatively homogenous. Except for sample M15-XS93-052118, the data pairs with large residuals all exhibited RPDs higher than average (>15 percent). All samples had RPDs less than 50 percent except for sample M21-XS-290-01-060918. This sample had an average ex situ

XRF arsenic concentration of 11.6 ppm and a laboratory-reported arsenic concentration of 25 mg/kg (RPD of 73 percent). The XRF measurement result was 2.2 times lower than the confirmatory sample result. An analysis occurred to remove all six large residual samples from the dataset and also to remove sample M21-XS-290-01-060918 from the regression analysis. Very little influence on the regression compared to Model AS-2 was observed between these two scenarios; however, given the high RPD evident between XRF measurement and laboratory-reported arsenic concentration in M21-XS-290-01-060918, conclusion was that this sample was a true outlier likely associated with the laboratory aliquot collected and related to the nugget effect. Therefore, only sample XS-290-01-060918 was removed prior to the third regression scenario, referred to as Model AS-3.

Table B-14 summarizes the various parameters associated with the three regression models evaluated as part of the arsenic comparability study. The third and final regression model evaluated was Model AS-3. This model is the same as Model AS-2 but excludes sample XS-290-01-060918 for the reasons described above. This model uses a total of 131 data pairs excluding two outliers and 131 nondetect data pairs. Model AS-3 has a calculated slope of 1.0407 and y-intercept of -0.5494 with an R^2 of 0.94 (r = 0.97). Figure B-13 shows the final selected data pairs included in Model AS-3 with the 95 percent prediction limits and the arsenic data pairs, with outliers removed. Model AS-3 is the final model selected to best represent the relationship between ex situ XRF bulk sample arsenic measurements and laboratory-reported arsenic concentrations from the XRF confirmation soil samples. This model omits the nondetects and outliers, and is the best representation of the data.

Table B-14. Summary of Parameters for Ex Situ Bulk Sample Arsenic Regression Models

Model Name	Data Pairs	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model AS-1	133	0	1.008	0.4943	0.59	0.77
Model AS-2	132	1	1.044	-0.4747	0.92	0.96
Model AS-3	131	2	1.0407	-0.5494	0.94	0.97

Notes:
A total of 131 data pairs were removed because they contained a nondetect.
b y-intercept as calculated by the linear regression least squares method
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination

Attachment B3 presents statistical analyses of all regression models evaluated for arsenic (Model AS-1, Model AS-2, and Model AS-3). This attachment includes a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residual, normal probability plot of standardized residuals, and histogram of standardized residuals for each regression model. Attachment B4 presents, in tabular format, all data used that were either included or excluded in the earlier arsenic models (Model AS-1 and Model AS-2), and also presents data pairs from Mobilization #7 through Mobilization #9. The following subsection presents results of the soil cup comparability study for arsenic.

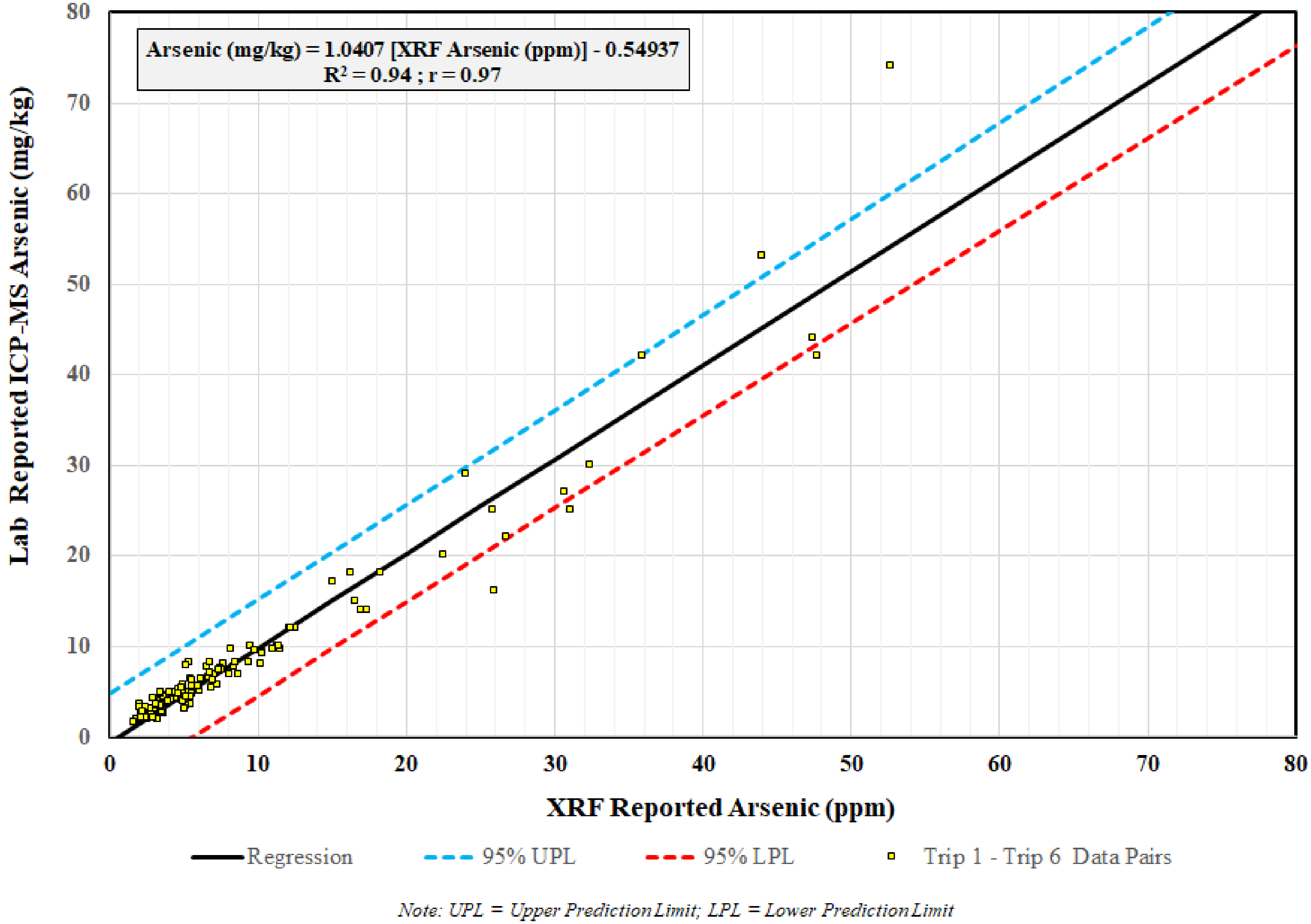


Figure B-13. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model AS-3 (Arsenic)

4.1.2 Linear Regression Analysis

A comparability study involved ex situ XRF arsenic measurements and laboratory-reported arsenic concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring arsenic concentration via this XRF method is presented in Section 3.4, and results are compared to those from the ex situ XRF bulk sample method. A complete graphical presentation of each linear regression model for each instrument is in Attachment B5. Table B-15 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-15. Summary of Arsenic Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.9353	-0.8868	0.99	0.99
Red	0.9163	-0.4927	0.99	0.99
White	0.9184	-0.0967	0.99	0.99
Average	**0.9233**	**-0.4921**	**0.99**	**0.99**

Notes:

1 Each XRF analyzer has a distinct serial number as presented in Section 3.3.2.
b y-intercept as calculated by the linear regression least squares method
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination
XRF X-ray fluorescence

Results indicate that slope did not vary greatly among XRF analyzers (RSD = 1.1 percent). Average R^2 (0.99) for the soil cup method is higher than the R^2 (0.94) computed for final bulk sample model (Model AS-3); however, both methods show acceptable correlation coefficients. Figure B-14 is a comparison among soil cup method bulk sample method regression models. At low arsenic levels (<10 ppm), very little difference is evident among the models; however, at greater than 10 ppm, the bulk sample regression model deviates upward, indicating the model presents a conservative estimate of the predicted laboratory-determined arsenic concentration. This is because the the average slope (m = 0.9233) of the soil cup method is lower than the slope (m = 1.0407) of the bulk sample method (Model AS-3).

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported arsenic concentrations. Figure B-15 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 43 of the 44 samples (98 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 23 percent. The mean of the bulk sample arsenic concentration from the 44 samples was 7.3 mg/kg, and decreased to 6.2 mg/kg in the soil cup samples—an RPD decrease of 16 percent. Further discussion on particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

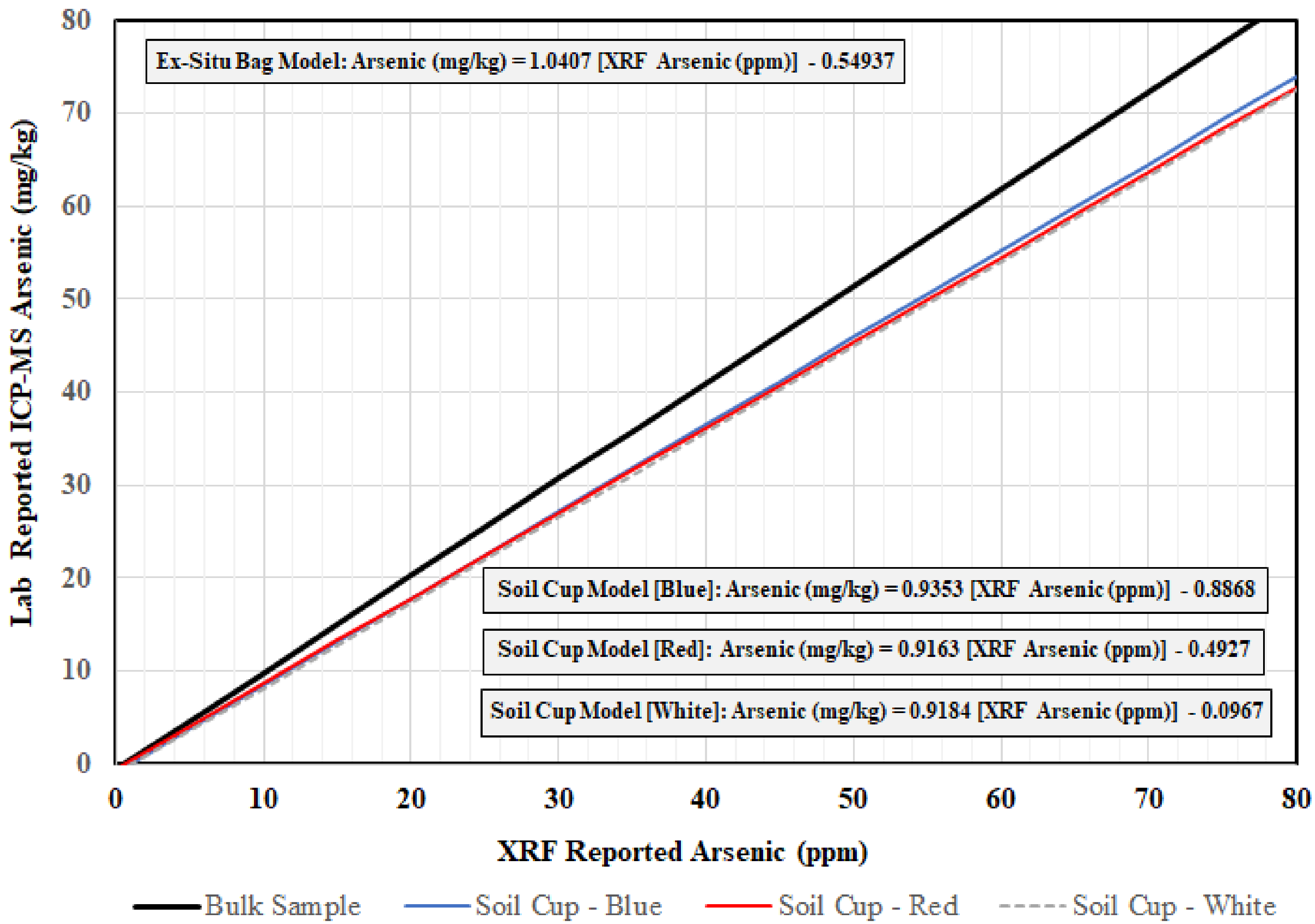


Figure B-14. Arsenic Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

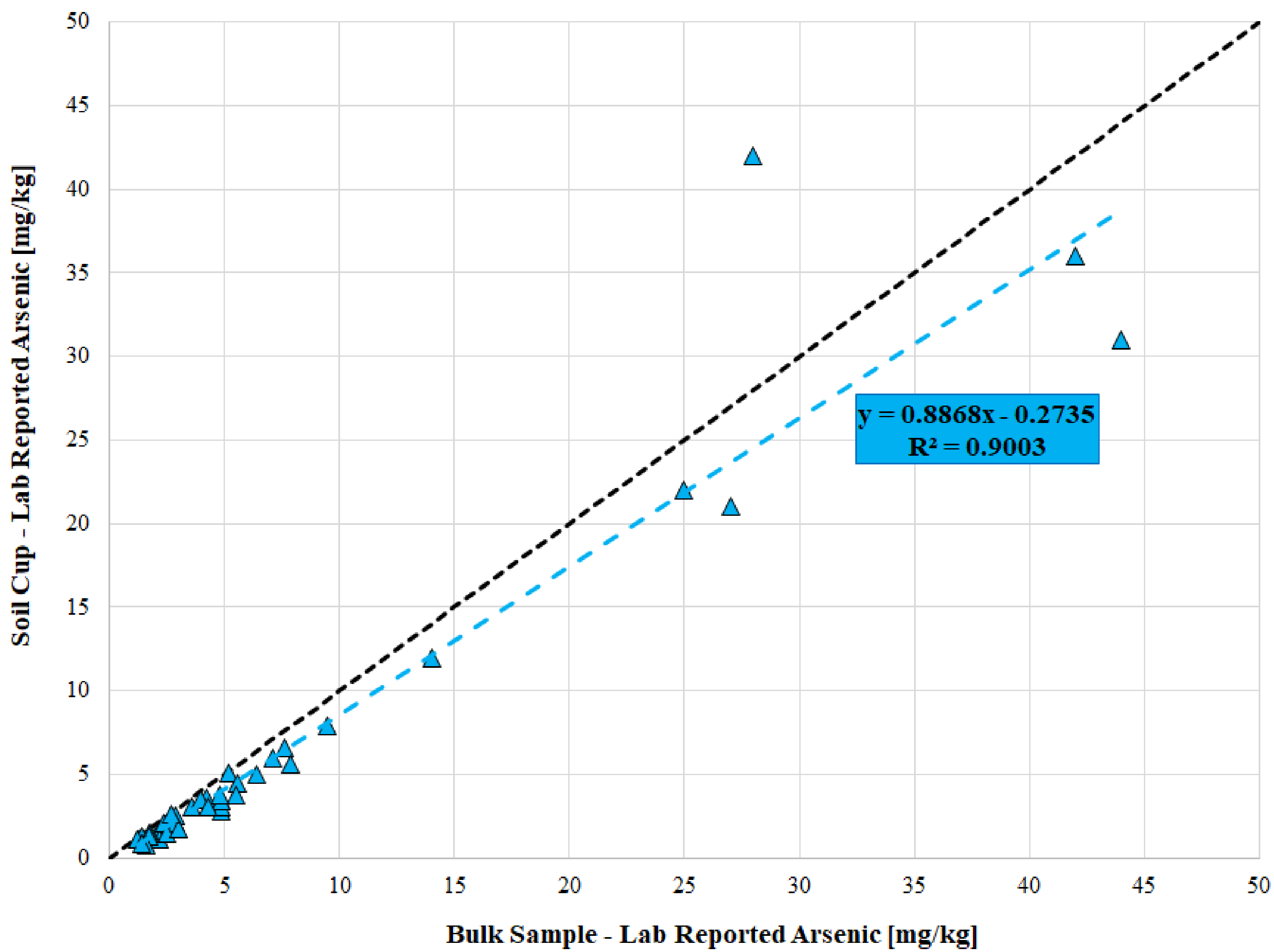


Figure B-15. Bulk Sample versus Soil Cup Arsenic Concentration

4.1.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-16. A large number of samples were evaluated in application of each of the methods, as listed in Table B-16.

Table B-16. Method Detection Limit for Arsenic by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	91	2.3
Ex Situ XRF Bulk Sample	107	3.3
Ex Situ XRF Soil Cup	74	2.3

Notes:

Manufacturer reported MDL of 2 mg/kg for arsenic using 60-second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

1 MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.

MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.1.4 Precision of XRF Analysis

An evaluation of precision for determination of arsenic was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. The precision was calculated for different ranges of arsenic concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are in Table B-11.

Table B-17 summarizes the calculated precision for the different ranges of concentrations for each method type. The in situ XRF method had the least precision (RSD = 19 percent), and the ex situ XRF soil cup method had the best precision (RSD = 14 percent). For all XRF methods of evaluating arsenic, the precision improved as the concentration increased. This was expected and shows the XRF analyzer responds better with higher arsenic concentrations in soil. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-17. Summary of Calculated Precision of XRF Method for Arsenic

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	62	21%	29	16%	8	10%	3	6.1%	102	19%
Ex Situ XRF Bulk Sample	46	23%	61	16%	12	12%	12	10%	131	17%
Ex Situ XRF Soil Cup	53	19%	21	12%	3	7.7%	15	4.6%	92	14%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with arsenic concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with arsenic concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with arsenic concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with arsenic concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.1.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-18 lists RPDs between XRF and confirmatory soil cup data for different arsenic soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory data from the soil cup samples. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-15) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined arsenic concentration, which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 92 soil cups had detectable data pairs, and all were evaluated for accuracy based on the range of concentrations observed within the data set. A description of the criteria for concentration ranges is in Table B-11. Similar to calculated precision of the soil cup method (Section 4.1.4), accuracy tends to increase (that is, RPD decreases) as sample concentration increases. Overall accuracy across all concentration ranges and for all data combined is significantly increased by applying a correction factor to the XRF data to estimate a predicted laboratory-determined arsenic concentration. By use of a correction factor, comparability is considered excellent according to the criteria of USEPA (1998, 2006a), as indicated in Table B-12.

Table B-18. Comparability for Ex Situ XRF Soil Cup Method Arsenic

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	53	33%	21	18%	3	10%	15	16%	92	24%
Ex Situ XRF Soil Cup (Corrected)	53	14%	21	10%	3	5.0%	15	7.0%	92	10%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with arsenic concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with arsenic concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with arsenic concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with arsenic concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-19 lists RPDs between XRF and confirmatory bulk sample data for different arsenic soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample arsenic regression model (Model AS-3) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined arsenic concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 131 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Unlike the soil cup method, comparability tends to remain consistent across all concentration ranges with or without the correction factor. By use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), as indicated in Table B-12.

Table B-19. Comparability for Ex Situ XRF Bulk Sample Method for Arsenic

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	46	15%	61	11%	12	10%	12	14%	131	13%
Ex Situ XRF Bulk Sample (Corrected)	46	17%	12	10%	12	10%	12	15%	131	13%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with arsenic concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with arsenic concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with arsenic concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with arsenic concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

To conclude, comparabilities of soil cup and bulk sample methods, when XRF data are corrected, are an overall RPD of 10 percent and 13 percent, respectively. For bulk samples, comparability is relatively unchanged with or without the correction factor for determination of arsenic concentration. An RPD of 13 percent is considered good by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies that the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation occurs to determine if this criterion is met in the following subsection.

4.1.6 Inferential Statistical Analysis

An analysis occurred to compare XRF and confirmatory arsenic data by way of two-sample hypothesis testing, supported by graphical analysis as recommended in USEPA (2015a). The ex situ XRF bulk sample arsenic measurement values were corrected by application of Model AS-3 identified in Section 4.1.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but because of the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of arsenic in both XRF and laboratory data were used in the analysis—that is nondetect data pairs were removed from the analysis as with the linear regression. Table B-20 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate equality of the XRF data sets and the laboratory data sets for both uncorrected and corrected values, as well as for both mobilization groupings.

An individual distribution analysis occurred in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed that the three-parameter lognormal distribution best fits the arsenic confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-16 is a three-parameter lognormal probability plot showing the XRF corrected arsenic data set and the confirmatory arsenic data set side by side, indicating a strong match between the two populations. A boxplot showing a side-by-side analysis is in Figure B-17, comparing the same two data sets to one another. Results of the hypothesis testing and graphical analysis indicate that the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-20. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Arsenic Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Arsenic	1 - 6	XRF = Lab	XRF = Lab
	7 - 9	XRF = Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01).

1 Mobilization #1 – Mobilization #6 was the Baseline Study.
2 Mobilization #7 – Mobilization #9 was the Site Characterization Study.
3 Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.
4 Corrected refers to the XRF data that was converted using Model AS-3 correction factors.

XRF X-ray fluorescence
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

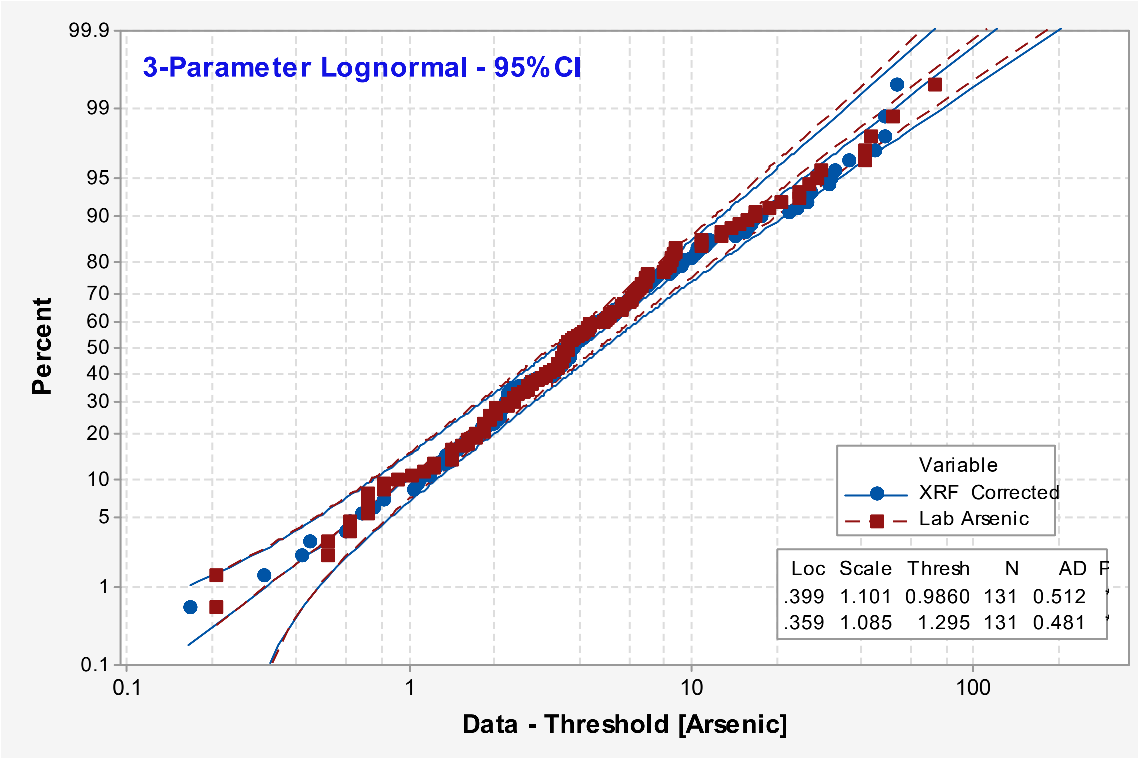


Figure B-16. Probability Plot of XRF Corrected Arsenic Data Set and Confirmatory Arsenic Data Set (3-Parameter Lognormal)

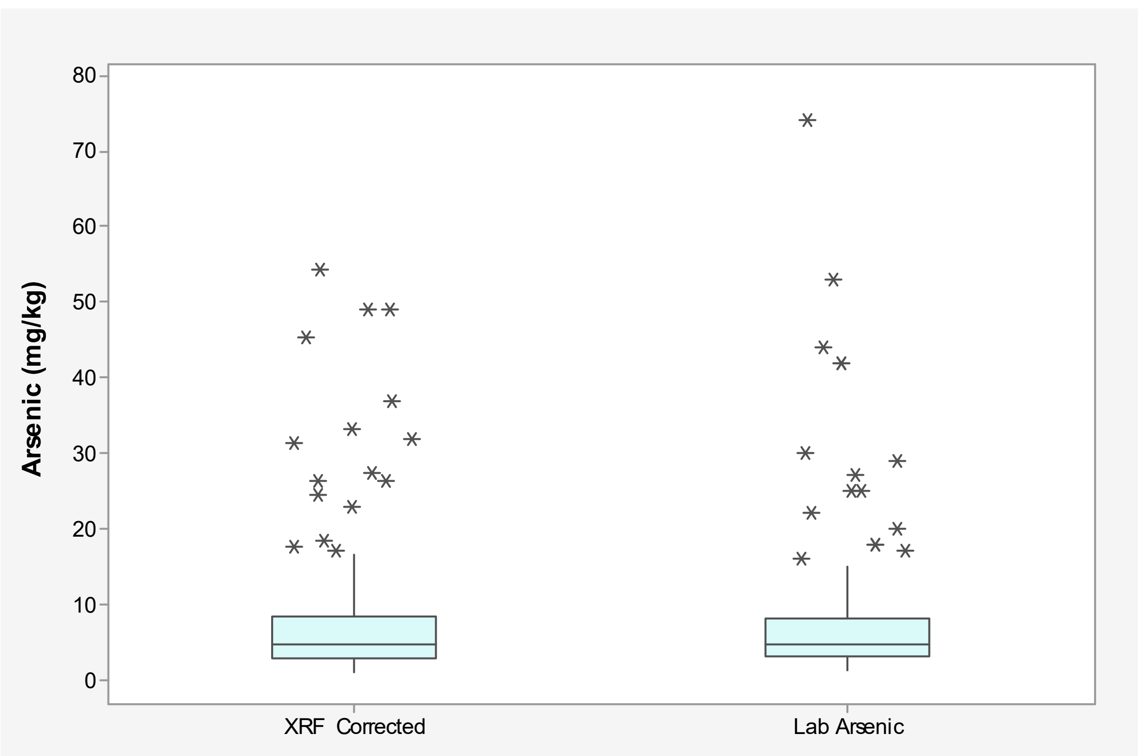


Figure B-17. Boxplot of XRF Corrected Arsenic and Laboratory Reported Arsenic

4.1.7 Sample Numbers and Descriptive Statistics

Table B-21 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF arsenic measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for arsenic with use of the XRF analyzer, 3,987 of these were below the MDL and qualified as such. The average detected arsenic concentration of in situ XRF measurements after correction was 5.6 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 4.8 mg/kg arsenic. A total of 292 surface soil samples were collected, averaging 4.9 mg/kg arsenic. Therefore, 794 analytical surficial (XRF confirmation and surface soil) soil samples were collected in total across the sites, averaging 4.8 mg/kg arsenic. In general, the average of the in situ XRF measurements was very close (RPD = 14 percent) to project-wide arsenic concentrations reported in surface soils via laboratory analytical method. The XRF unit reported a slightly higher average arsenic concentration than that from application of analytical sampling techniques for two primary reasons: (1) the lower level arsenic concentrations were nondetect and therefore were excluded from calculation of the average arsenic concentration from all measurements, and (2) application of the bulk sample correction method provides a conservative estimate across the sites.

Table B-21. Summary of Project Wide Arsenic Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	5,553	502	292	794
Nondetects	#	3,987	0	0	0
Minimum	mg/kg	1.8	0.54	0.48	0.48
Maximum	mg/kg	176	91	190	190
Average	mg/kg	5.6	4.8	4.9	4.8
Standard Deviation	mg/kg	7.0	8.5	12	10
Median	mg/kg	3.5	2.2	2.6	2.4
90th Percentile	mg/kg	10.9	8.9	8.7	8.8
95th Percentile	mg/kg	16	17	12	14
99th Percentile	mg/kg	31	44	28	42

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined arsenic concentrations using correction factors from Model AS-3.

3 Laboratory-reported arsenic concentrations were analyzed following partial digestion (3050B) via ICP-MS (6020A).

bgs Below ground surface

ICP-MS Inductively coupled plasma-mass spectrometry

mg/kg Milligrams per kilogram

XRF X-ray fluorescence

4.1.8 Final Model Selection

An evaluation occurred to compare ex situ XRF bulk sample measurements and laboratory-reported arsenic concentrations in the bulk soil samples, as summarized in Section 4.1.1. Model AS-3 was selected as the optimal model to best predict laboratory arsenic concentrations by use of XRF analyzers, and this model can be used to post-process in situ XRF measurements to correct them to a more accurate representation of the measurement technique applied to evaluate arsenic via laboratory analysis (that is, ICP-MS after acid partial digestion), and thus meet project DQOs. Criteria requirements for characterizing data quality for this project are listed in Table B-3. For determining arsenic by XRF, the correlation coefficient (r = 1.0), in situ XRF measurement precision (RSD = 19 percent), and corrected ex situ XRF bulk sample comparability (13 percent) all meet the criteria for arsenic data determined through XRF to be considered at a definitive level. The correlation coefficient is greater than 0.9, and inferential statistics indicate the two data sets are not unequal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparing the corrected XRF arsenic data set and the laboratory data set from Mobilization #1 through Mobilization #6 (used in development of Model VA-2) and from Mobilization #7 through Mobilization #9 (not used in model development). In both analyses, the inferential statistics indicate the mean of the XRF data equal to the mean of the laboratory confirmatory data for both corrected and uncorrected values. However, by application of correction factors to the XRF data, the data tend to represent the laboratory-reported arsenic concentrations at low levels better than the uncorrected values, and provide a slightly more conservative estimate of arsenic concentrations at the sites, more protective of human health and the environment.

Comparison of the soil cup method to the bulk sample method indicates that the bulk sample method is more conservative at estimating arsenic concentrations (Figure B-14). Also, application of the bulk sample method tends to reflect site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model AS-3 is the final model selected, and is applied to correct and post-process in situ XRF measurements to predicted laboratory arsenic concentrations for the RSE reports. Equation 2 expresses the resulting linear regression model calculated for arsenic by use of the 264 data pairs of ex situ XRF bulk sample arsenic measurements and laboratory-reported arsenic concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 – Mobilization #6:

Equation 2: $$[As]_{lab} = (1.0407 * [As]_{XRF}) - 0.54937$$

The coefficient of determination (R^2) is 0.94 and the correlation coefficient (r) is 0.97, indicating the regression model is significant (that is, $r \geq 0.9$). The linear regression resulted in a slope of 1.0407 and a y-intercept of -0.54937. Figure B-18 compares the primary bulk sample arsenic regression model (shown in blue) to unity line (shown in black—that is, if the model was 1:1 [XRF to lab]). The model fits well with the unity and provides general agreement with the laboratory data without any correction. However, consideration of the multiple reasons conveyed above induced a decision to correct the 9,540 in situ XRF measurement data for the RSE investigation by use of Equation 2 because this model provides a more protective approach and is also more accurate at low arsenic concentrations.

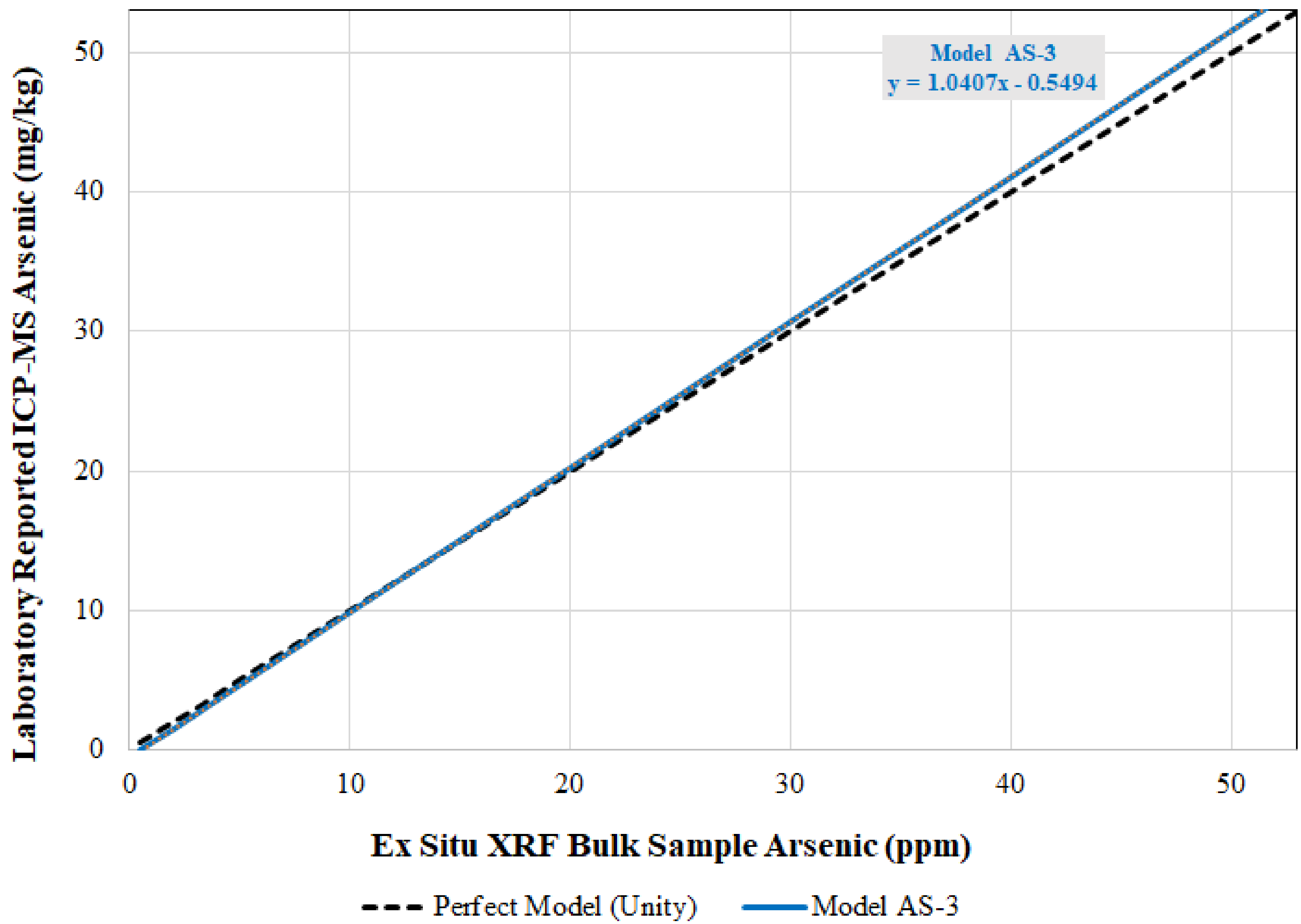


Figure B-18. Final Arsenic Regression Model – Unity Comparison

4.2 IRON

4.2.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 iron data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the iron comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis but, instead, were used for inferential statistics and model validation purposes. The entire iron data set was used except for eight data pairs that were removed because of an instrument error. Therefore, a total of 256 of 264 data pairs contained detectable values of iron. No nondetect iron data pairs were removed. A linear regression least squares analysis was applied to the 256 iron data pairs. For these data pairs, the laboratory reported iron concentrations from the data set ranging from 1,700 to 24,000 mg/kg, with an average of 5,929 mg/kg.

An analysis occurred to identify potential outliers and to bracket the action levels. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was performed using regression analysis tools in the Minitab statistical software. Additionally, an evaluation was conducted to assess effects of the different bracketed concentration ranges, which involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the iron data set, conclusion was that the range of iron data pairs observed warranted a single model with one scale. Only one regression scenario was evaluated and documented for this report, as described below.

Model FE-1 was the first and only model evaluated via linear regression least squares analysis This model included the entire iron dataset (with the anomalous readings from instrument error removed), totaling 256 data pairs. Through visual inspection of a fitted line plot, a number of data pairs were identified as having large residuals, but generally the spread of errors appeared random and no reason was evident to remove data as outliers. A full diagnostic report for Model FE-1 from the statistical software is in Attachment B3.

Model FE-1 was selected as the final model for comparability between XRF and confirmatory sample data for iron. Table B-22 summarizes the various parameters associated with the regression model evaluated as part of the iron comparability study.

Figure B-19 shows the final selected data pairs included in Model FE-1 with the 95 percent prediction limits and the iron data pairs with outliers removed. Model FE-1 is the final model selected to best represent the relationship between ex situ XRF bulk sample iron measurements and the laboratory-reported iron concentrations from the XRF confirmation soil samples. This model omits outliers and is the most meaningful representation of those data.

Attachment B3 presents statistical analysis for the single regression model evaluated for iron (Model FE-1), including a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residual, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 presents, in tabular format, all data either included or excluded in the final iron model, and also presents the data pairs from

Mobilization #7 through Mobilization #9. The following subsection presents results of the soil cup comparability study for iron.

Table B-22. Summary of Parameters for Ex Situ Bulk Sample Iron Regression Models

Model Name	Data Pairs	Outliers Removed	Other Data Pairs Removed[1]	Slope (m)	y-intercept (b)	R^2	r
Model FE-1	256	0	8	0.5179	-283.36	0.82	0.91

Notes:

[1] The eight other data pairs removed were because of an instrument error and not true outliers.

b y-intercept as calculated by the linear regression least squares method.

m Slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

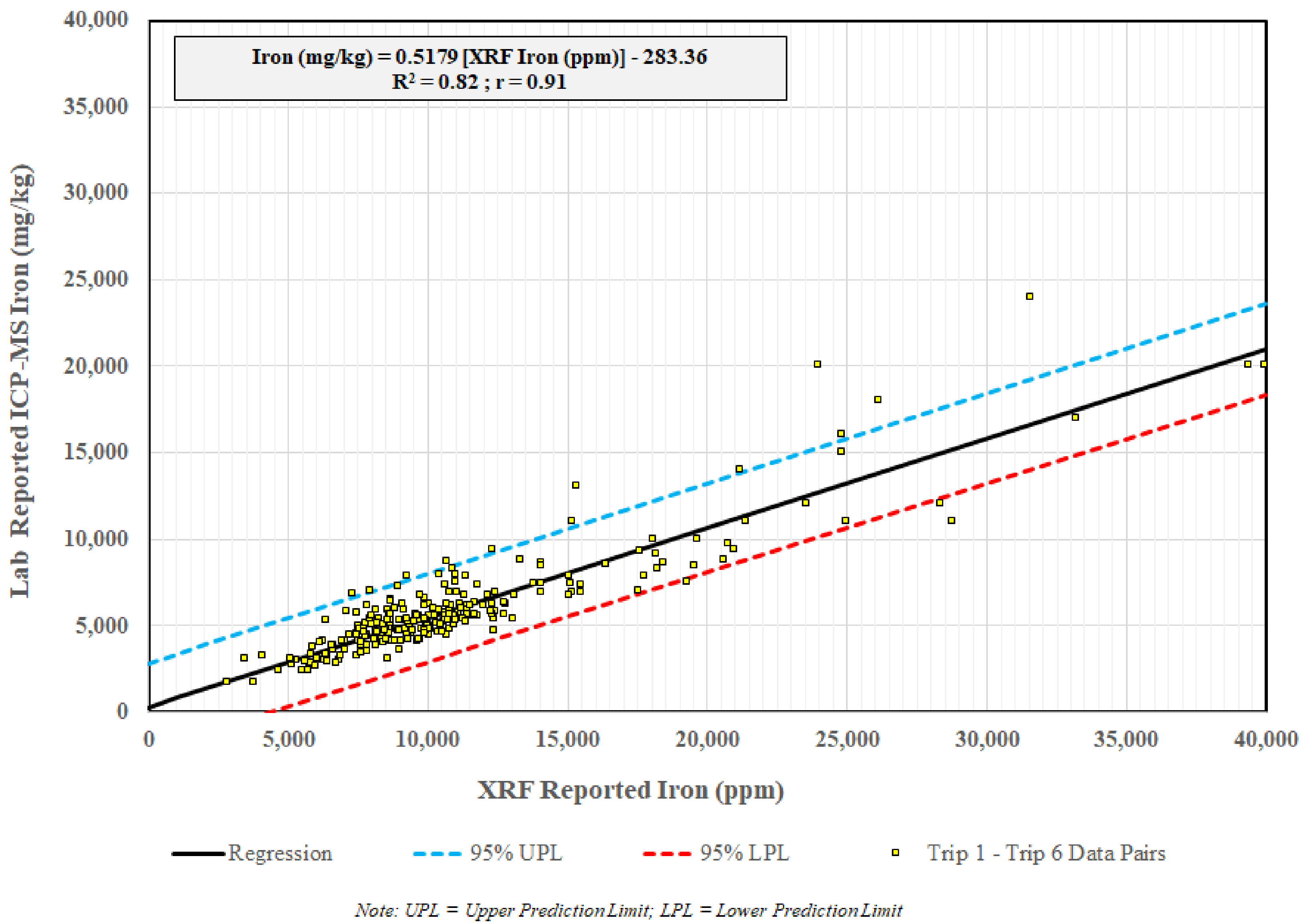


Figure B-19. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model (Iron)

4.2.2 Linear Regression Analysis

A comparability study involved ex situ XRF iron measurements and laboratory-reported iron concentrations from the soil cup samples prepared from the bulk soil samples as part of the XRF field survey program. The methodology for the soil cup sample preparation technique and the procedure followed for the XRF and laboratory data sources are conveyed in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring iron by application of this XRF method are discussed in Section 3.4, and results are compared to those from application of the ex situ XRF bulk sample method. A complete graphical presentation of each soil cup linear regression model for each instrument appears in Attachment B5. Table B-23 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-23. Summary of Iron Soil Cup Linear Regression Parameters for XRF Instruments

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.5549	-1260.2	0.95	0.98
Red	0.5499	-1174.4	0.96	0.98
White	0.5338	-1241.4	0.96	0.98
Average	**0.5462**	**-1225.3**	**0.96**	**0.98**

Notes:

1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.
b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination
XRF X-ray fluorescence

Results indicate that the slope did not vary significantly among XRF analyzers (RSD = 2.0 percent). Average R^2 (0.96) for the soil cup method is higher than the R^2 (0.82) computed for the bulk sample method; however, both methods show acceptable correlation coefficients. Figure B-20 compares the three regression models for the soil cup method and the single regression model for the bulk sample method. Over all concentration ranges shown, the bulk sample model overpredicts the iron concentration compared to all three soil cup models because of the difference in the y-intercept (-238 versus -1225). The following subsection evaluates data quality criteria for both methods.

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported iron concentrations. Figure B-21 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 42 of the 44 samples (95 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 25 percent. The mean of the bulk sample iron concentration from the 44 samples was 6,598 mg/kg, and decreased to 5,184 mg/kg in the soil cup samples—an RPD decrease of 24 percent. Further discussion on particle size effects on concentration is in Section 5.3.

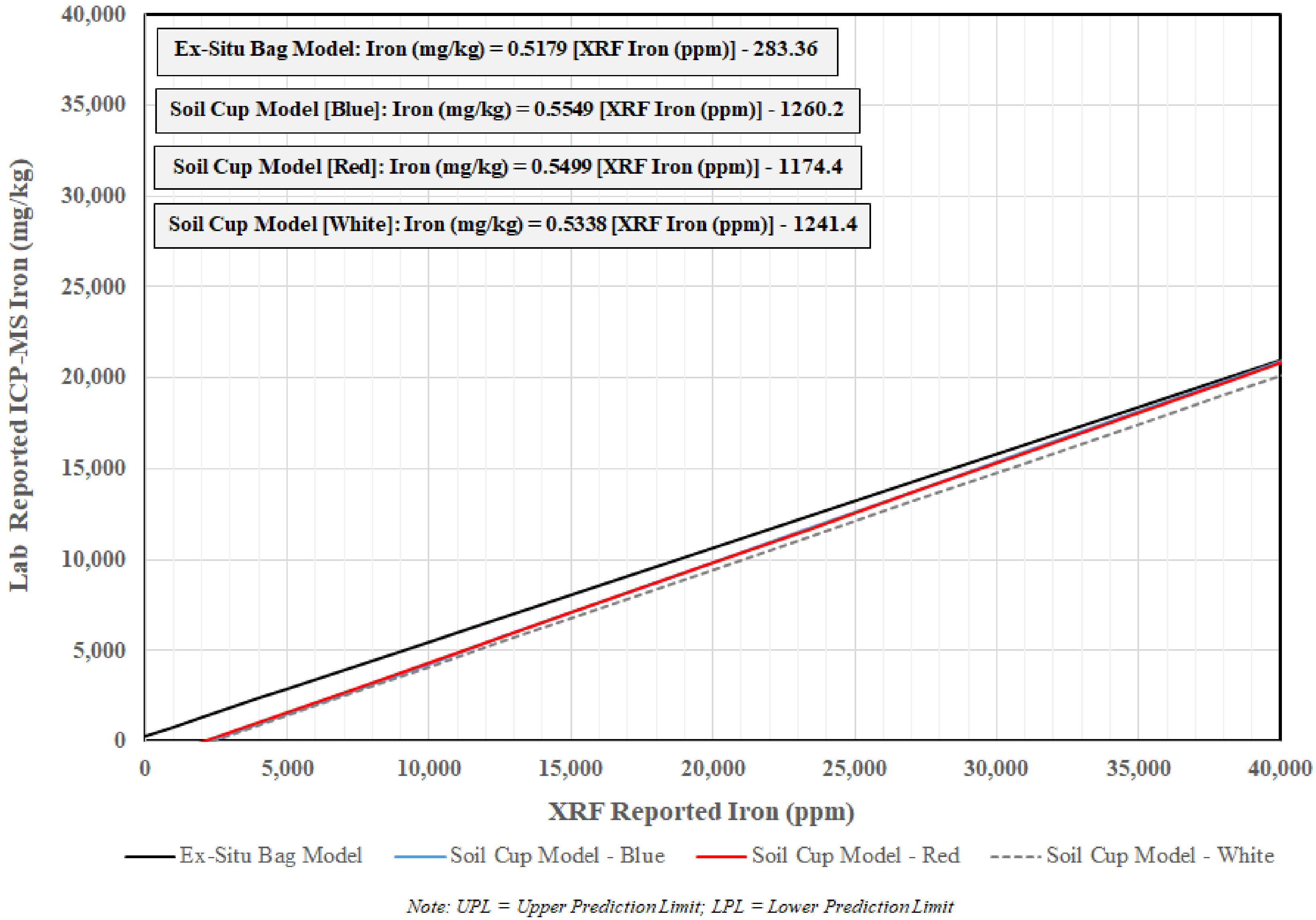


Figure B-20. Iron Linear Regression– Ex Situ Bulk Sample vs. Ex Situ Cup Sample Models

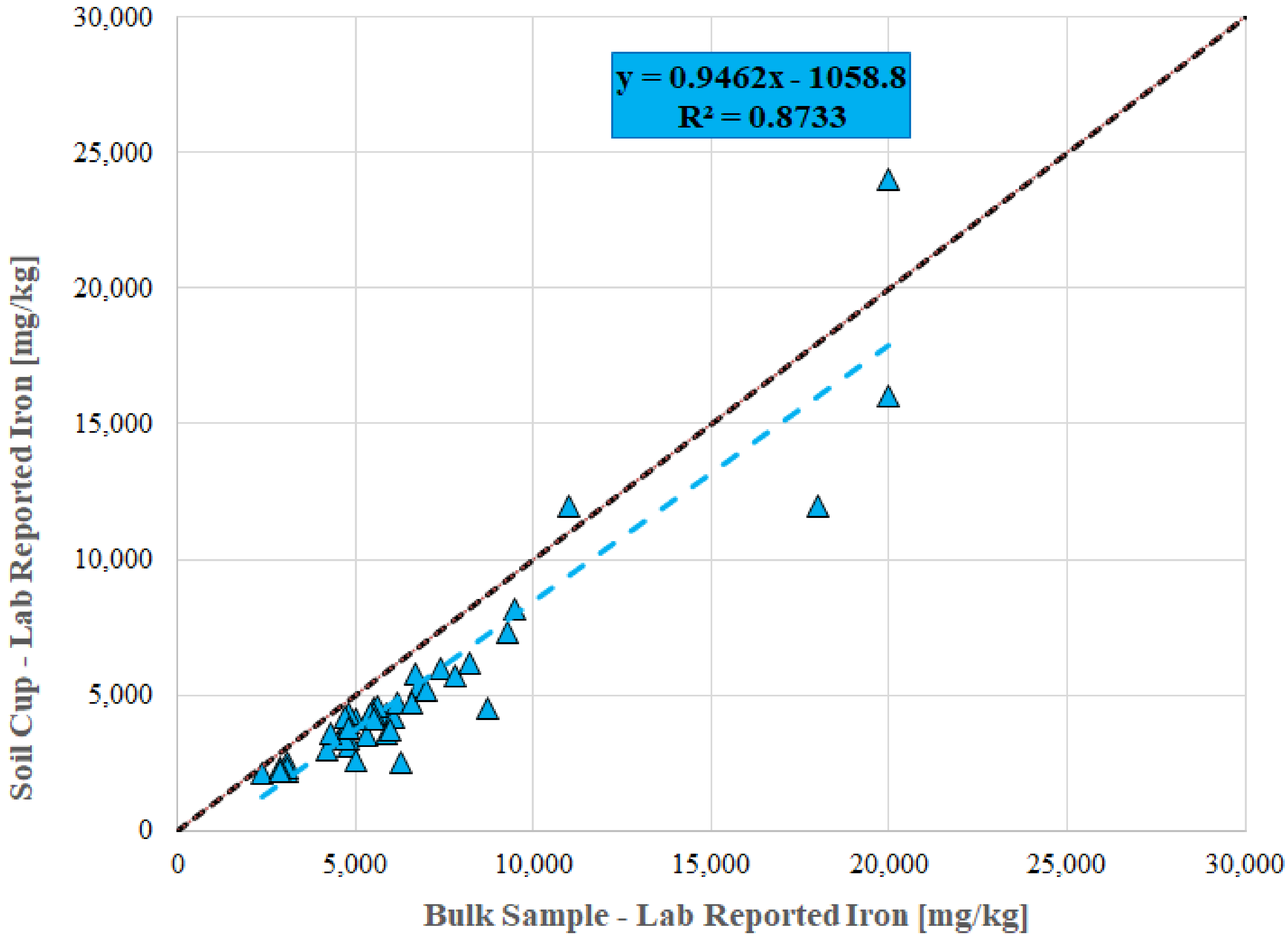


Figure B-21. Bulk Sample versus Soil Cup Iron Concentration

4.2.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations following the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-24. There were not a large number of samples within the range of interest to evaluate iron so the lowest 10 were evaluated in application of each of the methods, as listed in Table B-24.

Table B-24. Method Detection Limit for Iron by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1,2] (ppm)
In Situ XRF	10	2,030
Ex Situ XRF Bulk Sample	10	1,254
Ex Situ XRF Soil Cup	10	1,118

Notes:

Manufacturer reported MDL of 9 mg/kg for iron in silica sand using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

1 MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.
2 The average MDL for the lowest 10 iron measurements is presented here; MDL is biased high.

MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.2.4 Precision of XRF Analysis

An evaluation of precision for determination of iron was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of iron concentrations for each XRF method, as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-25 summarizes calculated precisions for the different ranges of concentrations for each method type. For iron, only samples within the high concentration range were available. The ex situ XRF bulk sample method had the least precision (RSD = 5.7 percent) and ex situ XRF soil cup method had the highest precision (RSD = 3.6 percent). Both of these would be considered good to excellent precision according to USEPA (2006a) precision rating criteria. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria specified in Method 6200.

Table B-25. Summary of Calculated Precision of XRF Method for Iron

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	0	-	0	-	0	-	190	1.5%	190	1.5%
Ex Situ XRF Bulk Sample	0	-	0	-	0	-	256	5.7%	256	5.7%
Ex Situ XRF Soil Cup	0	-	0	-	0	-	132	3.6%	132	3.6%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with iron concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with iron concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with iron concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with iron concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.2.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-26 lists RPDs between XRF and soil cup data for different iron soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory data from the soil cup samples. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-23) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined iron concentration, which then was compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 132 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of criteria for the concentration ranges is in Table B-11. All iron concentrations fell within the high category, so no assessment of comparability over different ranges was necessary. Regardless, the comparability is significantly increased by applying a correction factor to the XRF data to estimate a predicted laboratory-determined iron concentration. By use of a correction factor, the comparability is considered good according to the criteria of USEPA (1998, 2006a), and as indicated in Table B-12.

Table B-26. Comparability for Ex Situ XRF Soil Cup Method Iron

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	0	-	0	-	0	-	132	82%	132	82%
Ex Situ XRF Soil Cup (Corrected)	0	-	0	-	0	-	132	11%	132	11%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with iron concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with iron concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with iron concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with iron concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-27 lists RPDs between XRF and confirmatory bulk sample data for different iron soil concentration ranges, which in the case of iron, were all in the high range. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample iron regression model (Model FE-1) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined iron concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 256 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Because all iron data fell into one category, no assessment of comparability across different ranges of iron concentration was necessary.

Like the soil cup method, the comparability increased significantly by application of a correction factor to the XRF data to estimate a predicted laboratory-determined iron concentration. By use of a correction factor, the comparability is considered good according to the criteria of USEPA (1998, 2006a), and as indicated in Table B-12.

Table B-27. Comparability for Ex Situ XRF Bulk Sample Method for Iron

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	0	-	0	-	0	-	256	63%	256	63%
Ex Situ XRF Bulk Sample (Corrected)	0	-	0	-	0	-	256	12%	256	12%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with iron concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with iron concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with iron concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with iron concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

To conclude, comparabilities of both soil cup and bulk sample methods, when corrected, are 11 percent and 12 percent, respectively. An RPD of 12 percent calculated for the bulk sample is considered good by USEPA (1998, 2006a). However, Method 6200 does not provide a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met appears in the following subsection.

4.2.6 Inferential Statistical Analysis

An analysis was performed to compare XRF and confirmatory iron data by way of two-sample hypothesis testing, supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample iron measurement values were corrected by application of Model FE-1 identified in Section 4.2.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was conducted between Mobilization #1 through Mobilization #6 data sets, and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of iron in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis. Table B-28 lists results of comparing uncorrected and corrected XRF data sets to the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that the XRF data set from each mobilization grouping equals the laboratory data set after application of a correction factor.

An individual distribution analysis occurred in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis indicated that the three-parameter lognormal distribution best fits the iron confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-22 is a probability plot showing the XRF corrected iron data set and the confirmatory iron data set side by side, indicating a strong match between the two populations. A boxplot showing a side-by-side analysis is on Figure B-23, comparing the same two data sets to one another. Results of the hypothesis testing and graphical analysis indicate that the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations, if a correction factor is applied. Inferential statistics indicate that the two populations are from the same distribution, specified as a criterion in Method 6200.

Table B-28. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Iron Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Iron	1 - 6	XRF <> Lab	XRF = Lab
	7 - 9	XRF <> Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level ($\alpha = 0.01$)

[1] Mobilization #1 – Mobilization #6 was the Baseline Study.

[2] Mobilization #7 – Mobilization #9 was the Site Characterization Study.

[3] Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.

[4] Corrected refers to the XRF data that was converted using Model FE-1 correction factors.

XRF X-ray fluorescence

XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.

XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

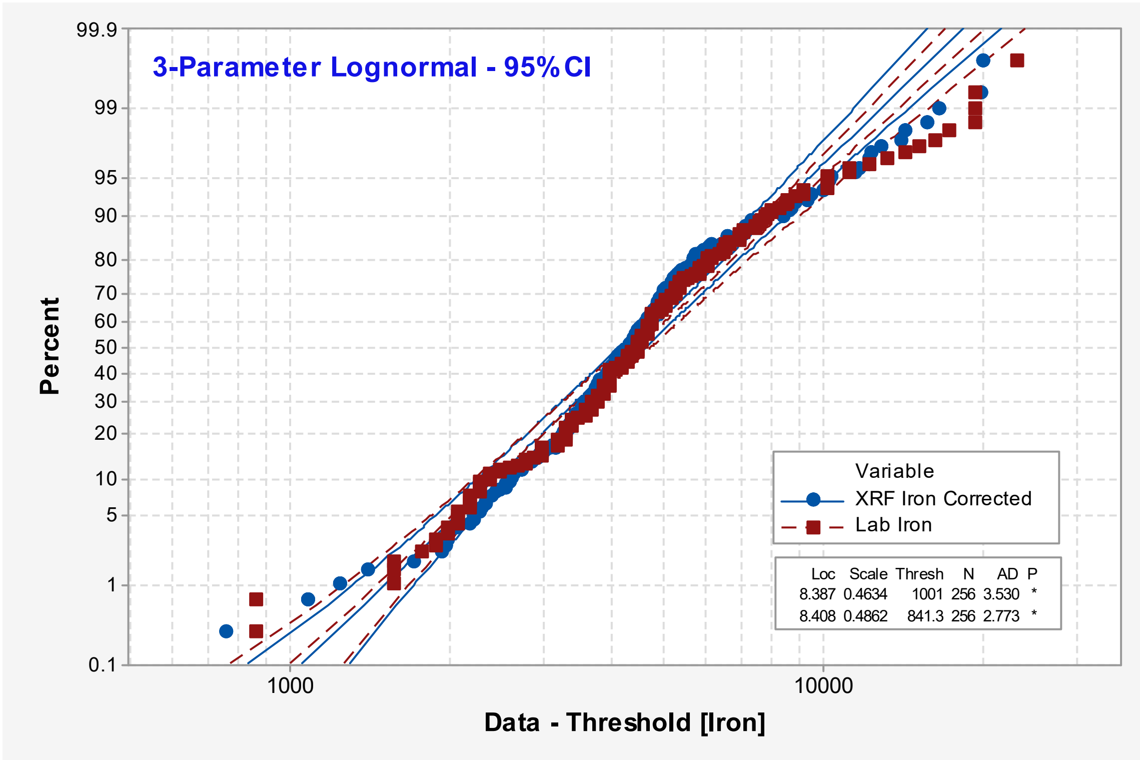


Figure B-22. Probability Plot of XRF Corrected Iron Data Set and Confirmatory Iron Data Set (3-Parameter Lognormal)

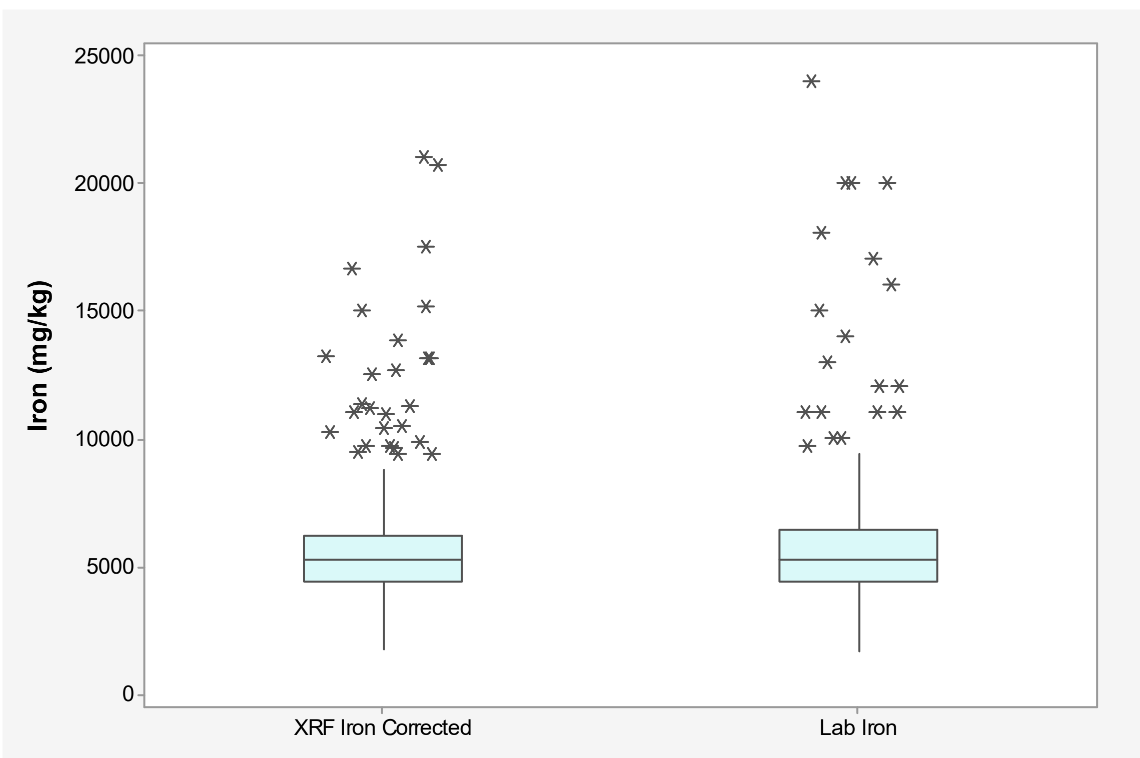


Figure B-23. Boxplot of XRF Corrected Iron and Laboratory Reported Iron

4.2.7 Sample Numbers and Descriptive Statistics

Table B-29 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF iron measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for iron by use of the XRF analyzer, 101 of these were below the MDL and qualified as such. The average detected iron concentration of in situ XRF measurements after correction was 6,487 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 5,798 mg/kg iron. A total of 292 surface soil samples were collected, averaging 5,828 mg/kg iron. Therefore, a total of 794 XRF confirmation and surface soil samples were collected across the sites, averaging 5,809 mg/kg iron. In general, the average of in situ XRF measurements was very close (RPD = 11 percent) to project-wide iron concentrations reported in surface soils via laboratory analytical method. The XRF-reported average iron concentration was slightly higher than that resulting from application of analytical techniques.

Table B-29. Summary of Project Wide Iron Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	9,439	502	292	794
Nondetects	#	101	0	0	0
Minimum	mg/kg	1,396	1,700	1,600	1,600
Maximum	mg/kg	387,380	24,000	20,000	24,000
Average	mg/kg	6,487	5,798	5,828	5,809
Standard Deviation	mg/kg	8,275	2,604	2,505	2,567
Median	mg/kg	5,973	5,300	5,500	5,400
90th Percentile	mg/kg	9,122	8,600	8,780	8,670
95th Percentile	mg/kg	10,736	10,000	10,450	10,350
99th Percentile	mg/kg	14,404	16,010	14,090	16,000

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined iron concentrations by use of correction factors from Model FE-1.

3 Laboratory reported iron concentrations were analyzed by partial digestion (3050B) and ICP-MS (6020A).

bgs below ground surface

ICP-MS Inductively Coupled-Mass Spectrometer

mg/kg Milligrams per kilogram

XRF X-ray fluorescence

4.2.8 Final Model Selection

An evaluation occurred to compare ex situ XRF bulk sample measurements and laboratory-reported iron concentrations in the bulk soil samples, as summarized in Section 4.2.1. Model FE-1 was selected as the optimal model to best predict laboratory iron concentrations by use of XRF analyzers, and this model can be utilized to post-process in situ XRF measurements to correct them to a more accurate representation of the measurement technique applied to evaluate iron via laboratory analysis (that is, ICP-MS after acid partial digestion), and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining iron by XRF, the correlation coefficient (r = 0.9), in situ XRF measurement precision (RSD = 1.5 percent), and corrected ex situ XRF bulk sample comparability (12 percent) all meet the criteria for arsenic data determined via XRF to be considered at a definitive level. The correlation coefficient is greater than 0.9, and inferential statistics indicate that the two data sets are not unequal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparison of the corrected XRF iron data set to the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model FE-1) and for Mobilization #7 through Mobilization #9 (not used in model development). In both of these analyses, the inferential statistics indicate that the data set generated from the XRF analyzer is the same as the laboratory confirmatory data set after correction of the data.

Comparison of the soil cup method to the bulk sample method indicated that the bulk sample method is more conservative at estimating iron concentrations (Figure B-20). Also, application of the bulk sample method tends to reflect site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model FE-1 is the final model selected and is applied to correct and post-process in situ XRF measurements to predicted laboratory iron concentrations for the RSE reports. Equation 3 expresses the resulting linear regression model calculated for iron by use of the 264 data pairs of ex situ XRF bulk sample iron measurements and laboratory-reported iron concentrations (via application of ICP-MS after partial digestion) obtained during Mobilization #1 – Mobilization #6:

Equation 3: $$[Fe]_{lab} = (0.5179 * [Fe]_{XRF}) - 283.36$$

The coefficient of determination (R^2) is 0.82 and the correlation coefficient (r) is 0.91, indicating the regression model is significant (that is, $r \geq 0.9$). The linear regression resulted in a slope of 0.5179 and a y-intercept of -283.36. Figure B-24 compares the primary bulk sample iron regression model (shown in blue) to unity line (shown in black—that is, if the model was 1:1 [XRF to laboratory]). The model fit indicates that the XRF analyzer reads much higher values of iron than the confirmatory data, indicating need for a correction factor to convert the XRF data into values similar to the laboratory data. Thus, the decision to correct the 9,540 in situ XRF measurement data for the RSE investigation by use of Equation 3.

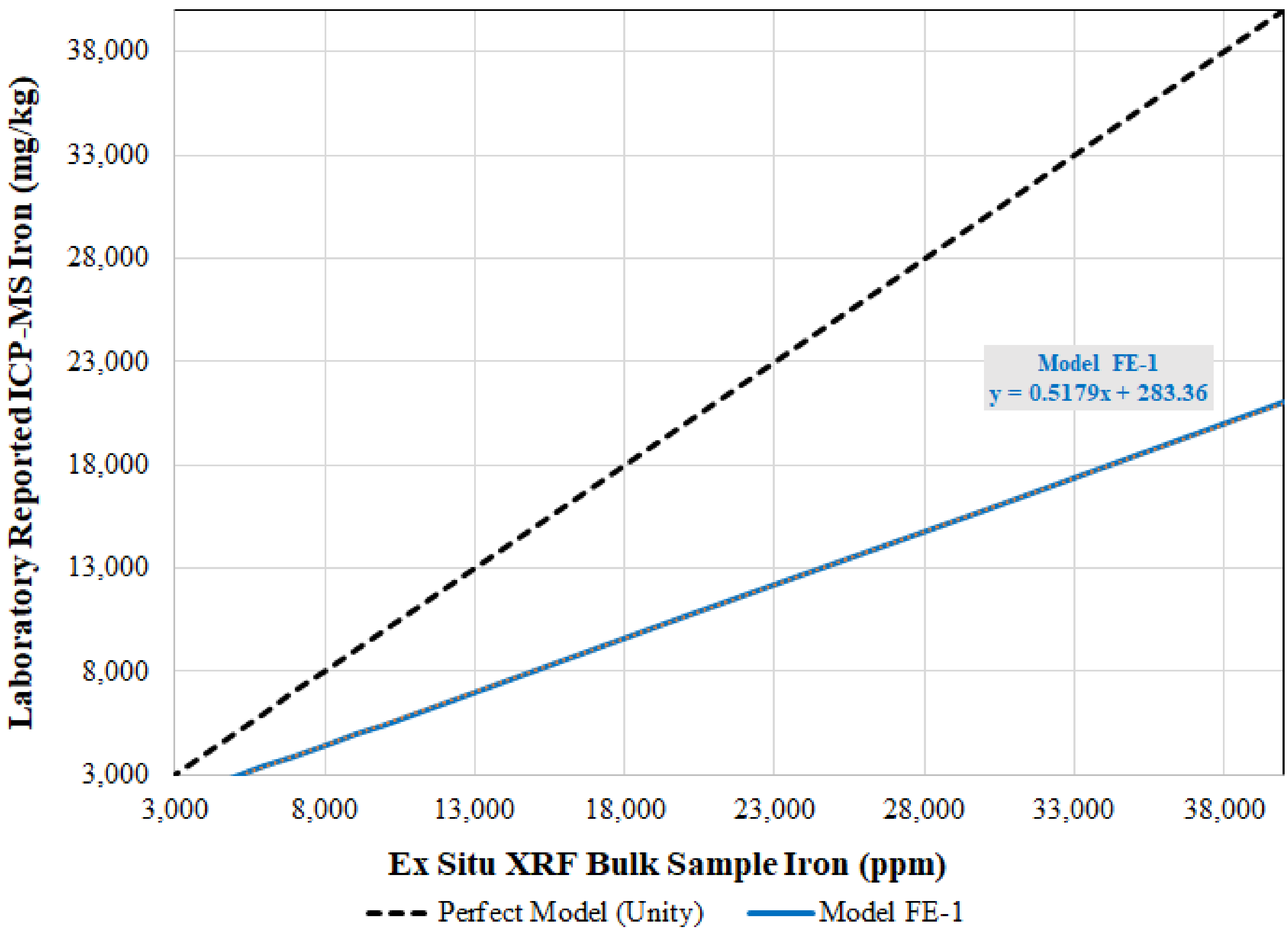


Figure B-24. Iron Correlation – Unity Comparison

4.3 LEAD

4.3.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 lead data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the lead comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis, but instead were used for inferential statistics and model validation purposes. The entire lead data set was used except for seven data pairs removed because of instrument error. Therefore, a total of 257 of 264 data pairs contained detectable values of lead. No nondetect lead data pairs were removed. A linear regression least squares analysis was applied on the remaining 257 lead data pairs, and this model is referred to as Model PB-1. For these data pairs, the laboratory reported lead concentrations from the data set ranging from 1.9 to 120 mg/kg, with an average 7.3 mg/kg.

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the lead data set, conclusion was that two separate models were warranted because one cluster of high lead concentrations influenced prediction of lower concentrations. Therefore, an analysis to remove the higher points and reevaluate the data occurred, and this model is referred to as Model PB-2. Several different regression scenarios were evaluated and documented for this report as described below, beginning with Model PB-2.

Model PB-1 was the first of a series of models involving linear regression least squares analysis. This model included the entire lead dataset (except for seven data pairs removed from instrument error), totaling 257 data pairs. Visual inspection of a fitted line plot revealed one sample with a data pair much higher than the primary cluster of data (T17-XS144-01-042618). This data pair consisted of a laboratory-reported lead concentration of 120 mg/kg and an average ex situ XRF lead concentration of 119 ppm. This point was removed prior to running a separate model with only the lower cluster of data pairs. The model with the lower cluster of data pairs was referred to as Model PB-2. Model PB-2 included 256 data pairs (with only T17-XS144-01-042618) removed.

Careful review of the model results from Model PB-2 revealed a number of data pairs with unusually large standardized residual values. The sample with the largest residual value was M24-XS128-01-061118, with a laboratory-reported lead concentration of 20 mg/kg and an average ex situ XRF lead concentration of 7.9 ppm (RPD = 87 percent). Another sample with an extremely large RPD was M16-XS45-01-052118, with a laboratory-reported lead concentration of 7.5 mg/kg and an average ex situ XRF lead concentration of 1.7 ppm (RPD = 126 percent). Both of these data pairs were considered outliers and were removed from future models. Another model, Model PB-2A, was evaluated without these two outliers, and a linear regression least squares analysis was performed again. Model PB-2A represented the lower cluster of data with outliers removed, and involved 254 data pairs. This model had a slope of 0.9519 and y-intercept of -1.476 with an R^2 of 0.79 (r = 0.9). An evaluation of the standardized residuals of

Model PB-2A exposed a number of values with large or unusual residuals, but these appeared to be randomly and evenly distributed across the range of concentrations. This is the optimal model selected for lead concentrations with XRF measurements less than 40 ppm. Model PB-1A involved removal of the same outliers removed from Model PB-2A, but the high sample was added back in (T17-XS144-01-042618). Model PB-1A represented the full range of data with outliers removed, and involved 255 data pairs. This model had a slope of 1.012 and y-intercept of -1.994 with an R^2 of 0.79 (r = 0.89; r ~ 0.9). Table B-30 summarizes the various parameters associated with the four regression models evaluated as part of the lead comparability study.

Table B-30. Summary of Parameters for Ex Situ Bulk Sample Lead Regression Models

Model Name	Data Pairs	Outliers Removed	High Values Removed	Other Data Pairs Removed[1]	Slope (m)	y-intercept (b)	R^2	r
Model PB-1	257	0	0	7	1.007	-1.864	0.94	0.97
Model PB-2	256	0	1	7	0.9327	-1.226	0.74	0.86
Model PB-1A	255	2	0	7	1.012	-1.994	0.79	0.89
Model PB-2A	254	2	1	7	0.9519	-1.476	0.79	0.89

Notes:

1 The seven other data pairs were removed because of an instrument error and were not true outliers.

b y-intercept as calculated by the linear regression least squares method.

m Slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

Figure B-25 shows the final selected data pairs included in Model PB-2A with the 95 percent prediction limits and the lead data pairs with outliers removed. The final regression model for the lower XRF concentrations of lead (< 30 ppm) is Model PB-2A, and the final regression model for any XRF concentration of lead above 30 ppm is Model PB-1A. Both of these models with the respective prediction limits and primary linear regression models tied together are shown on Figure B-26.

Attachment B3 presents statistical analyses of all regression models evaluated for lead (Model PB-1, Model PB-1A, Model PB-2, and Model PB-2A). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residual, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 presents, in tabular format, all data either included or excluded in the final lead models: Model PB-1A and Model PB-2A. The attachment presents the data pairs from Mobilization #7 through Mobilization #9 as well. The following subsection conveys results of the soil cup comparability study for lead. That subsection compares Model PB-2A (lower concentrations only) to the soil cup model for the same concentration range.

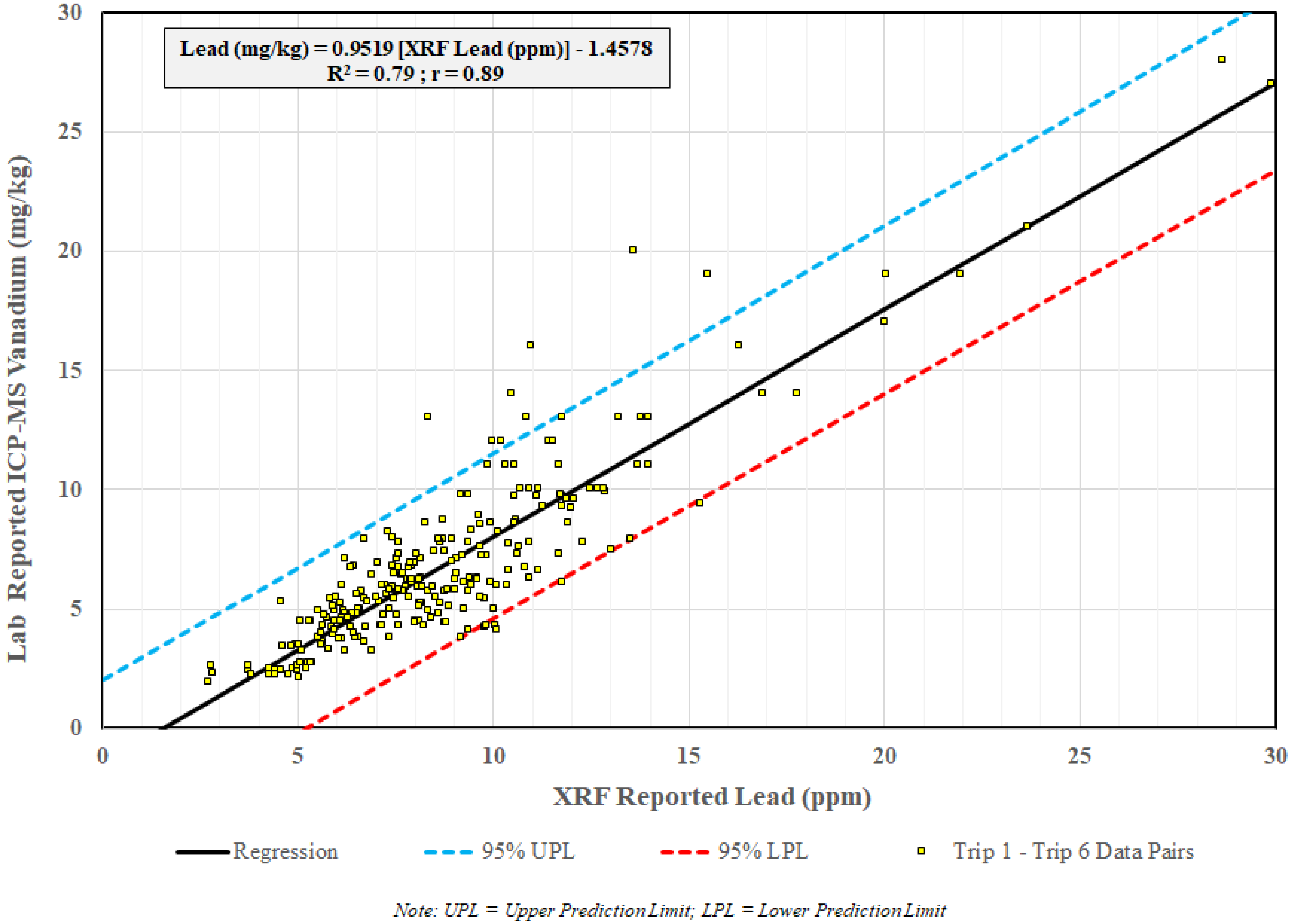


Figure B-25. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model PB-2A (Lead)

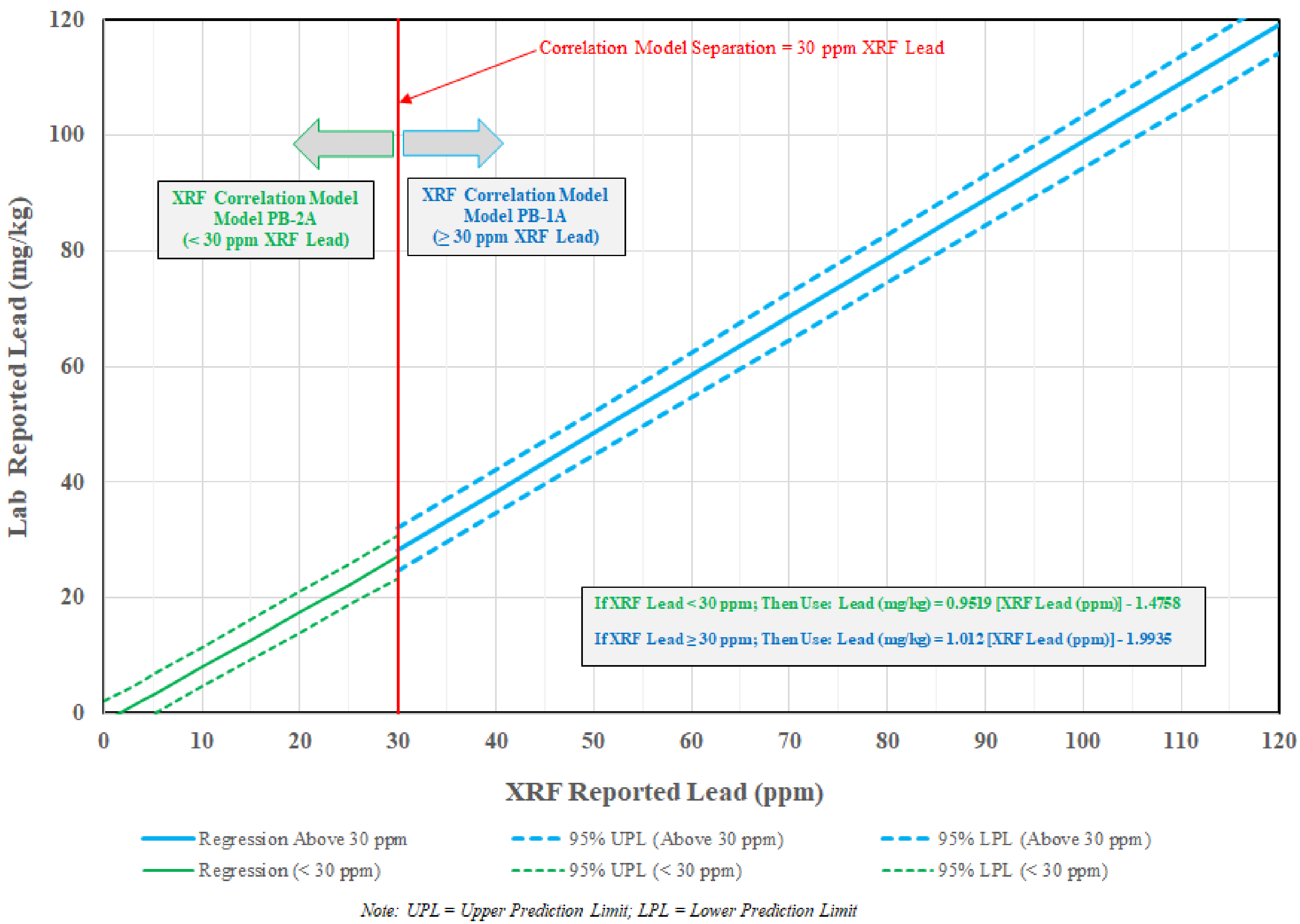


Figure B-26. Final XRF Correlation Models for Prediction of Lead using XRF Analyzer (Model PB-1A and Model PB-2A)

4.3.2 Linear Regression Analysis

A comparability study involved ex situ XRF lead measurements and laboratory-reported lead concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring lead concentrations via this XRF method are discussed in Section 3.4, and results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B4. Table B-31 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-31. Summary of Lead Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.8708	-1.5555	0.91	0.96
Red	0.8084	-2.1470	0.85	0.92
White	0.8555	-2.2856	0.86	0.92
Average	**0.8449**	**-1.9960**	**0.87**	**0.93**

Notes:

[1] Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.

b y-intercept as calculated by the linear regression least squares method

m Slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

XRF X-ray fluorescence

Results indicate that the slope does not vary much among XRF analyzers (RSD = 3.8 percent). The average R^2 (0.87) for results from application of the soil cup method is higher than the R^2 (0.79) computed for results from application of the bulk sample method; however, both methods show acceptable correlation coefficients. Figure B-27 compares soil cup method and bulk sample method regression models. At all concentrations, the bulk sample model is more conservative than all of the soil cups models—because the average slope (m = 0.8449) of the soil cup method is lower than the slope (m = 0.9519) of the bulk sample method (Model PB-2A).

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on bulk sample and soil cup laboratory-reported lead concentrations. Figure B-28 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 42 of the 44 samples (95 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 22 percent. The mean of the bulk sample lead concentration from the 44 samples was 12 mg/kg and decreased to 9.4 mg/kg in the soil cup samples—an RPD decrease of 21 percent. Further discussion of particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

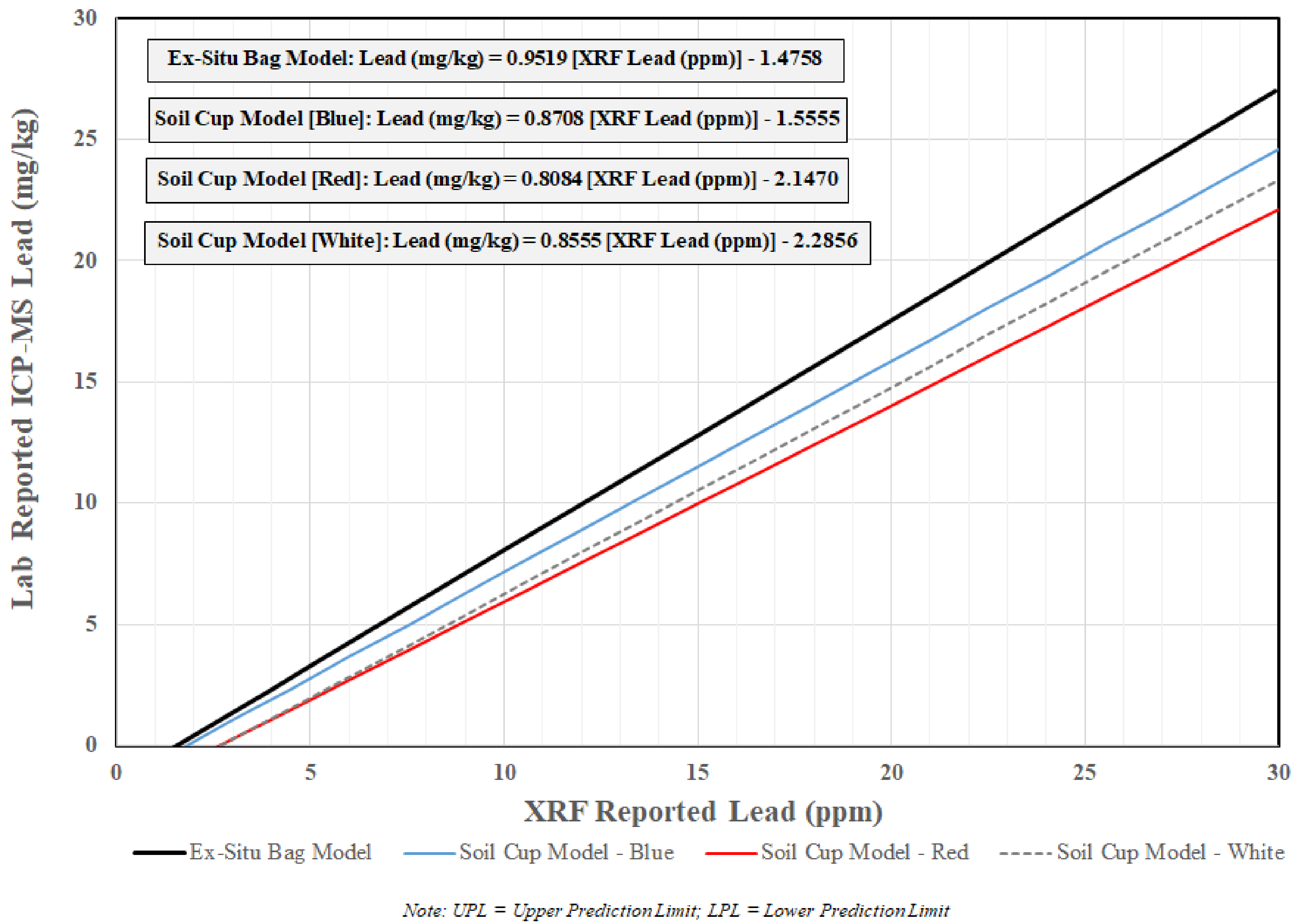


Figure B-27. Lead Linear Regression: Ex Situ Bulk Sample versus Ex Situ Soil Cup Sample Models

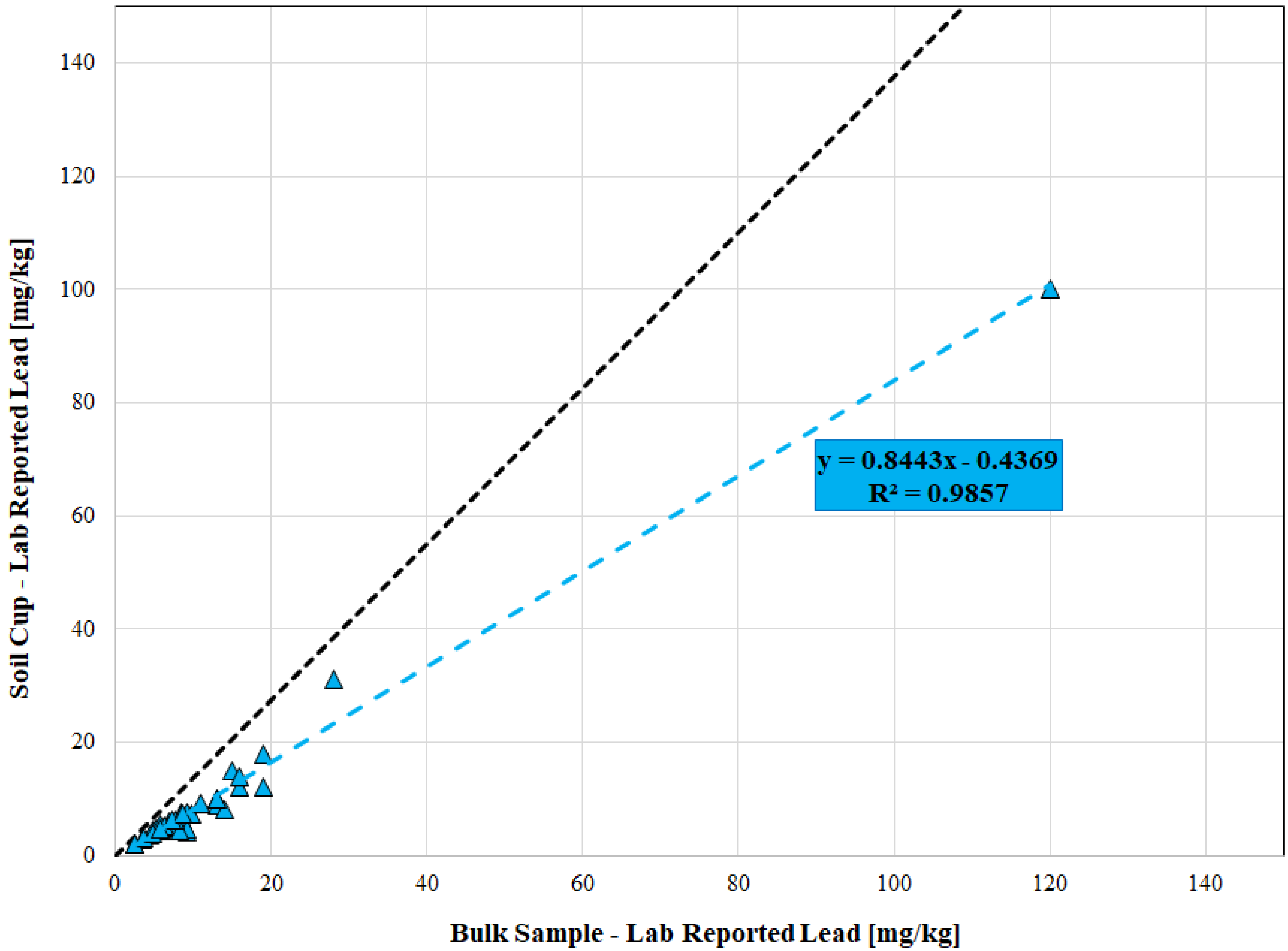


Figure B-28. Bulk Sample versus Soil Cup Lead Concentration

4.3.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-32. A large number of samples were evaluated in application of for each of the ex situ methods, as listed in Table B-32, the in situ XRF method had fewer samples (n = 11) within the range of interest (that is, < 5 times the MDL).

Table B-32. Method Detection Limit for Lead by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	11	1.8
Ex Situ XRF Bulk Sample	83	2.2
Ex Situ XRF Soil Cup	54	2.5

Notes:

Manufacturer reported MDL of 1 mg/kg for lead using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

1 MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.
MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.3.4 Precision of XRF Analysis

An evaluation of precision for determination of lead was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of lead concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-33 summarizes calculated precisions for the different ranges of concentrations for each method type. The ex situ XRF soil cup method had the lowest precision (9.2 percent), which was close to the precision of the in situ method (9.7 percent). The intrusive bulk sample method had a precision of 11 percent. For all XRF methods of evaluating lead, precision increased as concentration increased. This was expected and shows the XRF analyzer responded better at higher lead concentrations. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-33. Summary of Calculated Precision of XRF Method for Lead

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	1	21%	10	19%	146	10%	32	6.5%	189	9.7%
Ex Situ XRF Bulk Sample	1	16%	82	12%	136	11%	36	9.7%	255	11%
Ex Situ XRF Soil Cup	0	-	54	12%	48	9.6%	30	6.1%	132	9.2%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with lead concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with lead concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with lead concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with lead concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.3.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-34 lists the RPD between XRF and confirmatory soil cup data for different lead soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-31) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined lead concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 132 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of criteria for the concentration ranges is in Table B-11. Similar to the calculated precision of the soil cup method (Section 4.3.4), comparability tends to increase (that is RPD decreases) as sample concentration increases. Overall comparability across all concentration ranges and for all data combined significantly increases with application of a correction factor to the XRF data to estimate a predicted laboratory-determined lead concentration. With use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

Table B-34. Comparability for Ex Situ XRF Soil Cup Method Lead

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	0	-	54	56%	48	44%	30	24%	132	45%
Ex Situ XRF Soil Cup (Corrected)	0	-	54	19%	48	12%	30	6.8%	132	13%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with lead concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with lead concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with lead concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with lead concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-35 lists RPDs between XRF and confirmatory bulk sample data for different lead soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample lead regression models (Model PB-2A and Model PB-1A) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined lead concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 255 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Similar to calculated precision of the bulk sample method, comparability tends to increase (that is, RPD decreases) as sample concentration increases. Comparability tends to increase across all concentration ranges (except for very low concentration, but only one soil sample is in this category) with application of a correction factor to XRF data to estimate a predicted laboratory-determined lead concentration. By use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are 13 percent and 15 percent, respectively. For both the soil cup method and bulk sample method, comparability increases significantly with application of a correction factor for determination of lead concentration. An RPD of 15 percent is considered good by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is in the following subsection.

Table B-35. Comparability for Ex Situ XRF Bulk Sample Method for Lead

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	1	36%	82	49%	136	25%	36	12%	255	29%
Ex Situ XRF Bulk Sample (Corrected)	1	52%	82	21%	136	14%	36	12%	255	15%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 "Very low" refers to samples with lead concentrations < 2x manufacturer reported MDL.

3 "Low" refers to samples with lead concentrations ≥ 2x to < 5x manufacturer reported MDL.

4 "Medium" refers to samples with lead concentrations ≥ 5x to < 10x manufacturer reported MDL.

5 "High" refers to samples with lead concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit

n Number of samples used for calculating median RPD

RPD Relative percent difference (presented as median RPD)

XRF X-ray fluorescence

4.3.6 Inferential Statistical Analysis

An analysis occurred to compare XRF and confirmatory lead data by way of two-sample hypothesis testing and supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample lead measurement values were corrected by application of two regression models: Model PB-2A (for XRF lead measurements less than 30 ppm) and Model PB-1A (for XRF lead measurements greater than or equal to 30 ppm) identified in Section 4.3.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of lead in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis. Table B-36 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that the XRF data set from each mobilization grouping is equal to the laboratory data set after application of a correction factor.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed the lognormal distribution best fits the lead confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-29 is a probability plot showing the XRF-corrected lead data set and the confirmatory lead data set side by side, and indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-30 compares the same two data sets with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-36. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Lead Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Lead	1 - 6	XRF <> Lab	XRF = Lab
	7 - 9	XRF <> Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01)

[1] Mobilization #1 – Mobilization #6 was the Baseline Study.

[2] Mobilization #7 – Mobilization #9 was the Site Characterization Study.

[3] Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.

[4] Corrected refers to the XRF data that was converted using Model PB-2A or Model PB-1A correction factors.

XRF X-ray fluorescence

XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.

XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

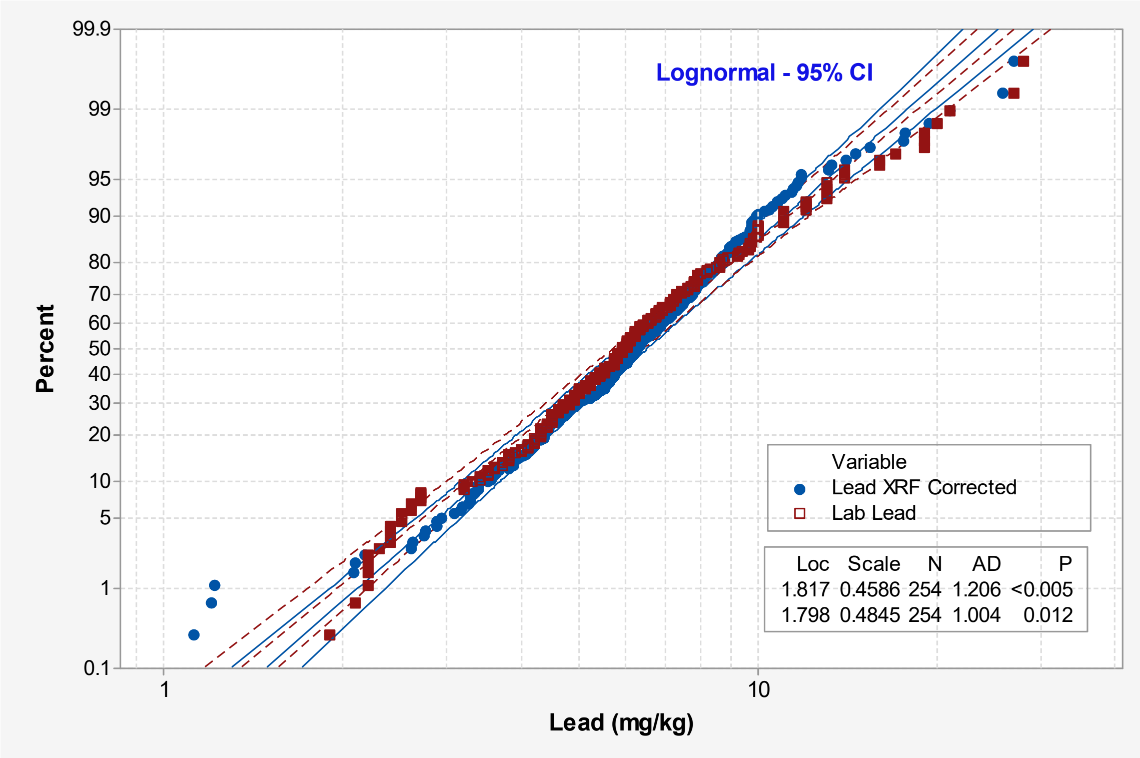


Figure B-29. Probability Plot of XRF Corrected Lead Data Set and Confirmatory Lead Data Set (3-Parameter Lognormal)

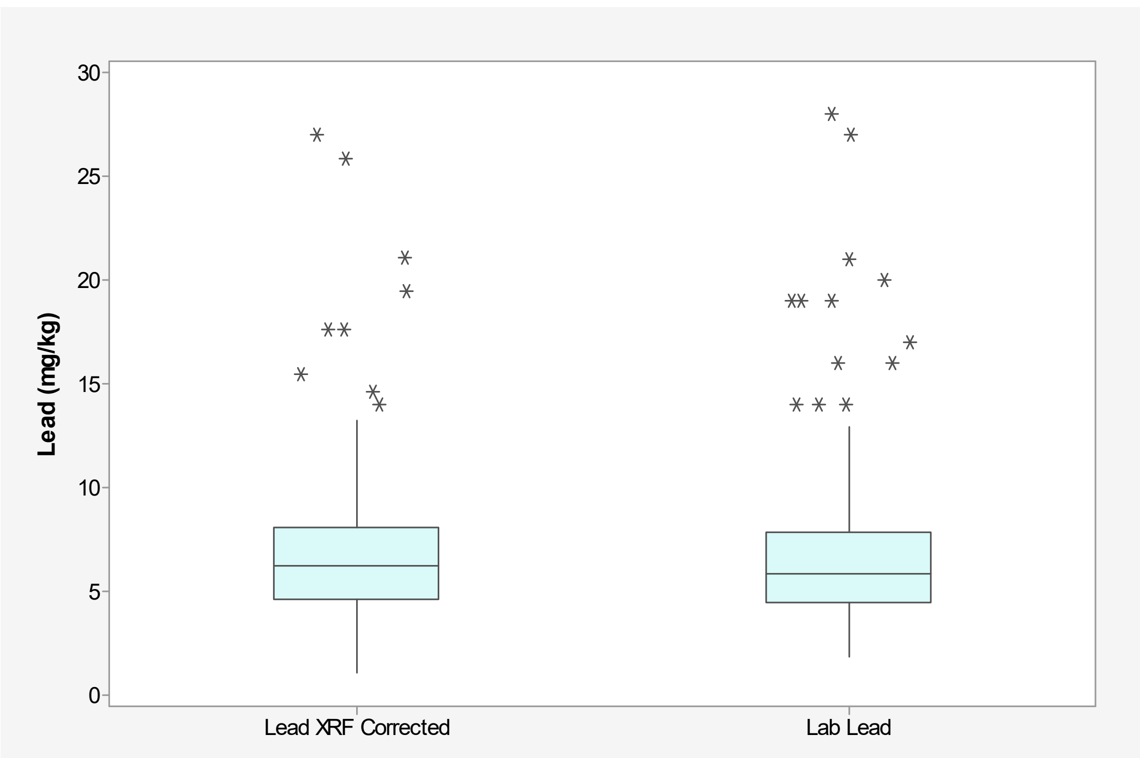


Figure B-30. Boxplot of XRF Corrected Lead and Laboratory Reported Lead

4.3.7 Sample Numbers and Descriptive Statistics

Table B-37 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF lead measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for lead with use of the XRF analyzer, 48 of these were below the MDL and qualified as such. The average detected lead concentration of in situ XRF measurements after correction is 6.7 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 7.4 mg/kg lead. A total of 292 surface soil samples were collected, averaging 6.6 mg/kg lead. Therefore, 794 analytical surficial (XRF confirmation and surface soil) soil samples were collected in total across the sites, averaging 7.1 mg/kg lead. In general, the average of in situ XRF measurements was very close to the project-wide lead concentrations reported in surface soils via laboratory analytical method (RPD = 7.2 percent) but slightly higher.

Table B-37. Summary of Project Wide Lead Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	9,492	502	292	794
Nondetects	#	48	0	0	0
Minimum	mg/kg	0.27	1.7	1.6	1.6
Maximum	mg/kg	195	360	24	360
Average	mg/kg	6.7	7.4	6.6	7.1
Standard Deviation	mg/kg	4.7	17	3.6	14
Median	mg/kg	6.2	5.9	5.9	5.9
90th Percentile	mg/kg	9.8	10	11	11
95th Percentile	mg/kg	11	13	14	13
99th Percentile	mg/kg	17	20	20	20

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined lead concentrations using correction factors from Model PB-2A or Model PB-1A.

3 Laboratory-reported lead concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).

bgs Below ground surface

ICP-MS Inductively coupled plasma-mass spectrometry

mg/kg Milligrams per kilogram

XRF X-ray fluorescence

4.3.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported lead concentrations in the bulk soil samples, as summarized in Section 4.3.1, led to determination that two models would be necessary to appropriately bracket the concentrations of interest at the site. Model PB-2A was selected as the optimal model to best predict laboratory lead concentrations by use of XRF analyzers when lead concentrations are near background levels (< 30 ppm), and Model PB-1A was selected as the optimal model when lead concentrations exceed 30 ppm. These models were both used to post-process in situ XRF measurements to correct them to a more accurate representation of lead concentrations reported from laboratory application of ICP-MS after acid partial digestion, and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining lead concentrations by use of XRF analyzers (Model PB-2A only), the correlation coefficient (r = 0.89), in situ XRF measurement precision (RSD = 9.7 percent), and corrected ex situ XRF bulk sample comparability (15 percent) all meet the criteria for lead data reported by XRF analyzers to be considered at a definitive level. Assuming the r value would be 0.9 with the appropriate significant figures, the correlation coefficient is greater than or equal to 0.9, and inferential statistics indicate that the two data sets are not unequal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparison of the corrected XRF lead data set and the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model PB-1A) and for Mobilization #7 through Mobilization #9 (not used in model development). In both analyses, the inferential statistics indicate the mean of corrected XRF data equal to the laboratory confirmatory data at a 99 percent confidence level.

Comparison of results from the soil cup method to results from the bulk sample method indicates that the bulk sample method is more conservative at estimating lead concentrations (Figure B-27). Also, application of the bulk sample method tends to reflect site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model PB-2A and Model PB-1A are the final models selected, and were applied to correct and post-process in situ XRF measurements to predicted laboratory lead concentrations for the RSE reports. Equation 4 (Model PB-2A) and Equation 5 (Model PB-1A) express the resulting linear regression model calculated for lead by use of the 264 data pairs of ex situ XRF bulk sample lead measurements and laboratory-reported lead concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 – Mobilization #6:

Equation 4 (< 30 ppm): $[Pb]_{lab} = (0.9519 * [Pb]_{XRF}) - 1.476$

Equation 5 (≥ 30 ppm): $[Pb]_{lab} = (1.012 * [Pb]_{XRF}) - 1.994$

Via Model PB-2A (Equation 4), the coefficient of determination (R^2) is 0.79, and the correlation coefficient (r) is 0.9, indicating the regression model is significant (that is, r ≥ 0.9). Figure B-31 shows the primary bulk sample lead regression models, which differ depending on concentration of lead. Model PB-2A (shown in blue) is used for predicting lead when XRF measurements are less than 30 ppm, and Model PB-1A (shown in green) is used when XRF measurements are greater than or equal to 30 ppm. These lines are shown with respect to the unity line (displayed in black)—indicating perfection of the model (a perfect match of XRF to lab data). Both models fit well with unity and achieve general agreement with the laboratory data without any correction; however, multiple reasons conveyed above led to a decision to correct the 9,540 in situ XRF measurement data for the RSE investigation by use of Equation 4 or Equation 5 because these models provide a more protective approach and are also more accurate at low lead concentrations (using Model PB-2A for low lead concentrations).

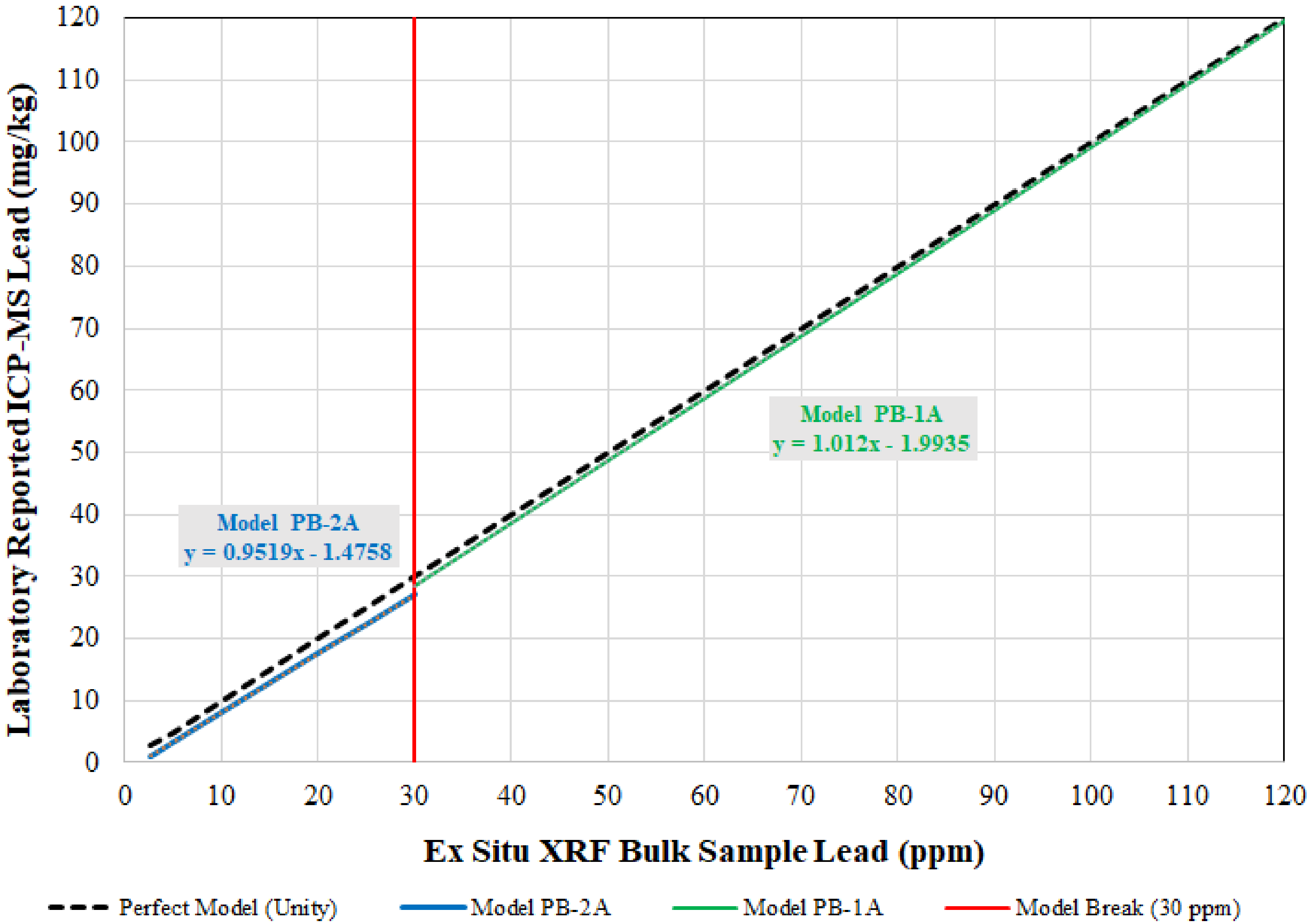


Figure B-31. Final Lead Regression Models– Unity Comparison

4.4 MANGANESE

4.4.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 manganese data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the manganese comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis, but instead were used for inferential statistics and model validation purposes. A total of 10 of 264 data pairs contained nondetects and were therefore removed from the dataset prior to the initial linear regression least squares analysis. All 10 nondetect manganese data pairs were removed because of issues with XRF instrument detection capabilities, not presence in the laboratory data of nondetects (that is, all results from confirmatory samples were detected results). Following removal of these data pairs, a linear regression least squares analysis was applied on the remaining 254 manganese data pairs. For these remaining data pairs, the laboratory reported manganese concentrations from the data set ranging from 63 to 1,300 mg/kg, with an average 203 mg/kg.

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the manganese data set, conclusion was that the range of manganese data pairs warranted a single model with one scale; however, further investigation of the three highest data pairs was to occur, discussed below. Two different regression scenarios were evaluated and documented for this report as described below.

Model MN-1 is the first of a series of models involving linear regression least squares analysis. This model included the entire manganese dataset (without nondetects), totaling 254 data pairs. Visual inspection of a fitted line plot revealed three influential outliers (samples M8-XS102-01-050918, M6-XS102-02-050918, and M33-XS22-01-071218). These samples contained the three highest soil manganese concentrations and also had the highest residuals noted from the regression analysis. Table B-38 summarizes the data pairs from these samples identified as having the largest residuals.

Because RPDs of the data pairs listed in Table B-38 were all higher than the average 30 percent, indicating these were less comparable than data pairs from most other samples, these data pairs were removed because they did not best represent the data set and were clearly visual outliers based on the probability plot of standardized residuals. Attachment B4 presents further statistical information for Model MN-1. The second regression model, referred to as Model MN-2, consisted of 251 data pairs after exclusion of the three outliers discussed above. The correlation coefficient improved in Model MN-2. Model MN-2 was inspected, no extreme outliers were identified, and the residuals appeared to be evenly distributed across the range of concentrations but skewed slightly right. No additional outliers were identified for exclusion, and Model MN-2 was determined to best represent the data. Table B-39 summarizes the various parameters associated with the two regression models evaluated as part of the manganese comparability study. Model MN-2 has a calculated slope of 0.8912 and y-intercept of 62.27 with an R^2 of 0.74

(r = 0.86). Figure B-32 shows the final selected data pairs included in Model MN-2, with 95 percent prediction limits and manganese data pairs with outliers removed. Model MN-2 is the final model selected to best represent the relationship between ex situ XRF bulk sample manganese measurements and laboratory-reported manganese concentrations from the XRF confirmation soil samples. This model omits nondetects and outliers, and is the most meaningful representation of the data.

Table B-38. Summary of Data Pairs with Large Residuals for Manganese in Model MN-1

Sample ID	Average Ex Situ XRF Vanadium Value (ppm)[1]	RSD of Ex Situ XRF Values[2]	Laboratory Vanadium Result (ppm)[3]	RPD of Data Pairs
M8-XS102-01-050918	630	12%	350	57%
M8-XS102-02-050918	584	5.7%	340	53%
M33-XS22-01-071218	545	11%	1,300	82%

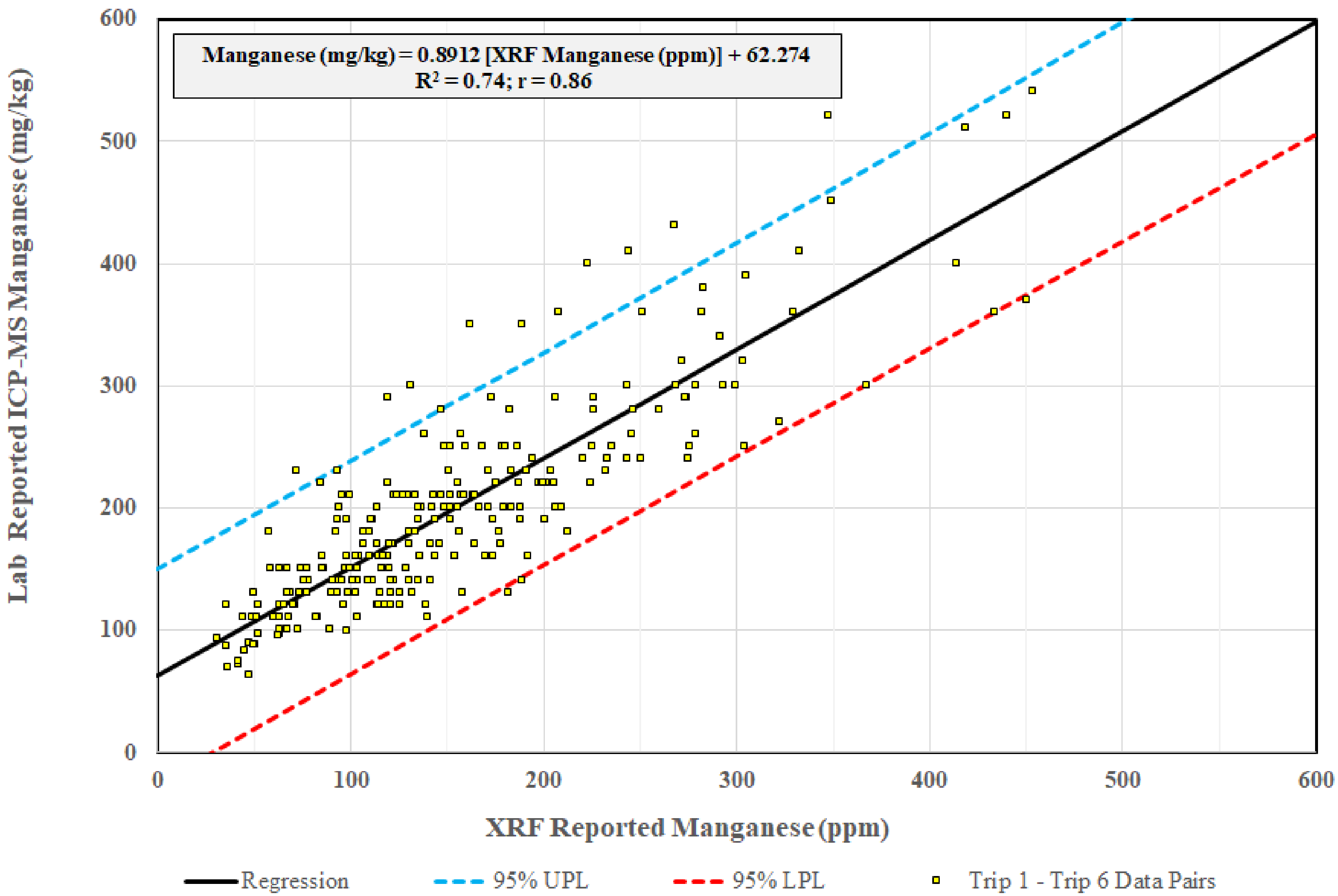
Notes:
1 Average of six ex situ XRF manganese measurements taken from the bulk sample.
2 RSDs of the six ex situ XRF manganese measurements taken from the bulk sample.
3 Laboratory-reported manganese concentration obtained via partial digestion (3050B) and ICP-MS (6020A).
ICP-MS Inductively coupled plasma-mass spectrometry
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

Table B-39. Summary of Parameters for Ex Situ Bulk Sample Manganese Regression Models

Model Name	Data Pairs	NDs Removed	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model MN-1	254	10	-	0.9164	59.243	0.62	0.79
Model MN-2	251	10	3	0.8912	62.274	0.74	0.86

Notes:
Outliers removed were all concentrations exceeding 500 milligrams per kilogram.
b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
ND Nondetect
r Pearson's correlation coefficient
R^2 Coefficient of determination

Attachment B3 presents statistical analyses of both regression models evaluated for manganese (Model MN-1 and Model MN-2). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residuals, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 presents, in tabular format, all data either included or excluded in the final manganese model (Model MN-2). The attachment presents data pairs from Mobilization #7 through Mobilization #9 as well. The following subsection conveys results of the soil cup comparability study for manganese.



Note: UPL = Upper Prediction Limit; LPL = Lower Prediction Limit

Figure B-32. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model MN-2 (Manganese)

4.4.2 Linear Regression Analysis

A comparability study involved ex situ XRF manganese measurements and laboratory-reported manganese concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring manganese using this XRF method are discussed in Section 3.4, and results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B4. Table B-40 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-40. Summary of Manganese Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.7212	40.253	0.72	0.85
Red	0.8088	22.556	0.81	0.90
White	0.6934	19.463	0.83	0.91
Average	**0.7411**	**27.424**	**0.79**	**0.89**

Notes:

1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.

b y-intercept as calculated by the linear regression least squares method

m Slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

XRF X-ray fluorescence

Results indicate that the slope varies more among XRF analyzers (RSD = 8.0 percent) than does the slope of some other target elements. Average R^2 (0.79) for the soil cup method is higher than the R^2 (0.74) computed for the bulk sample method; however, correlation coefficients are acceptable from application of both methods. Figure B-33 compares soil cup method bulk sample method regression models. At all manganese levels, the bulk sample regression line is higher than all three soil cup regression lines, indicating the model presents a conservative estimate of the predicted laboratory-determined manganese concentration. This is because the average slope (m = 0.7411) of the soil cup method is lower than the slope (m = 0.8912) of the bulk sample method (Model MN-2). To evaluate concentration effects of particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported manganese concentrations. Figure B-34 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 38 of the 44 samples (86 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 24 percent. The mean of the bulk sample manganese concentration from the 44 samples was 196 mg/kg and decreased to 165 mg/kg in the soil cup samples—an RPD decrease of 17 percent. Further discussion on particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

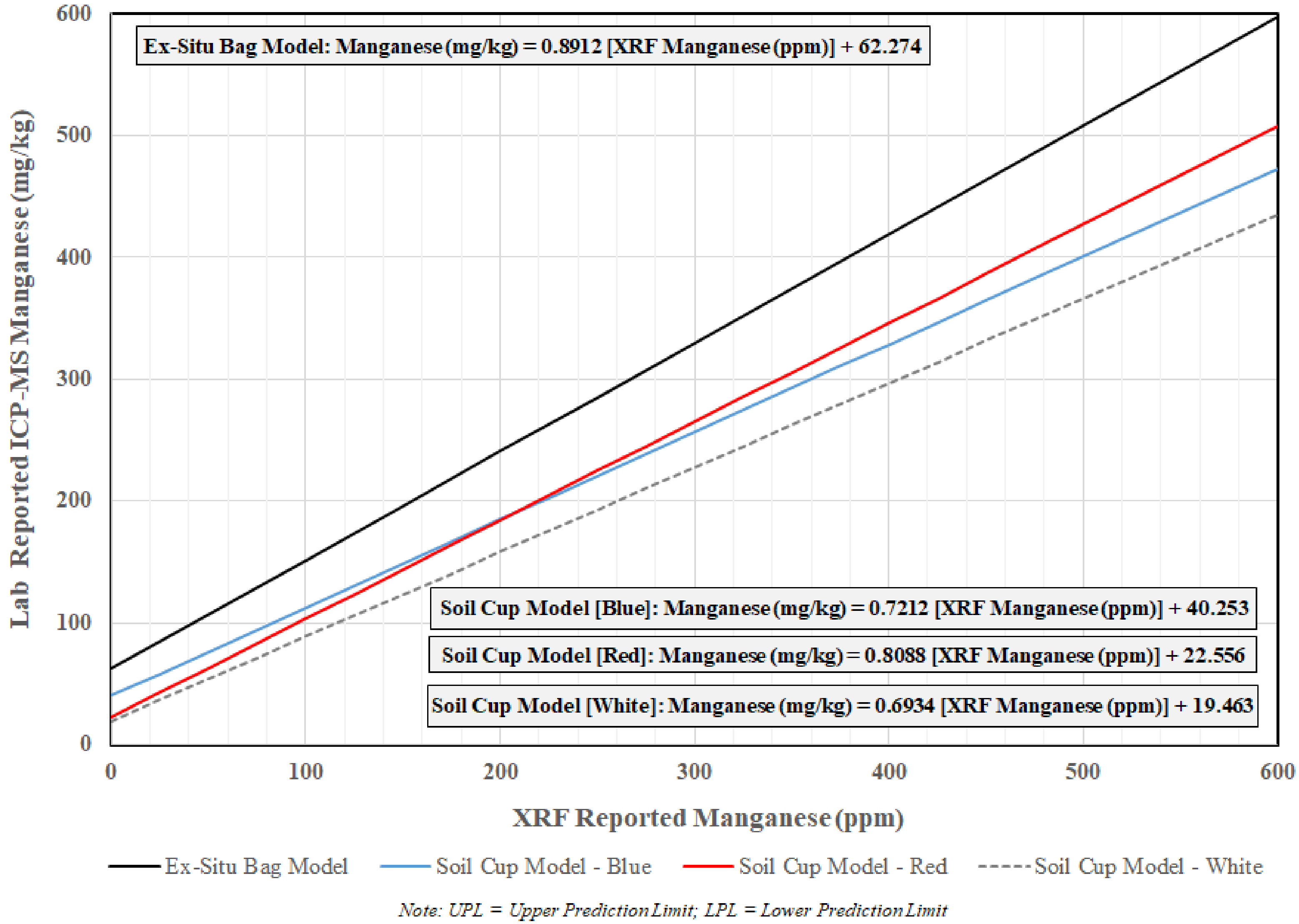


Figure B-33. Manganese Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

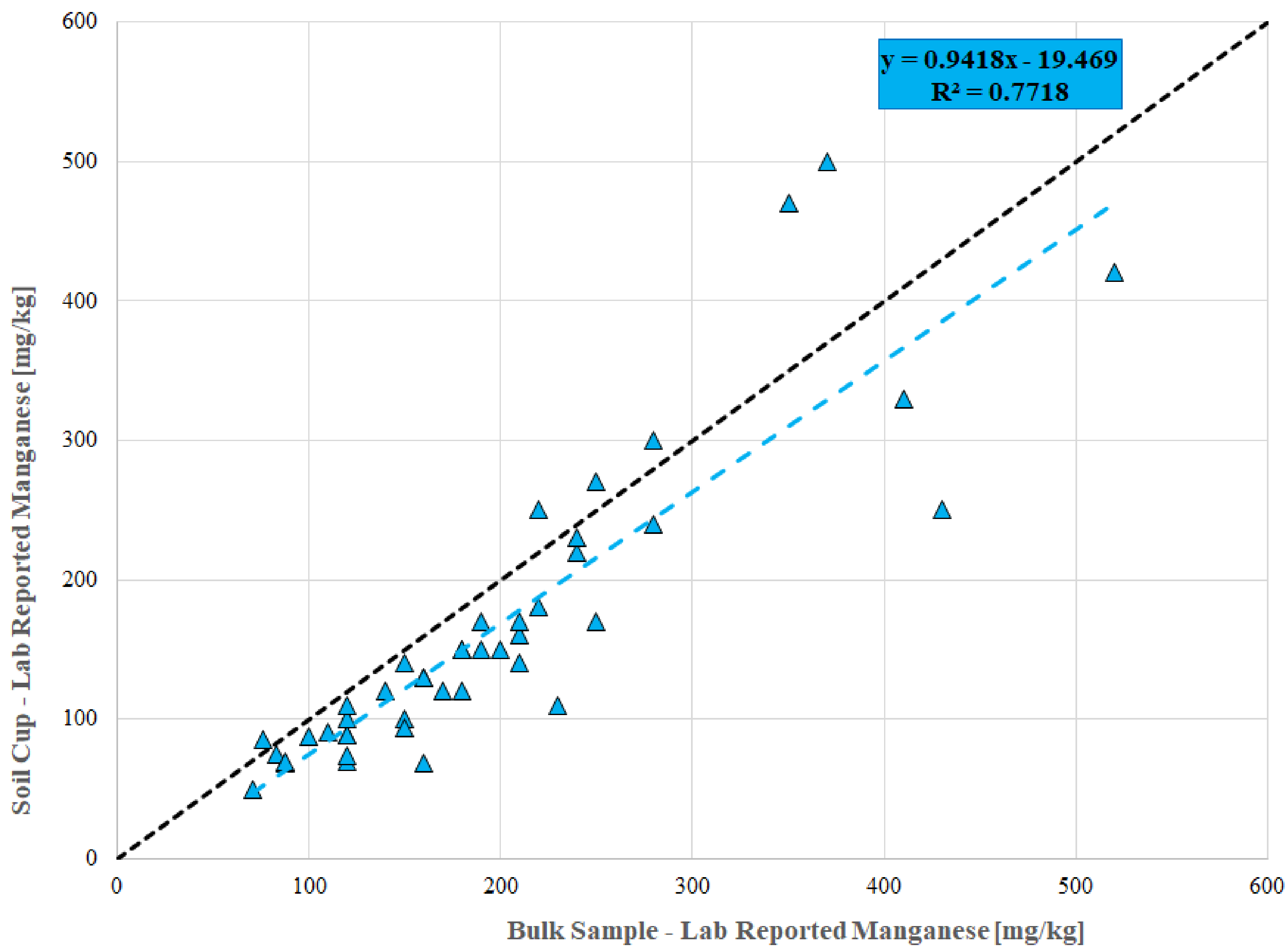


Figure B-34. Bulk Sample versus Soil Cup Manganese Concentration

4.4.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-41. A low number of samples were evaluated during application of each method, as listed in Table B-41.

Table B-41. Method Detection Limit for Manganese by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	5	21
Ex Situ XRF Bulk Sample	10	34
Ex Situ XRF Soil Cup	3	31

Notes:

Manufacturer reported MDL of 13 mg/kg for manganese using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

1 MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.
MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.4.4 Precision of XRF Analysis

An evaluation of precision for determination of manganese was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of manganese concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-42 summarizes calculated precisions for the different ranges of concentrations for each method type. The in situ XRF method had the best precision (RSD = 7.5 percent), and the ex situ XRF soil cup method had the lowest precision (RSD = 14 percent). For all XRF methods of evaluating manganese, precision improved as concentration increased. This was expected and shows the XRF analyzer responded better at higher manganese concentrations in soil. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent and, therefore, meet the criteria set forth in Method 6200.

Table B-42. Summary of Calculated Precision of XRF Method for Manganese

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	0	-	5	13%	48	11%	133	6.3%	186	7.5%
Ex Situ XRF Bulk Sample	0	-	1	40%	45	19%	205	13%	251	14%
Ex Situ XRF Soil Cup	0	-	3	20%	57	17%	72	9.3%	132	12%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with manganese concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with manganese concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with manganese concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with manganese concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.4.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-43 lists the RPD between the XRF and confirmatory soil cup data for different manganese soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-40) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined manganese concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 132 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of criteria for the concentration ranges is in in Table B-11. Overall comparability across all concentration ranges and for all data combined significantly increases with application of a correction factor to the XRF data to estimate a predicted laboratory-determined manganese concentration. With use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a) and indicated in Table B-12.

Table B-43. Comparability for Ex Situ XRF Soil Cup Method Manganese

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	0	-	3	13%	57	21%	72	16%	132	19%
Ex Situ XRF Soil Cup (Corrected)	0	-	3	30%	57	19%	72	13%	132	17%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with manganese concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with manganese concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with manganese concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with manganese concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-44 lists RPDs between XRF and confirmatory bulk sample data for different manganese soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample manganese regression model (Model MN-2) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined manganese concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 251 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Comparability significantly improves across all concentration ranges (except for low concentration because only one sample is in this category) with application of a correction factor to the XRF data to estimate a predicted laboratory-determined manganese concentration. By use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are 17 percent and 13 percent, respectively. For both methods, comparability is significantly improved with application of a correction factor for determination of manganese concentration. An RPD of 13 percent is considered good by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is in the following subsection.

Table B-44. Comparability for Ex Situ XRF Bulk Sample Method for Manganese

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	0	-	1	28%	45	52%	205	29%	251	31%
Ex Situ XRF Bulk Sample (Corrected)	0	-	1	50%	45	20%	205	13%	251	13%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 "Very low" refers to samples with manganese concentrations < 2x manufacturer reported MDL.

3 "Low" refers to samples with manganese concentrations ≥ 2x to < 5x manufacturer reported MDL.

4 "Medium" refers to samples with manganese concentrations ≥ 5x to < 10x manufacturer reported MDL.

5 "High" refers to samples with manganese concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit

n Number of samples used for calculating median RPD

RPD Relative percent difference (presented as median RPD)

XRF X-ray fluorescence

4.4.6 Inferential Statistical Analysis

An analysis occurred to compare the XRF and the confirmatory manganese data by way of two-sample hypothesis testing and supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample manganese measurement values were corrected by application of Model MN-2 identified in Section 4.4.2. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of manganese in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis (as done with the linear regression). Table B-45 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that the XRF data set from each mobilization grouping equals the laboratory data set after application of a correction factor.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed the lognormal distribution best fits the manganese confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-35 is a lognormal probability plot showing the XRF corrected manganese data set and the confirmatory manganese data set side by side, indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-36 compares the same two data sets with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-45. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Manganese Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Manganese	1 - 6	XRF <> Lab	XRF = Lab
	7 - 9	XRF <> Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01)

[1] Mobilization #1 – Mobilization #6 was the Baseline Study.

[2] Mobilization #7 – Mobilization #9 was the Site Characterization Study.

[3] Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.

[4] Corrected refers to the XRF data that was converted using Model MN-2 correction factors.

XRF X-ray fluorescence

XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.

XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

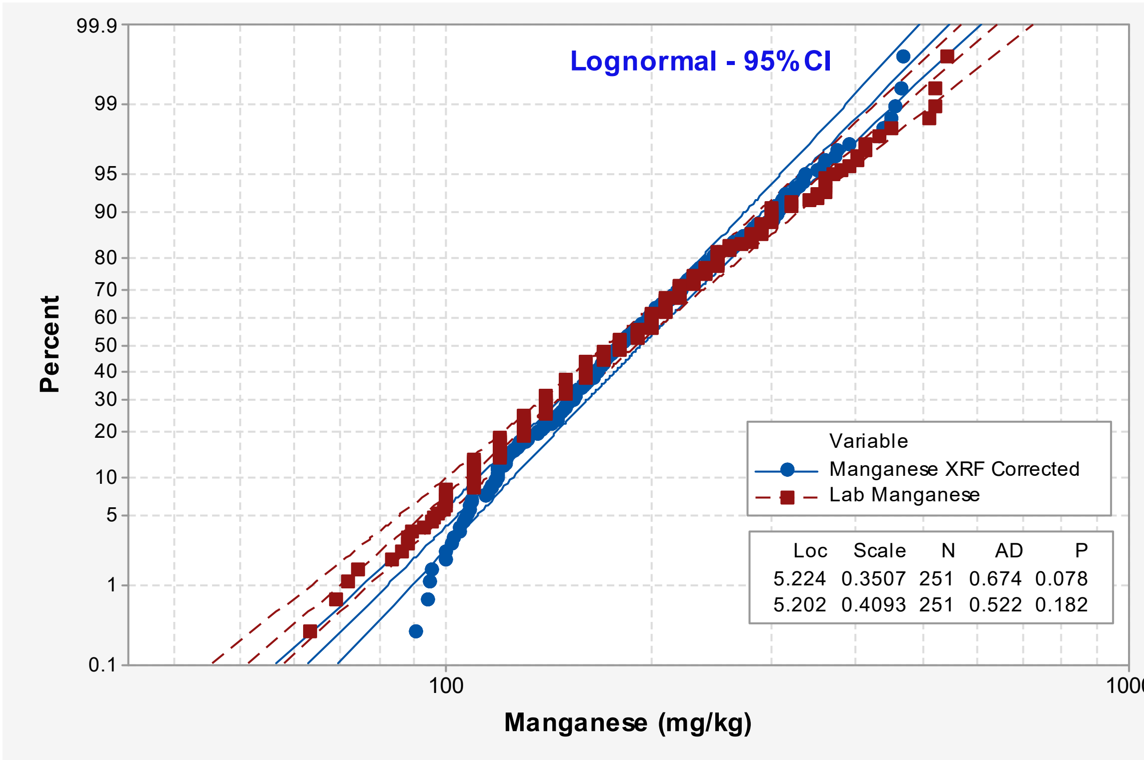


Figure B-35. Probability Plot of XRF Corrected Manganese Data Set and Confirmatory Manganese Data Set (3-Parameter Lognormal)

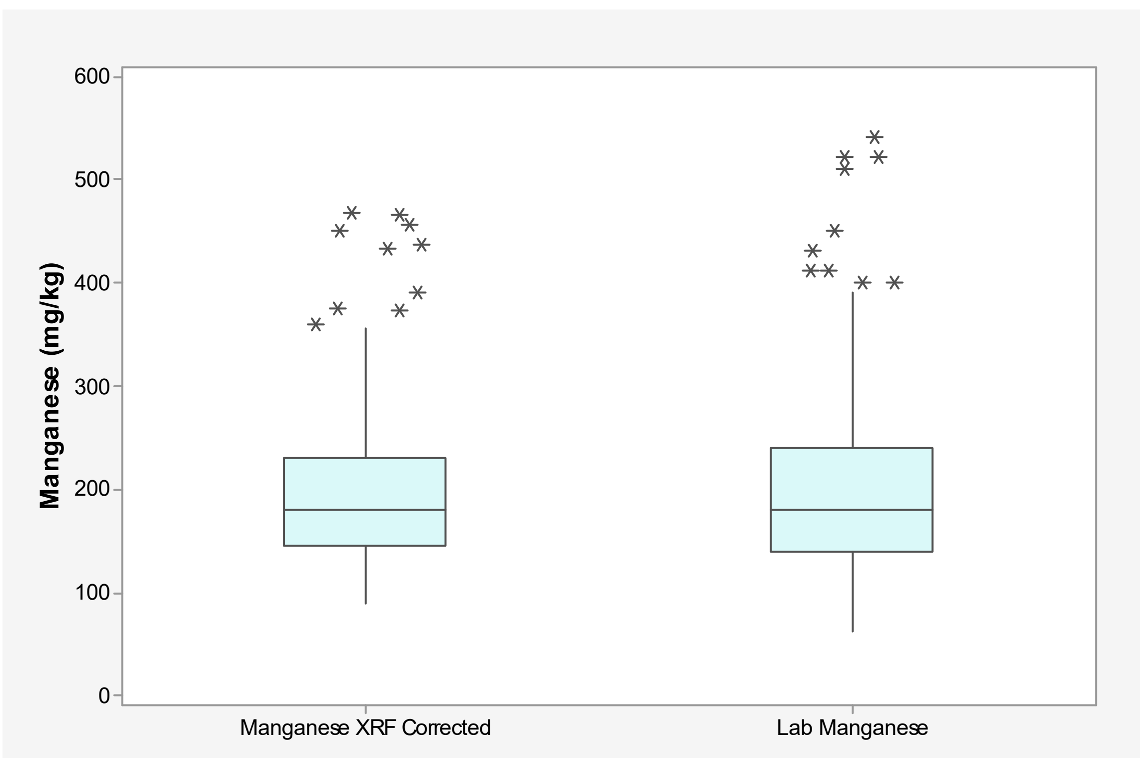


Figure B-36. Boxplot of XRF Corrected Manganese and Laboratory Reported Manganese

4.4.7 Sample Numbers and Descriptive Statistics

Table B-46 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF manganese measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for manganese with use of the XRF analyzer, 70 of these were below the MDL and qualified as such. The average detected manganese concentration of in situ XRF measurements after correction is 248 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 203 mg/kg manganese. A total of 292 surface soil samples were collected, averaging 197 mg/kg manganese. Therefore, 794 analytical surficial (XRF confirmation and surface soil) soil samples were collected in total across the sites, averaging 201 mg/kg manganese. In general, the average of in situ XRF measurements was close to the project-wide manganese concentrations reported in surface soils via laboratory analytical method (RPD = 21 percent), but slightly higher.

Table B-46. Summary of Project Wide Manganese Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	9,470	502	292	794
Nondetects	#	70	0	0	0
Minimum	mg/kg	81	49	39	39
Maximum	mg/kg	2700	1,500	1,100	1,500
Average	mg/kg	248	203	197	201
Standard Deviation	mg/kg	122	113	102	109
Median	mg/kg	226	190	180	180
90th Percentile	mg/kg	369	300	290	300
95th Percentile	mg/kg	430	360	340	360
99th Percentile	mg/kg	648	500	514	510

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined manganese concentrations using correction factors from Model PB-2A or Model PB-1A.

3 Laboratory-reported manganese concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).

bgs Below ground surface

ICP-MS Inductively coupled plasma-mass spectrometer

mg/kg Milligrams per kilogram

XRF X-ray fluorescence

4.4.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported manganese concentrations in the bulk soil samples, as summarized in Section 4.4.1, led to selection of Model MN-2 as the optimal model to best predict laboratory manganese concentrations by use of XRF analyzers. This model was used to post-process in situ XRF measurements to correct them to a more accurate representation of manganese concentrations reported from laboratory application of ICP-MS after acid partial digestion, and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining manganese concentrations by use of XRF analyzers, the correlation coefficient (r = 0.86), in situ XRF measurement precision (RSD = 7.5 percent), and corrected ex situ XRF bulk sample comparability (13 percent) all meet the criteria for manganese data reported by XRF analyzers to be considered at a definitive level. Assuming the r value would be 0.9 with the appropriate significant figures, the correlation coefficient is greater than or equal to 0.9, and inferential statistics indicate that the two data sets are not unequal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparison of the corrected XRF manganese data set and the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model MN-2) and for Mobilization #7 through Mobilization #9 (not used in model development). In both analyses, the inferential statistics indicate the mean of corrected XRF data equal to the mean of laboratory confirmatory data at a 99 percent significance level.

Comparison of results from the soil cup method to results from the bulk sample method indicate that the bulk sample method is more conservative at estimating manganese concentrations (Figure B-33). Also, application of the bulk sample method tends to reflect the site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model MN-2 is the final model selected, and was used to correct and post-process in situ XRF measurements to predicted laboratory manganese concentrations for the RSE reports. Equation 6 expresses the resulting linear regression model calculated for manganese by use of the 264 data pairs of ex situ XRF bulk sample manganese measurements and laboratory-reported manganese concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 – Mobilization #6:

Equation 6: $$[Mn]_{lab} = (0.8912 * [Mn]_{XRF}) + 62.274$$

The coefficient of determination (R^2) is 0.74 and the correlation coefficient (r) is 0.86, indicating the regression model is significant (that is, $r \geq 0.9$). The linear regression resulted in a slope of 0.8912 and a y-intercept of 62.274. Figure B-37 compares the primary bulk sample manganese regression model (shown in blue) to unity line (shown in black—that is if the model was 1:1 [XRF to laboratory]). provides primary bulk sample manganese regression model (shown in blue) as it compares to unity line (as shown in black), that is if the model was 1:1 (XRF to lab). The XRF tends to underpredict the estimated manganese laboratory concentration and, therefore, requires a correction factor to better predict the laboratory concentrations. The decision was made to correct the 9,540 in situ XRF measurement data for the RSE investigation by using Equation 6.

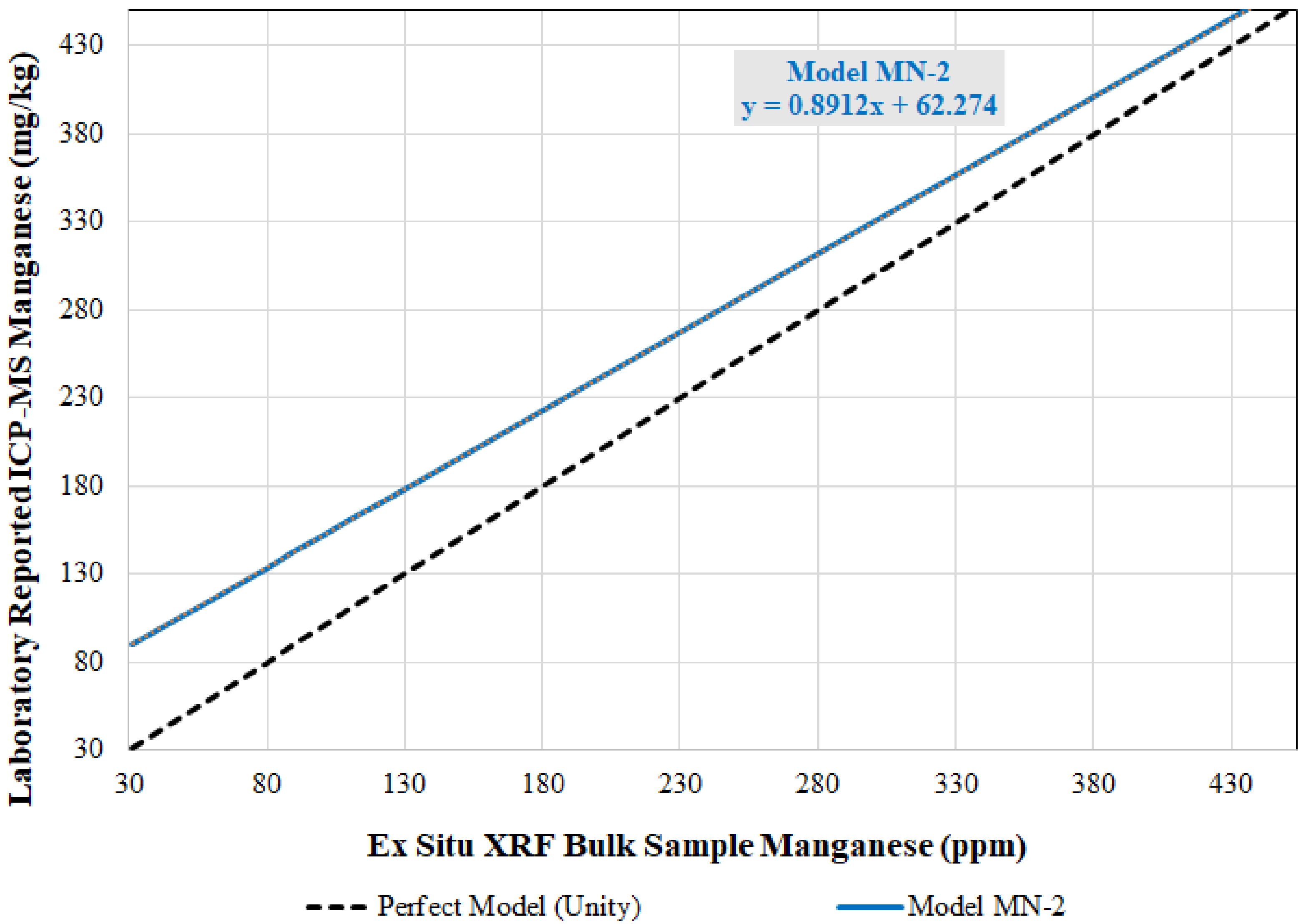


Figure B-37. Final Manganese Regression Model – Unity Comparison

4.5 MOLYBDENUM

4.5.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 molybdenum data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the molybdenum comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis but, instead, were used for inferential statistics and model validation purposes.

A total of 111 of 264 data pairs contained nondetects and were therefore removed from the dataset prior to the initial linear regression least squares analysis. The laboratory reported that molybdenum concentrations in the removed bulk soil sample dataset ranged from nondetect to 3.0 mg/kg. Following removal of these data pairs, a linear regression least squares analysis was applied on the remaining 153 molybdenum data pairs. For these remaining data pairs, the laboratory reported molybdenum concentrations from the data set ranging from 0.040 to 60 mg/kg, with an average of 2.0 mg/kg.

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the molybdenum data set, conclusion was that the range of molybdenum data pairs observed warranted a single model with one scale. Several different regression scenarios were evaluated and documented for this report as described below.

Model MO-1 was the first of a series of models involving linear regression least squares analysis. This model included the entire molybdenum dataset (without nondetects), totaling 153 data pairs. Visual inspection of a fitted line plot revealed an influential outlier that was flagged (molybdenum concentration in sample M21-XS46-01-060818). This extreme outlier had an average ex situ XRF molybdenum concentration of 19.3 ppm, with a relative standard deviation of 177 percent, indicating poor precision, which could be indicative of an instrument malfunction or outlier within the replicate measurements, given the laboratory-reported molybdenum concentration of 1.3 mg/kg. The sample was removed from the comparability study prior to evaluation of any further models. A full diagnostic report regarding Model MO-1 from the statistical software is in Attachment B4; this model still included sample M21-XS46-01-060818 identified as an outlier.

The second model, referred to as Model MO-1A, contained the same dataset as Model MO-1 excluding the single outlier cited above (M21-XS46-01-060818). An improvement of correlation coefficients from Model MO-1 (r = 0.97) to Model MO-1A (r = 0.99) resulted from removal of the outlier.

A similar approach was followed to identify potential outliers by visual inspection and by statistical evaluation of standardized residuals from the third regression model, Model MO-2.

Model MO-2 was intended to evaluate all data within the main cluster of data, excluding the highest value (from sample M28-XS148-01-062018). This model had a slope of 0.727 and y-intercept of -1.381 with a high correlation coefficient (r = 0.95). An analysis of this model with the highest value removed to determine if any outliers were prominently visible revealed eight data pairs with unusually large residuals. Table B-47 lists the eight data pairs identified by use of the statistical software. All of these data pairs were outside of the 95 percent prediction limits (see Model MO-2 fitted line plot in Attachment B4). Six of the eight data pairs with lowest XRF-reported molybdenum concentrations were considered outliers and were removed prior to evaluation of the fourth regression model, Model MO-2A. These six outliers were excluded from Model MO-2A and so was the earlier outlier identified in Model MO-1 (M21-XS46-01-060818). The two samples among those eight with highest concentrations of molybdenum (M21-XS40-01-060818 and M30-XS138-01-062218) were included for further analysis in Model MO-2A. These two samples appeared to split the regression well, and their inclusion did not affect model parameters.

Table B-47. Summary of Data Pairs with Large Residuals for Molybdenum in Model MO-2

Sample ID	Average Ex Situ XRF Molybdenum Value (ppm)[1]	RSD of Ex Situ XRF Molybdenum Values[2]	Laboratory Molybdenum Result (ppm)[3]	RPD of Data Pairs
M7-XS74-01-051018	2.1	31%	3.3	43%
T4-XS43-01-051218	6.3	16%	0.16	190%
M17-XS83-01-052618	17	52%	7.5	78%
T26-XS8-01-061018	5.9	7.1%	6.0	1.9%
M28-XS43-01-062018	7.4	7.6%	7.9	6.8%
M25-XS47-01-071718	3.4	68%	3.0	14%
M21-XS40-01-060818	22	3.3%	13	53%
M30-XS138-01-062218	21	8.1%	18	17%

Notes:

1 Average of six ex situ XRF molybdenum measurements collected on the bulk sample.
2 RSDs of the six ex situ XRF molybdenum measurements taken from the bulk sample.
3 Laboratory-reported molybdenum concentration via partial digestion (3050B) and ICP-MS (6020A).

ICP-MS Inductively coupled plasma-mass spectrometry
mg/kg Milligrams per kilogram
ppm Parts per million
RSD Relative standard deviation
RPD Relative percent difference
XRF X-ray fluorescence

As conveyed above, Model MO-2A was applied after removal of the six outliers identified from inspection of Model MO-2. Model MO-2A had a total of 145 data pairs and a reported slope of 0.7489, y-intercept of -1.5041, and correlation coefficient of r = 0.97. Inspection of the standardized residuals of Model MO-2A revealed no more outliers. A final model was evaluated, referred to as Model MO-1B, which excluded all outliers identified previously from applications of Model MO-1 and Model MO-2, but included the highest value (from sample M28-XS148-01-062018). This model resulted in a correlation coefficient of r = 0.99 with relatively normally distributed standardized residuals. Model MO-1B had a slope (m = 0.7964) and y-intercept (b = -1.6827) similar to the other models, but with outliers removed. Model MO-1B was the final model selected to best represent the relationship between ex situ XRF bulk sample molybdenum measurements and laboratory-reported molybdenum concentrations from XRF confirmation soil samples. Figure B-38 shows the final selected data pairs included in Model MO-1B with the 95 percent prediction limits and the molybdenum data pairs with outliers removed. Model MO-1B omits nondetects and outliers, and is the most meaningful representation of the data. Table B-48 summarizes parameters for the various molybdenum regression models.

Table B-48. Summary of Parameters for Ex Situ Bulk Sample Molybdenum Regression Models

Model Name	Data Pairs	Higher Values Removed	Nondetects Removed	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model MO-1	153	0	111	0	0.7642	-1.586	0.94	0.97
Model MO-1A	152	0	111	1	0.7886	-1.619	0.97	0.99
Model MO-2	151	1	111	1	0.7272	-1.381	0.90	0.95
Model MO-2A	145	1	111	7	0.7489	-1.5041	0.95	0.97
Model MO-1B	146	0	111	7	0.7964	-1.6827	0.99	0.99

Notes:

b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination

Attachment B3 presents statistical analyses of all the regression models evaluated for molybdenum (Model MO-1, Model MO-1A, Model MO-2, Model MO-2A, and Model MO-1B). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residuals, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 presents, in tabular format, all data either included or excluded in the final molybdenum model: Model MO-1B. The attachment presents the data pairs from Mobilization #7 through Mobilization #9 as well. The following subsection conveys results of the soil cup comparability study for molybdenum. That subsection compares Model MO-1B to the various soil cup regression models (lower concentrations only).

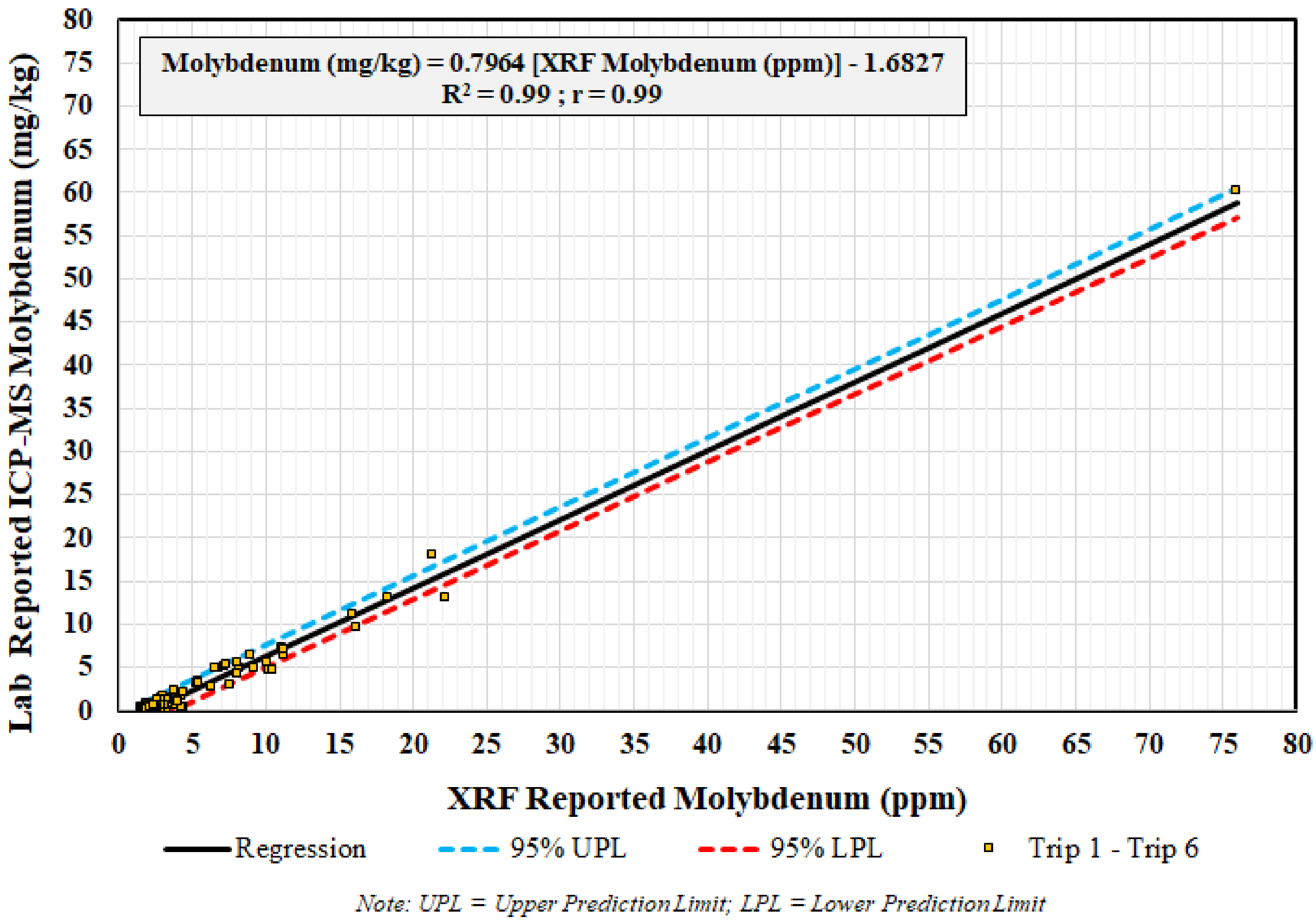


Figure B-38. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model MO-1B (Molybdenum)

4.5.2 Linear Regression Analysis

A comparability study involved ex situ XRF molybdenum measurements and laboratory-reported molybdenum concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring molybdenum using this XRF method are discussed in Section 3.4, and results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B4. Table B-49 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-49. Summary of Molybdenum Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.6337	0.8766	0.77	0.88
Red	0.5869	0.9174	0.80	0.90
White	0.4907	0.8587	0.65	0.81
Average	**0.5704**	**0.8842**	**0.74**	**0.86**

Notes:

1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.

b y-intercept as calculated by the linear regression least squares method

m slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

XRF X-ray fluorescence

Results indicate that the slope varies more among XRF analyzers (RSD = 13 percent) than the slopes of all other target elements. The average R^2 (0.74) for results from application of the soil cup method is less than the R^2 (0.99) computed for results from application of the bulk sample method; however, the bulk sample method correlation depends highly on a large data point. Figure B-39 compares soil cup method and bulk sample method regression models. At low molybdenum levels (<20 ppm), the bulk sample regression model is less than the soil cup regression models; however, at concentrations exceeding 20 ppm, the bulk sample regression model deviates upward, indicating the model presents a conservative estimate of predicted laboratory-determined molybdenum concentration. This is because the average slope (m = 0.5704) of the soil cup method is lower than the slope (m = 7964) of the bulk sample method (Model MO-1B).

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported molybdenum concentrations. Figure B-40 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 31 of the 44 samples (72 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 19 percent. The mean of the bulk sample molybdenum concentration from the 44 samples was

1.9 mg/kg and decreased to 1.6 mg/kg in the soil cup samples—an RPD decrease of 15 percent. Further discussion of particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

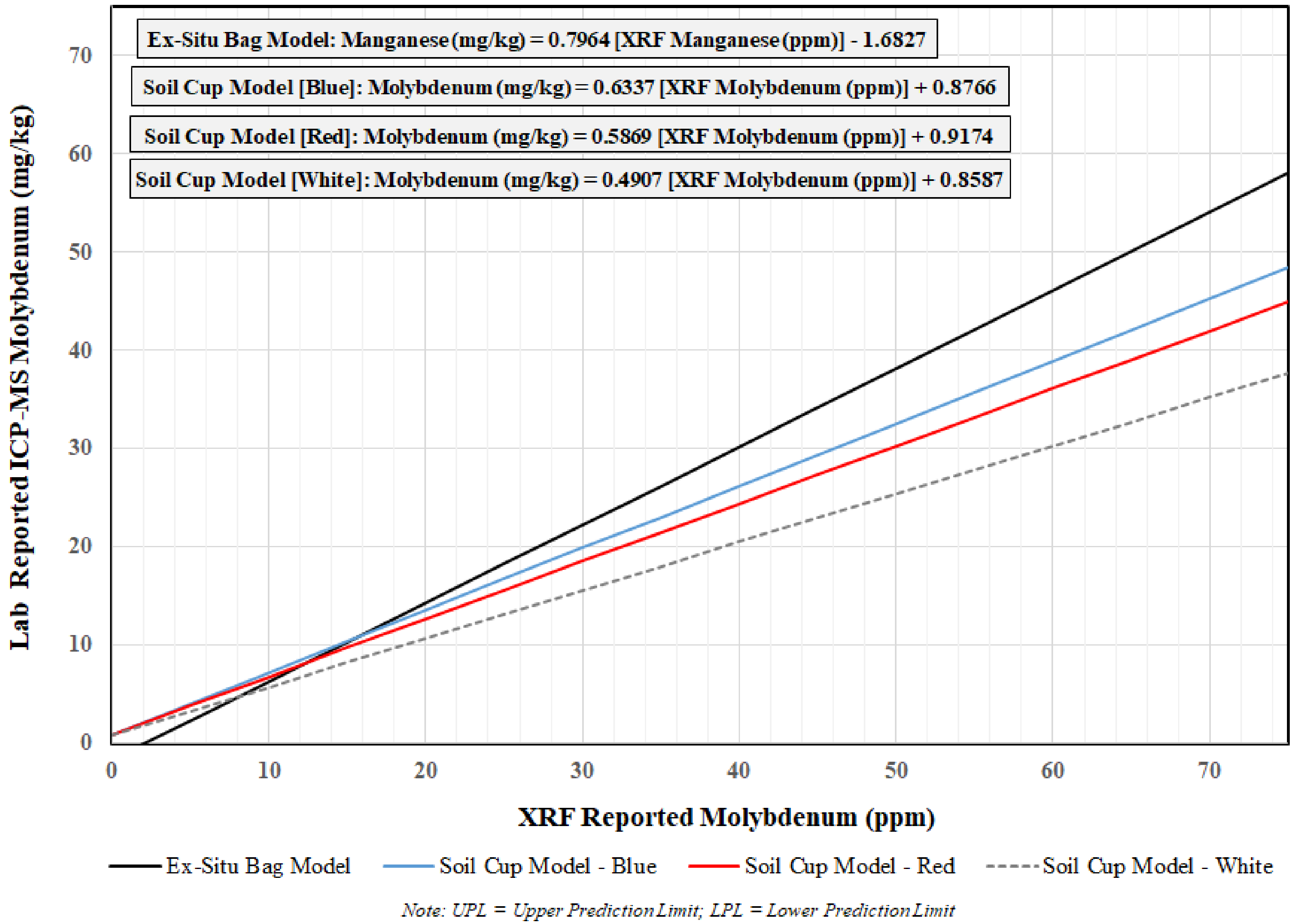


Figure B-39. Molybdenum Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

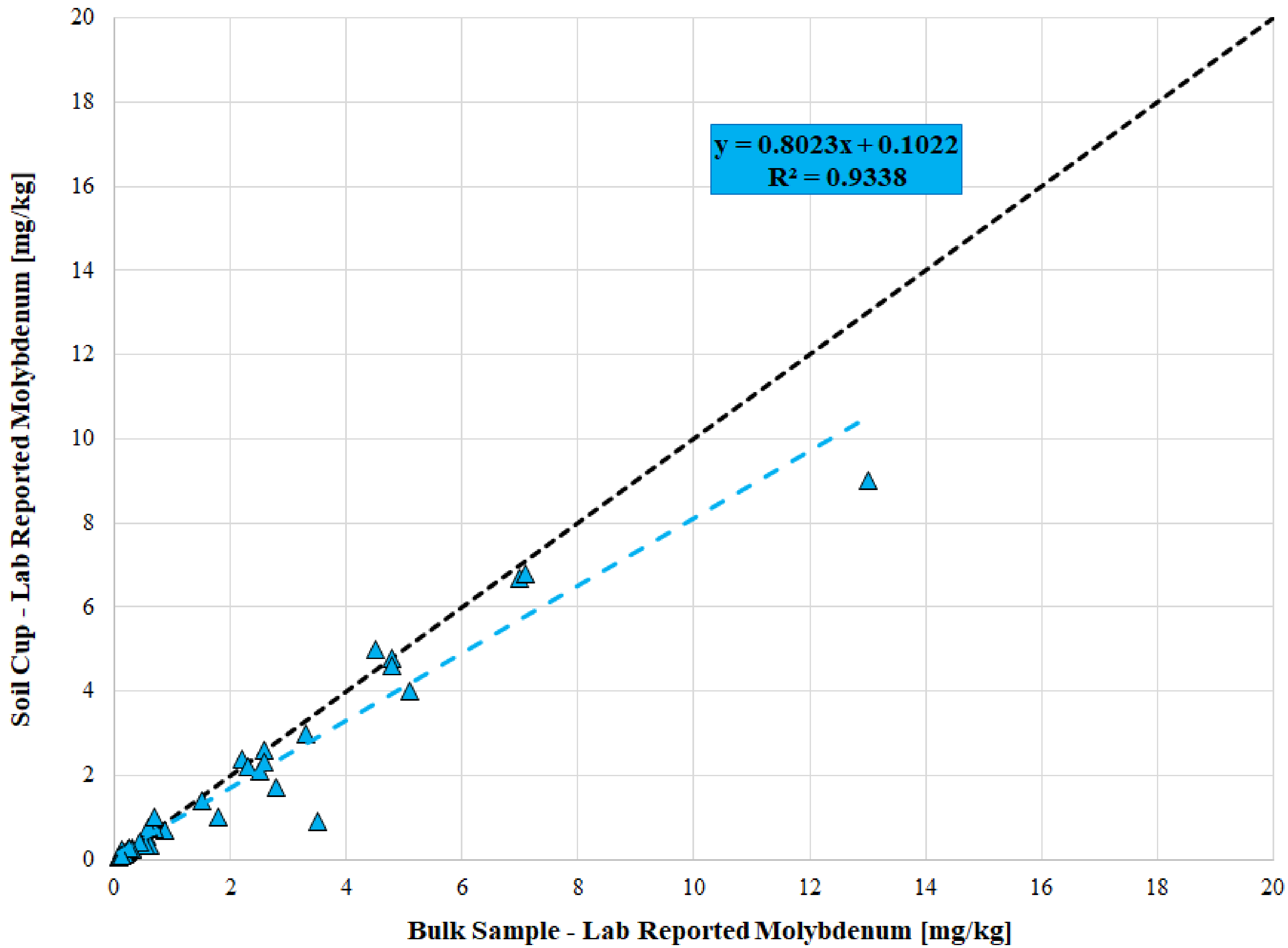


Figure B-40. Bulk Sample versus Soil Cup Molybdenum Concentration

4.5.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-50. A large number of samples were evaluated in application of each of the methods, as listed in Table B-50.

Table B-50. Method Detection Limit for Molybdenum by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	47	1.6
Ex Situ XRF Bulk Sample	132	2.1
Ex Situ XRF Soil Cup	19	9.8

Notes:

Manufacturer reported MDL of 1 mg/kg for molybdenum using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

1 MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.

MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.5.4 Precision of XRF Analysis

An evaluation of precision for determination of molybdenum was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of molybdenum concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-51 summarizes calculated precisions for the different ranges of concentrations for each method type. The intrusive bulk sample had the worst precision and was heavily weighted by the very low concentrations where measurements were not as precise (RSD = 23 percent). The ex situ XRF soil cup method had the best precision (RSD = 15 percent). For all XRF methods of evaluating molybdenum, precision improved as concentration increased (except by application of the in situ method whereby only one sample point was in the highest range, so it is difficult to infer with so little data). This was expected, and indicates that the XRF analyzer responded better at higher molybdenum concentrations in soil. Except for the intrusive bulk sample method, the XRF methods evaluated had overall median RSDs of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-51. Summary of Calculated Precision of XRF Method for Molybdenum

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	11	18%	36	19%	10	13%	1	35%	58	18%
Ex Situ XRF Bulk Sample	118	23%	14	15%	9	12%	5	8.1%	146	22%
Ex Situ XRF Soil Cup	3	21%	16	23%	12	6.3%	0	-	31	15%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with molybdenum concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with molybdenum concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with molybdenum concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with molybdenum concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.5.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-52 lists the RPD between the XRF and confirmatory soil cup data for different molybdenum soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-47) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined molybdenum concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 31 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of criteria for the concentration ranges is in Table B-11. Overall comparability across all concentration ranges and for all data combined increases significantly by application of a correction factor to the XRF data to estimate a predicted laboratory-determined molybdenum concentration. With use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a) and indicated in Table B-12.

Table B-52. Comparability for Ex Situ XRF Soil Cup Method Molybdenum

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	3	111%	16	10%	12	35%	0	-	31	30%
Ex Situ XRF Soil Cup (Corrected)	3	86%	16	19%	12	9.4%	0	-	31	14%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with molybdenum concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with molybdenum concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with molybdenum concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with molybdenum concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-53 lists RPDs between XRF and confirmatory bulk sample data for different molybdenum soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample molybdenum regression model (Model MO-1B) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined molybdenum concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. Prior to use of the correction factor, 146 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. After use of the correction factor, some data became negative and were not included in the comparability calculation analysis.

Similar to precision resulting from application of the bulk sample method, comparability tends to increase (that is, RPD decreases) as concentration increases. Overall comparability across all concentration ranges and for all data combined increases significantly by use of a correction factor to the XRF data to estimate a predicted laboratory-determined molybdenum concentration. Notably, comparability is not very good at very low molybdenum soil concentrations, and these data reduce overall comparability of the method. By use of a correction factor, comparability is considered fair according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are 14 percent and 44 percent, respectively. For the bulk sample method, comparability is improved by use of the correction factor for determination of molybdenum concentration. An RPD of 44 percent is considered fair by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is in the following subsection.

Table B-53. Comparability for Ex Situ XRF Bulk Sample Method for Molybdenum

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	118	167%	14	59%	9	45%	5	34%	146	155%
Ex Situ XRF Bulk Sample (Corrected)	88	66%	14	24%	9	14%	5	2%	116	44%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 "Very low" refers to samples with molybdenum concentrations < 2x manufacturer reported MDL.

3 "Low" refers to samples with molybdenum concentrations ≥ 2x to < 5x manufacturer reported MDL.

4 "Medium" refers to samples with molybdenum concentrations ≥ 5x to < 10x manufacturer reported MDL.

5 "High" refers to samples with molybdenum concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit

n Number of samples used for calculating median RPD

RPD relative percent difference (presented as median RPD)

XRF X-ray fluorescence

4.5.6 Inferential Statistical Analysis

An analysis occurred to compare XRF and the confirmatory molybdenum data by way of two-sample hypothesis testing and supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample molybdenum measurement values were corrected by application of Model MO-1B identified in Section 4.5.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue because of the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of molybdenum in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis (as in the linear regression). Table B-58 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that the XRF data set from each mobilization grouping equals the laboratory data set after application of a correction factor.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed the three-parameter lognormal distribution best fits the molybdenum confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-41 is a three-parameter lognormal probability plot showing the XRF-corrected molybdenum data set and the confirmatory molybdenum data set side by side, and indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-42 compares the same two data sets with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-54. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Molybdenum Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Molybdenum	1 - 6	XRF <> Lab	Conclude XRF = Lab
	7 - 9	NA	NA

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01).

1 Mobilization #1 – Mobilization #6 was the Baseline Study.
2 Mobilization #7 – Mobilization #9 was the Site Characterization Study.
3 Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.
4 Corrected refers to the XRF data that was converted using Model MO-1B correction factors.

NA Not applicable because of an instrument error with Molybdenum with Red XRF during Mobilization #7.
XRF X-ray fluorescence
XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

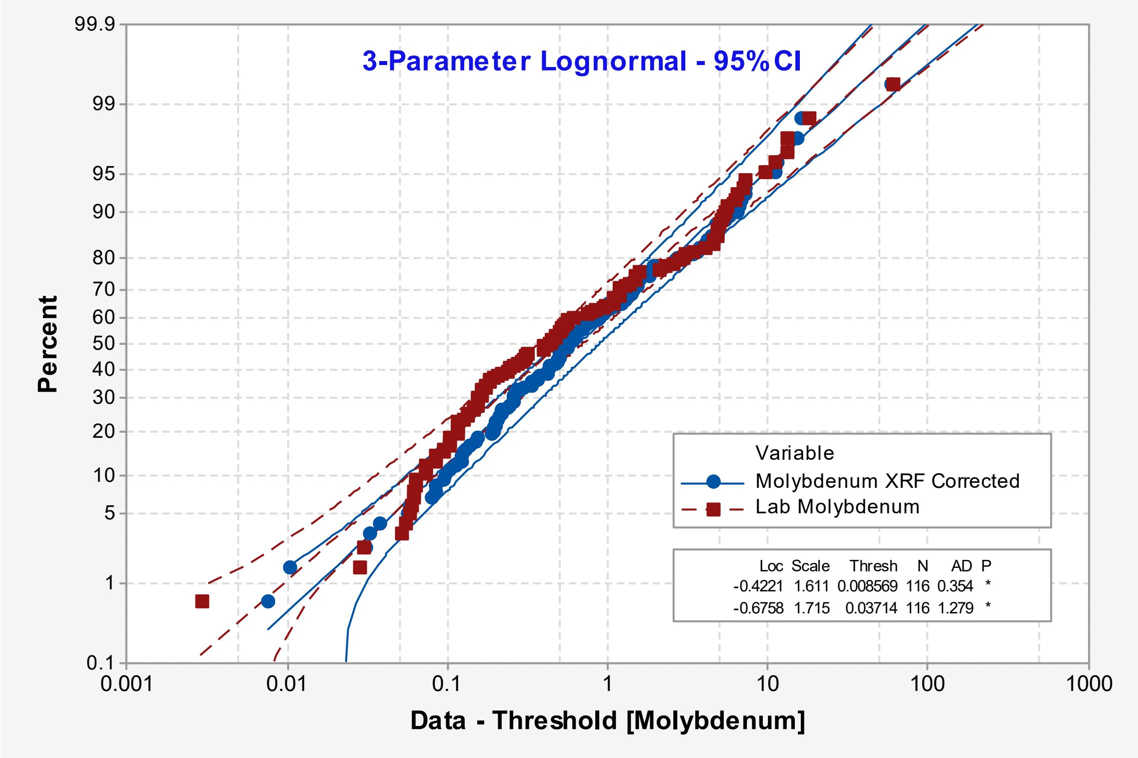


Figure B-41. Probability Plot of XRF Corrected Molybdenum Data Set and Confirmatory Molybdenum Data Set (3-Parameter Lognormal)

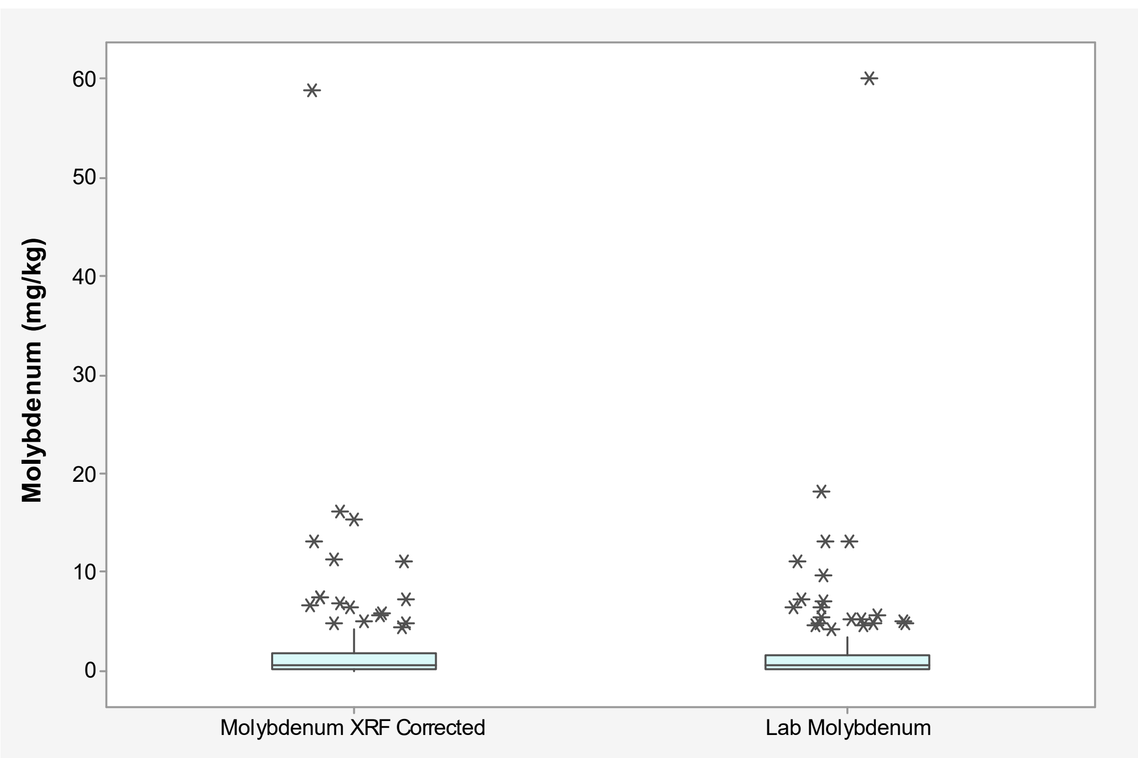


Figure B-42. Boxplot of XRF Corrected Molybdenum and Laboratory Reported Molybdenum

4.5.7 Sample Numbers and Descriptive Statistics

Table B-55 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF molybdenum measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for molybdenum with use of the XRF analyzer, 6,304 of these were below the MDL and qualified as such. The average detected molybdenum concentration of in situ XRF measurements after correction is 2.1 mg/kg. A total of 496 detected XRF confirmatory soil sample results averaged 1.0 mg/kg molybdenum. A total of 274 detected surface soil sample results averaged only 0.66 mg/kg molybdenum. Therefore, 770 detected analytical surficial (XRF confirmation and surface soil) soil sample results averaged 0.87 mg/kg molybdenum. In general, the average of in situ XRF measurements was higher than project-wide molybdenum concentrations reported in surface soils via laboratory analytical method. This is because the XRF analyzers' capabilities to determine molybdenum concentrations were inferior to the laboratory analytical method. Thus, many molybdenum concentrations at or near background were qualified as nondetects and were not used in the calculation of the site-wide average by application of the XRF method.

Table B-55. Summary of Project Wide Molybdenum Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	3,236	496	274	770
Nondetects	#	6,304	6	18	24
Minimum	mg/kg	0.0380	0.0370	0.0350	0.0350
Maximum	mg/kg	58	60	14	60
Average	mg/kg	2.1	1.0	0.66	0.87
Standard Deviation	mg/kg	3.5	3.9	1.5	3.2
Median	mg/kg	1.1	0.21	0.19	0.20
90th Percentile	mg/kg	4.2	2.0	1.5	1.9
95th Percentile	mg/kg	7.2	3.6	2.9	3.4
99th Percentile	mg/kg	16	11	7.6	8.9

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined lead concentrations using correction factors from Model PB-2A or Model PB-1A.

3 Laboratory-reported lead concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).

bgs Below ground surface

ICP-MS Inductively coupled plasma-mass spectrometry

mg/kg Milligrams per kilogram

XRF X-ray fluorescence

4.5.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported molybdenum concentrations in the bulk soil samples, as summarized in Section 4.5.1, led to selection of Model MO-1B as the optimal model to best predict laboratory molybdenum concentrations by use of XRF analyzers—and to a decision that this model could be used to post-process in situ XRF measurements to correct them to a more accurate representation of the measurement technique applied to evaluate molybdenum via laboratory analysis (ICP-MS after acid partial digestion), and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining molybdenum concentrations by use of XRF analyzers, the correlation coefficient (r = 1.0), in situ XRF measurement precision (RSD = 18 percent), and corrected ex situ XRF bulk sample comparability (44 percent) all meet the criteria for molybdenum data reported by XRF analyzers to be considered at a quantitative screening level. Notably, the median RPD is 44 percent, weighted by poor comparability at lower concentrations; however, comparability improves with increasing soil concentration. The inferential statistics indicate that the mean of XRF data equals the mean of laboratory confirmatory data at a 99 percent significance level after application of a correction factor to the XRF data.

Comparison of results from the soil cup method to results from the bulk sample method indicates that the bulk sample method is more conservative at estimating molybdenum concentrations (Figure B-39). Also, application of the bulk sample method tends to reflect site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model MO-1B is the final model selected, and was applied to correct and post-process in situ XRF measurements to predicted laboratory molybdenum concentrations for the RSE reports. Equation 7 expresses the resulting linear regression model calculated for molybdenum by use of the 264 data pairs of ex situ XRF bulk sample molybdenum measurements and laboratory-reported molybdenum concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 through Mobilization #6:

Equation 7: $$[Mo]_{lab} = (0.7964 * [Mo]_{XRF}) - 1.6827$$

The correlation coefficient (r = 0.99) is significant (that is, r ≥ 0.9). The linear regression resulted in a slope of 0.7964 and a y-intercept of -1.6827. Figure B-43 shows primary bulk sample molybdenum regression model (shown in blue) as it compares to unity line (as shown in black; that is, if the model was 1:1 [XRF to lab]). The model is shown below the unity line for all concentration ranges, indicating that the XRF analyzer returns a value higher than the laboratory-reported molybdenum concentration, and applying a correction factor to the XRF data is required to ensure that the corrected data better reflect predicted laboratory-determined molybdenum concentrations.

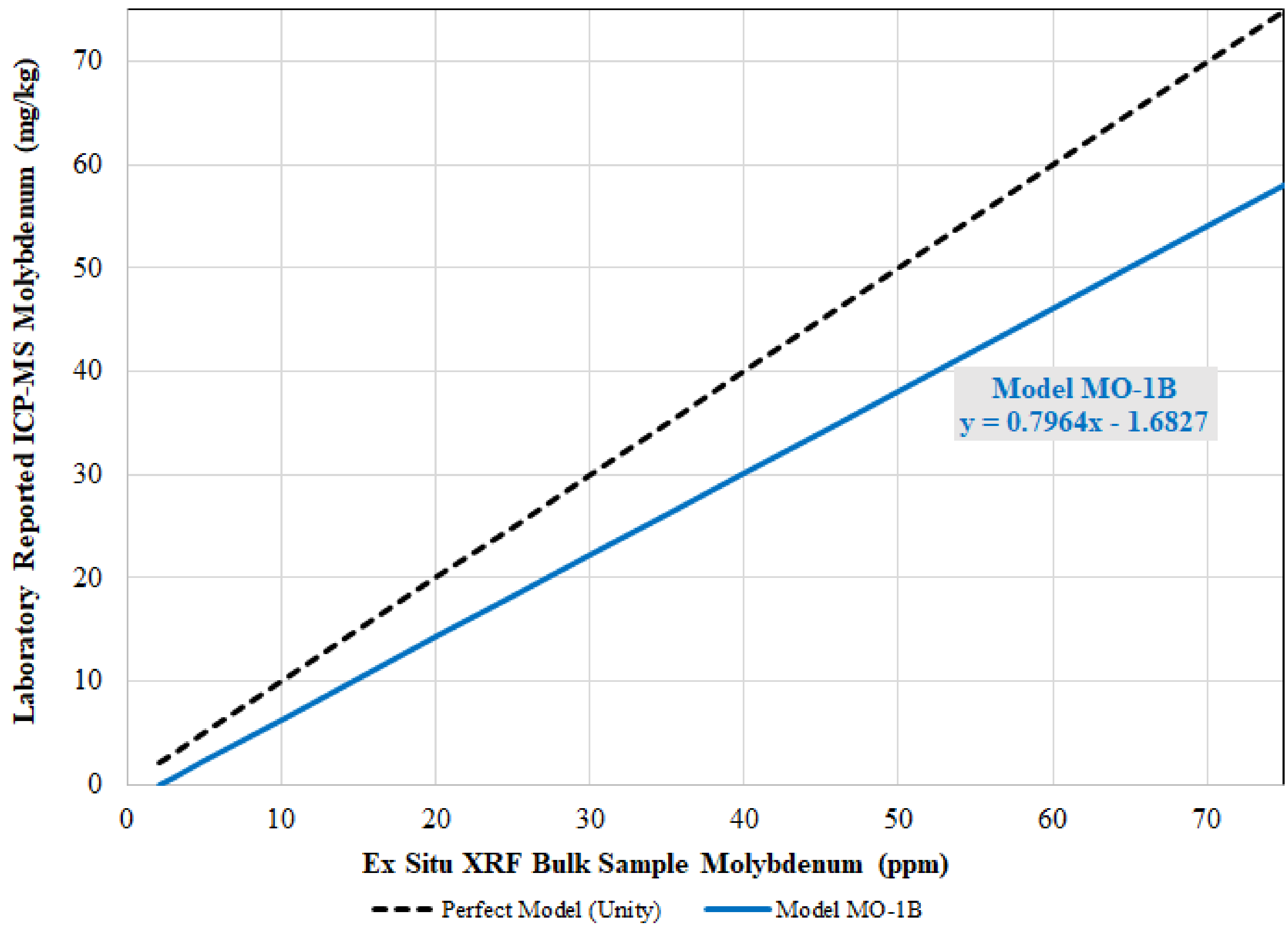


Figure B-43. Final Molybdenum Regression Model – Unity Comparison

4.6 THORIUM

4.6.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 thorium data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the thorium comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis, but instead were used for inferential statistics and model validation purposes. The entire thorium data set was retained except for five nondetects that were removed.

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Because of the two sample points with much higher thorium concentrations than the rest, an evaluation of the complete data set (Model TH-1) occurred with the two highest values removed (Model TH-2).

Model TH-1 included a total of 259 of 264 data pairs of thorium concentrations. A linear regression least squares analysis was applied on the 259 thorium data pairs. The laboratory reported thorium concentrations from the data set ranging from 1.0 to 38 mg/kg with, an average of 2.7 mg/kg. The maximum thorium concentrations were in samples M8-XS102-01-050918 and M8-XS102-02-050918, both at a laboratory-reported 38 mg/kg—far removed from the primary data cluster, considered influential outliers, and designated to undergo further inspection. The next highest thorium laboratory-reported concentration was 8.8 mg/kg in sample M4-XS238-01-051018.

Model TH-2 was the full data set excluding the two highest values cited above. This model included 257 data pairs of thorium concentrations ranging from 1.0 to 8.0 mg/kg. The correlation coefficient lowered from Model TH-1 ($r = 0.98$) to Model TH-2 ($r = 0.84$), as did the slope (from 0.6984 to 0.5616), showing the significant influence of the two excluded values on the regression. Upon visual inspection of the Model TH-2 regression and of the standardized residuals, three data pairs were evident outliers: M4-XS238-01-051018 (XRF = 11 ppm, Lab = 8.8 mg/kg), M24-XS115-01-071418 (XRF = 9.4 ppm, Lab = 7.7 mg/kg), and T10-XS20-01-042518 (XRF = 7.0 ppm, Lab = 1.9 mg/kg). These samples were removed from the data set, as they did not best represent the model, and another analysis occurred.

The third regression model, Model TH-2A, represented the lower thorium concentrations (< 12 ppm XRF), characteristic of most of the data pairs. This model excluded the two highest values and the three outliers discussed above. Model TH-2A included 254 data pairs ranging in thorium concentrations from 1.0 to 7.7 mg/kg. The correlation coefficient was the same as in Model TH-2, but the slope lowered from 0.5616 to 0.5189, showing the influence of the three outliers on the lower regression model. Upon further visual inspection and evaluation of standardized residuals, conclusion was that these residuals were normally distributed and no more outliers were obvious. Model TH-2A is considered the model of choice to best represent the determination of thorium by XRF, and should be applied to XRF thorium data measurements less than 12 ppm.

Model TH-2A is the final model for lower thorium levels; however, for thorium values greater than 12 ppm, recommendation is to use the complete data set. Therefore, Model TH-1A was analyzed, involving inclusion of the two samples with highest thorium concentrations (M8-XS102-01-050918 and M8-XS102-02-050918), but exclusion of the same three outliers identified in Model TH-2 (M4-XS238-01-051018, M24-XS115-01-071418, and T10-XS20-01-042518. The correlation coefficient, slope, and intercept were essentially unchanged between Model TH-1 and Model TH-1A; however, the residuals from Model TH-1A were more normally distributed. Model TH-1A is the final model selected for determination of thorium if the XRF measurement exceeds or equals 12 ppm. Table B-56 summarizes the various parameters associated with the four regression models evaluated as part of the thorium comparability study.

Table B-56. Summary of Parameters for Ex Situ Bulk Sample Thorium Regression Models

Model Name	Data Pairs	Higher Values Removed	Nondetects Removed	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model TH-1	259	0	5	0	0.6984	-0.8522	0.96	0.98
Model TH-2	257	2	5	0	0.5616	-0.2173	0.71	0.84
Model TH-2A	254	2	5	3	0.5189	-0.0333	0.70	0.84
Model TH-1A	256	0	5	3	0.6955	-0.8443	0.97	0.98

Notes:

b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
ND Nondetect
r Pearson's correlation coefficient
R^2 Coefficient of determination

Figure B-44 shows the final selected data pairs included in Model TH-2A with the 95 percent prediction limits and the thorium data pairs with outliers removed. Figure B-45 shows the final regression model for the lower XRF concentrations of thorium (< 12 ppm) (Model TH-2A), and the final regression model for any XRF concentration of thorium above 12 ppm (Model TH-1A)—with the respective prediction limits and primary linear regression models tied together.

Attachment B3 presents statistical analyses of all the regression models evaluated for thorium (Model TH-1, Model TH-1A, Model TH-2, and Model TH-2A). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residuals, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 shows, in tabular format, all data included or excluded in the final thorium models: Model TH-1A and Model TH-2A, and also presents the data pairs from Mobilization #7 through Mobilization #9. The following subsection conveys results of the soil cup comparability study for thorium. That subsection compares Model TH-2A to the various soil cup regression models (lower concentration models only).

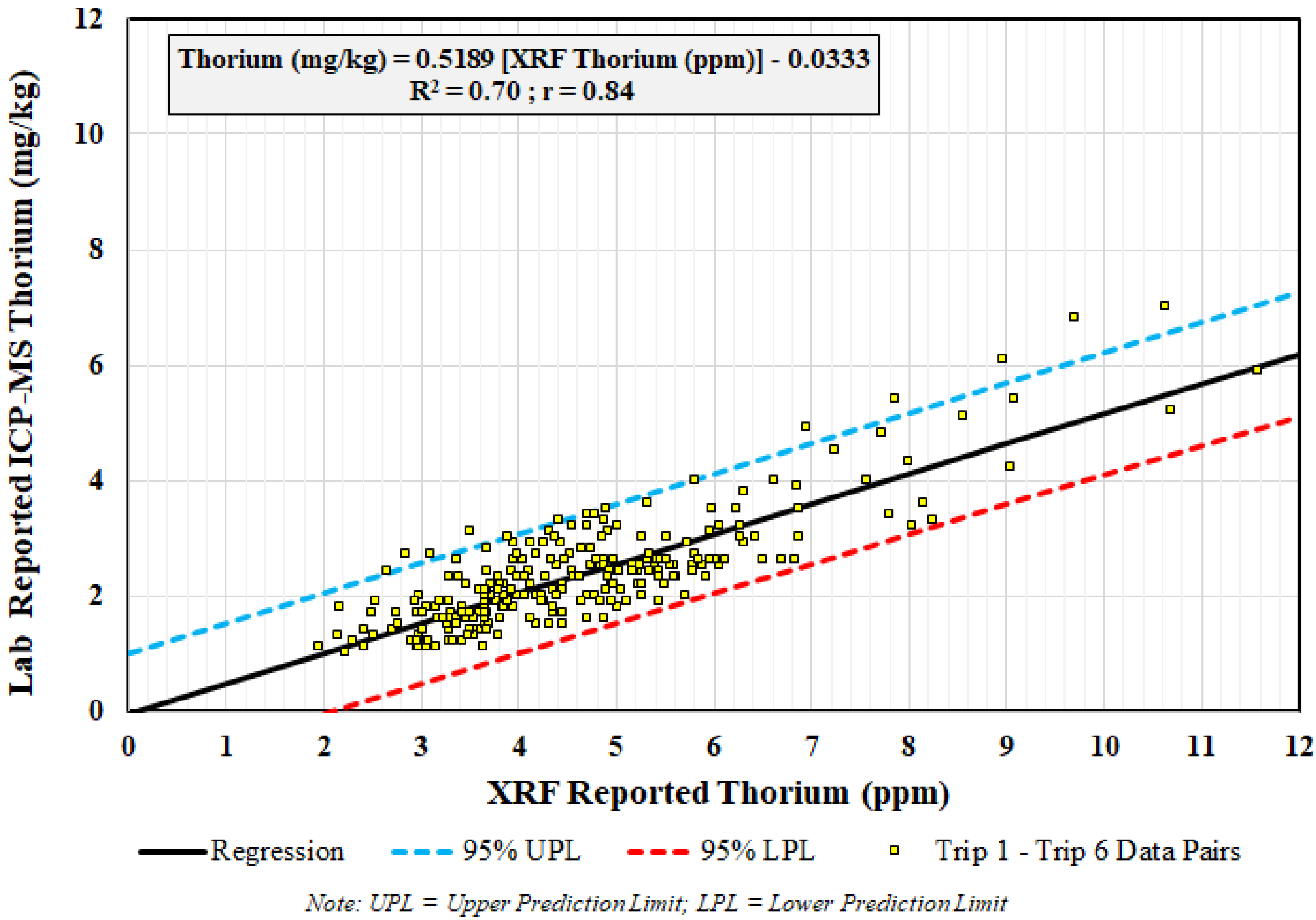


Figure B-44. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model TH-2A (Thorium)

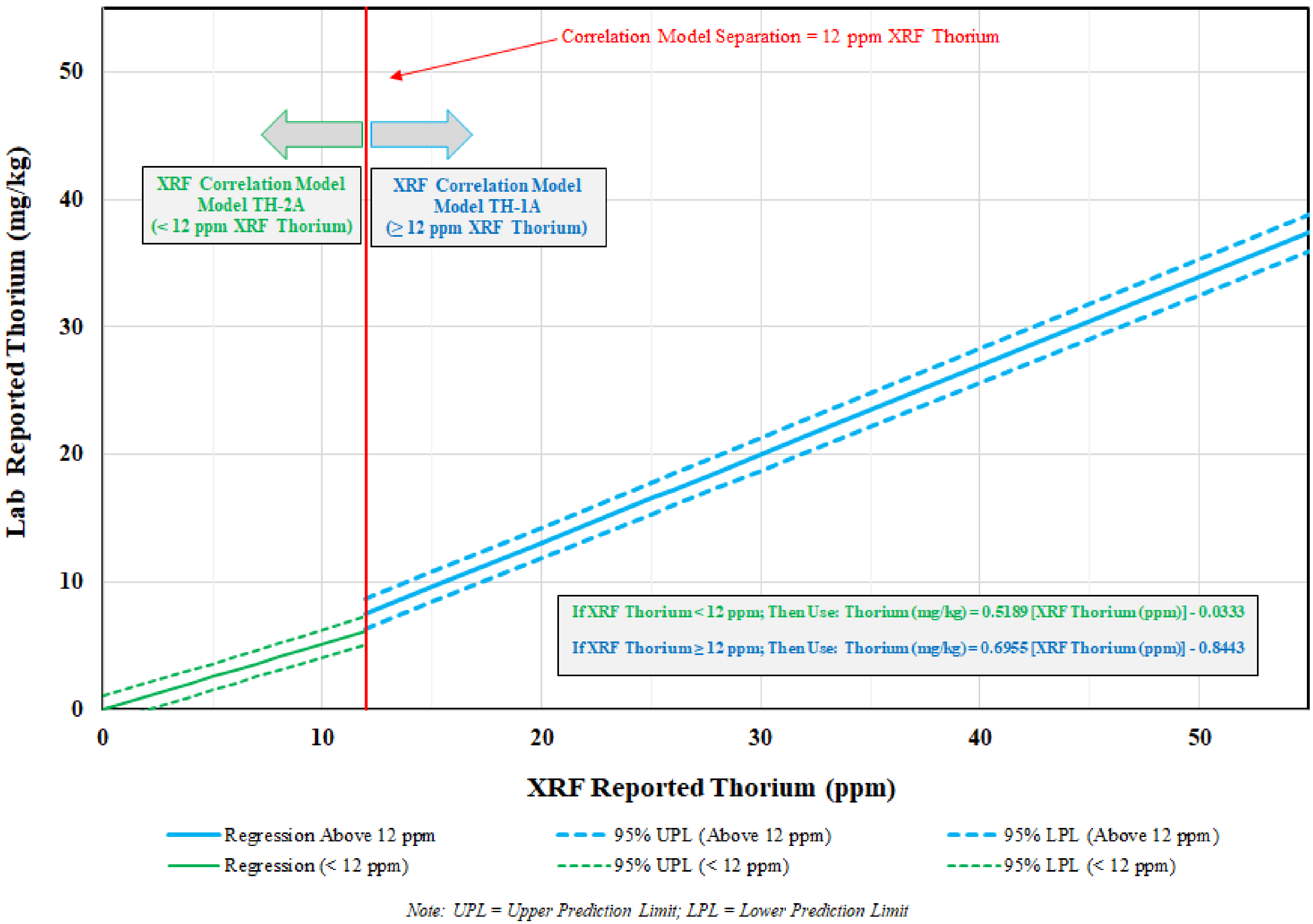


Figure B-45. Final XRF Correlation Models for Prediction of Thorium using XRF (Model TH-1A and Model TH-2A)

4.6.2 Linear Regression Analysis

A comparability study involved ex situ XRF thorium measurements and laboratory-reported thorium concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring thorium using this XRF method are discussed in Section 3.4, and the results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B5. Table B-57 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-57. Summary of Thorium Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.4237	0.2687	0.85	0.92
Red	0.403	0.5985	0.86	0.93
White	0.4395	0.1879	0.87	0.93
Average	**0.4221**	**0.3517**	**0.86**	**0.93**

Notes:
1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.
b y-intercept as calculated by the linear regression least squares method
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination
XRF X-ray fluorescence

Results indicate that the slope matches very well among XRF analyzers (RSD = 4.3 percent). The average R^2 (0.86) for results from application of the soil cup method is higher than the R^2 (0.84) computed from application of the bulk sample method; however, both methods show acceptable correlation coefficients. Figure B-46 compares soil cup method and bulk sample method regression models. In general, the bulk sample regression line agrees relatively closely with the range soil cup regression models; however, at XRF thorium levels above 6 ppm, the bulk sample model tends to represent a conservative estimate of the predicted laboratory-determined thorium concentration. This is because the average slope (m = 0.4221) of the soil cup method is lower than the slope (m = 0.5189) of the bulk sample method (Model TH-2A).

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported thorium concentrations. Figure B-47 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 38 of the 44 samples (86 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 21 percent. The mean of the bulk sample thorium concentration from the 44 samples was 3.3 mg/kg and decreased to 3.0 mg/kg in the soil cup samples—an RPD decrease of 11 percent.

Further discussion of particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

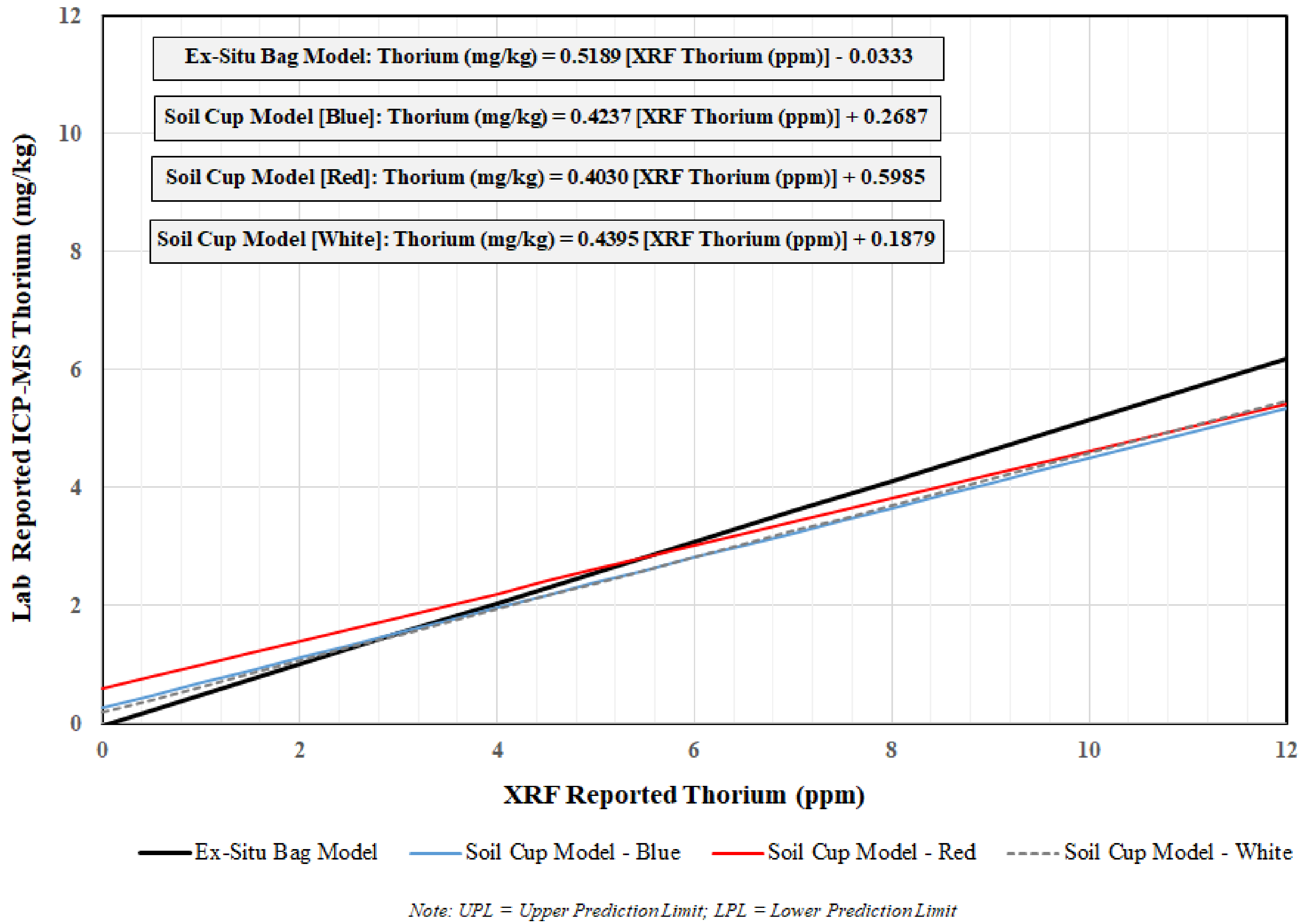


Figure B-46. Thorium Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

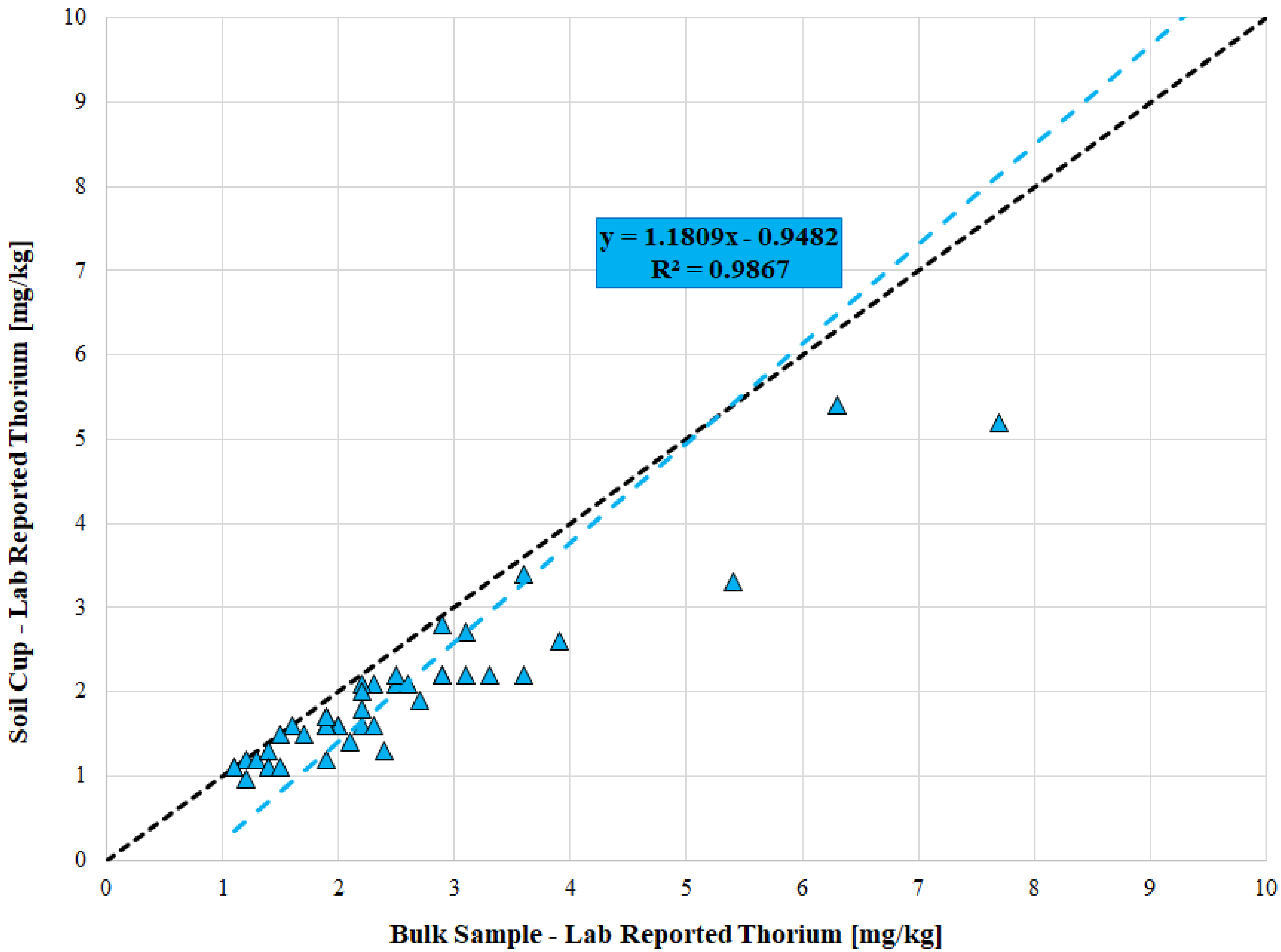


Figure B-47. Bulk Sample versus Soil Cup Thorium Concentration

4.6.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-58. A large number of samples were evaluated in application of each of the methods, as listed in in Table B-58.

Table B-58. Method Detection Limit for Thorium by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	111	2.0
Ex Situ XRF Bulk Sample	246	2.1
Ex Situ XRF Soil Cup	104	2.1

Notes:

Manufacturer reported MDL of 1 mg/kg for thorium using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

1 MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.

MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.6.4 Precision of XRF Analysis

An evaluation of precision for determination of thorium was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of thorium concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-59 summarizes calculated precisions for the different ranges of concentrations for each method type. For all XRF methods of measuring thorium concentration, precision improved as concentration increased. This was expected and shows the XRF analyzer responded better at higher thorium concentrations in soil. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-59. Summary of Calculated Precision of XRF Method for Thorium

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	1	31%	110	17%	63	12%	1	5.8%	175	14%
Ex Situ XRF Bulk Sample	91	17%	155	14%	8	10%	2	5.6%	256	15%
Ex Situ XRF Soil Cup	57	21%	47	16%	6	7.5%	3	2.9%	113	18%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with thorium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with thorium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with thorium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with thorium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.6.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-60 lists the RPD between the XRF and confirmatory soil cup data for different thorium soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-57) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined thorium concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 113 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of the criteria used for the concentration ranges is in Table B-11. Overall comparability across all concentration ranges and for all data combined significantly increases with application of a correction factor to the XRF data to estimate a predicted laboratory-determined thorium concentration. With use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

Table B-60. Comparability for Ex Situ XRF Soil Cup Method Thorium

XRF Method	Very Low		Low		Medium		High		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	57	67%	47	62%	6	66%	3	32%	113	65%
Ex Situ XRF Soil Cup (Corrected)	57	13%	47	14%	6	33%	3	2.9%	113	13%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with thorium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with thorium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with thorium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with thorium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSP
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-61 lists RPDs between XRF and confirmatory bulk sample data for different thorium soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample thorium regression model (Model TH-1A or Model TH-2A) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined thorium concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 256 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Overall comparability across all concentration ranges and for all data combined improves significantly with application of a correction factor to the XRF data to estimate a predicted laboratory-determined thorium concentration. By use of a correction factor, the comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are 13 percent and 15 percent, respectively. For both methods, comparability is significantly improved to acceptable levels with application of a correction factor for determination of thorium concentration. An RPD of 15 percent is considered good by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is in the following subsection.

Table B-61. Comparability for Ex Situ XRF Bulk Sample Method for Thorium

XRF Method	Very Low		Low		Medium		High		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	91	76%	155	63%	8	46%	2	35%	256	68%
Ex Situ XRF Bulk Sample (Corrected)	91	16%	155	15%	8	19%	2	3%	256	15%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 “Very low” refers to samples with thorium concentrations < 2x manufacturer reported MDL.
3 “Low” refers to samples with thorium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 “Medium” refers to samples with thorium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 “High” refers to samples with thorium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSP
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

4.6.6 Inferential Statistical Analysis

An analysis occurred to compare the XRF and the confirmatory thorium data by way of two-sample hypothesis testing and supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample thorium measurement values were corrected by application of Model TH-1A or Model TH-2A identified in Section 4.6.1. The hypothesis testing method selected was the Student’s t-test in ProUCL. The Student’s two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of thorium in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis (as in the linear regression). Table B-62 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that the XRF data set from each mobilization grouping equals the laboratory data set after application of a correction factor.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed the three-parameter lognormal distribution best fits the thorium confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-48 is a three-parameter lognormal probability plot showing the XRF-corrected thorium data set and the confirmatory thorium data set side by side, and indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-49 compares the same two data sets compared with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-62. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Thorium Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Thorium	1 - 6	XRF <> Lab	XRF = Lab
	7 - 9	XRF <> Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01).

1 Mobilization #1 – Mobilization #6 was the Baseline Study.

2 Mobilization #7 – Mobilization #9 was the Site Characterization Study.

3 Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.

4 Corrected refers to the XRF data that was converted using Model TH-1A or Model TH-2A correction factors.

XRF X-ray fluorescence

XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.

XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

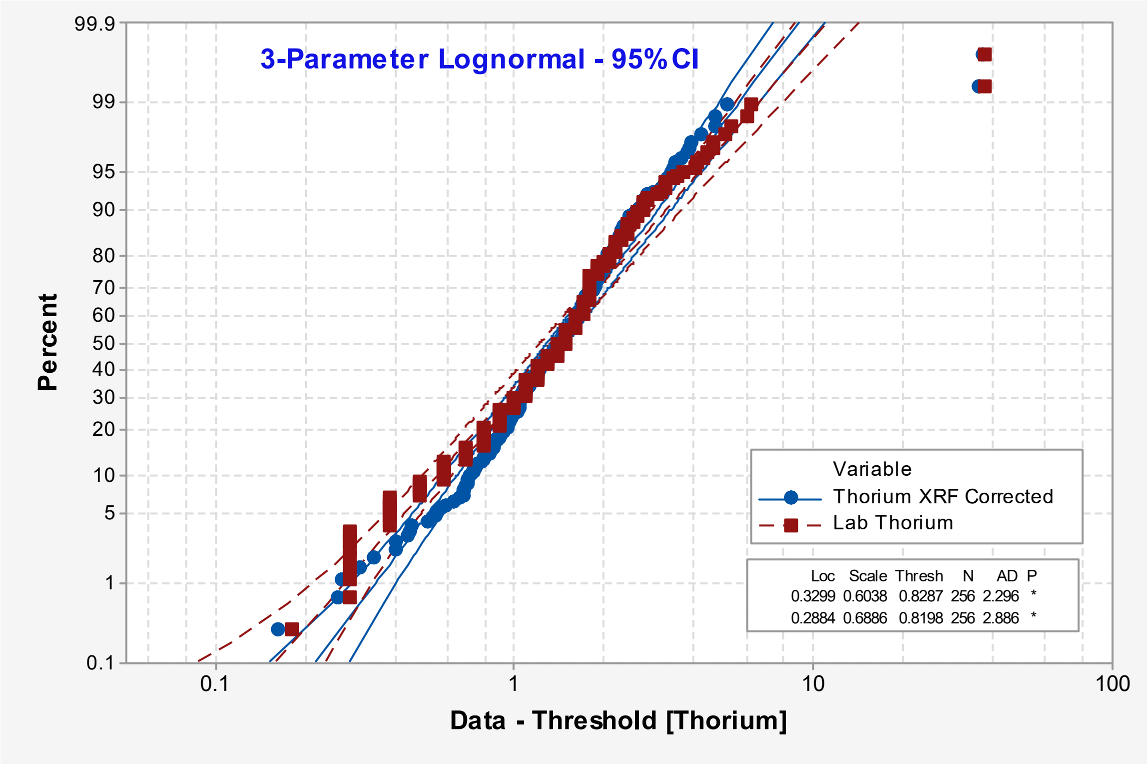


Figure B-48. Probability Plot of XRF Corrected Thorium Data Set and Confirmatory Thorium Data Set (3-Parameter Lognormal)

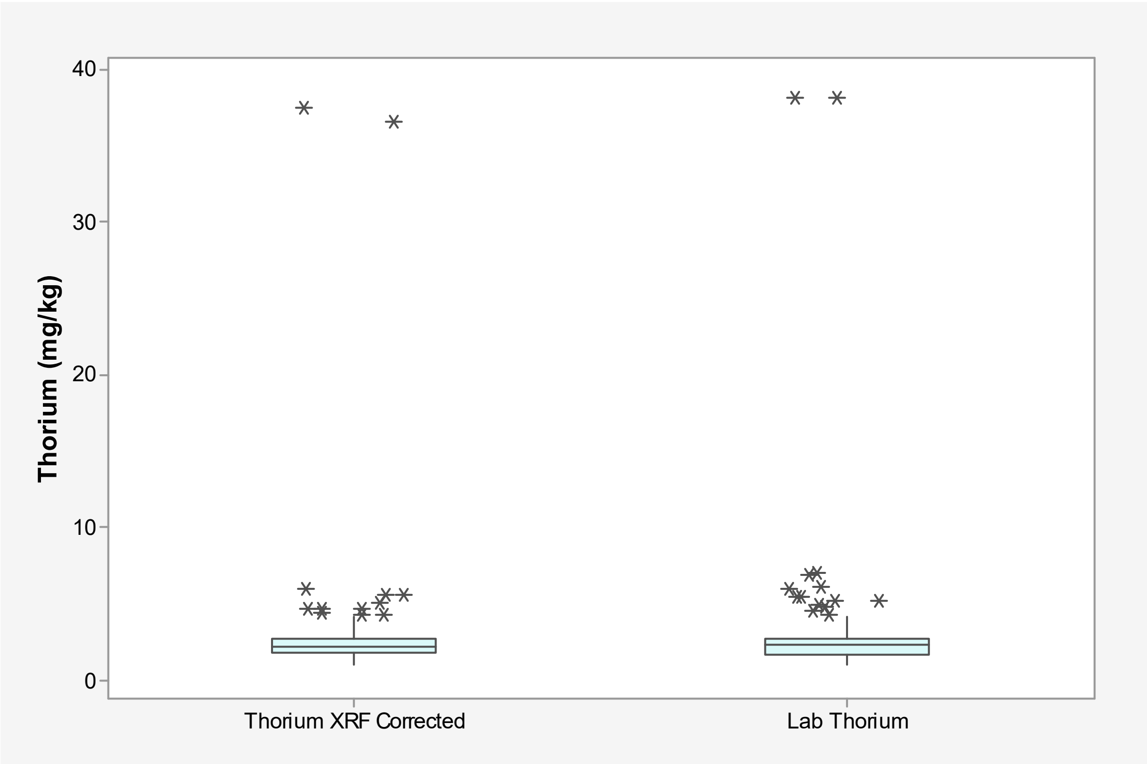


Figure B-49. Boxplot of XRF Corrected Thorium and Laboratory Reported Thorium

4.6.7 Sample Numbers and Descriptive Statistics

Table B-63 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF thorium measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for thorium with use of the XRF analyzer, 504 of these were below the MDL and qualified as such. The average detected thorium concentration of in situ XRF measurements after correction is 2.5 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 2.5 mg/kg thorium. A total of 292 surface soil samples were collected, averaging 2.7 mg/kg thorium. Therefore, 794 analytical surficial (XRF confirmation and surface soil) soil samples were collected in total across the sites, averaging 2.6 mg/kg thorium. In general, the average of the in situ XRF measurements was very close (RPD = 4.9 percent) to the project-wide thorium concentrations reported in surface soils via laboratory analytical method. XRF-reported average thorium concentration was slightly higher than that from application of laboratory analytical techniques, likely because the detection limit is not as low for the XRF method as for the analytical method.

Table B-63. Summary of Project Wide Thorium Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	9,036	502	292	794
Nondetects	#	504	0	0	0
Minimum	mg/kg	1.0	0.66	0.77	0.66
Maximum	mg/kg	90	38	15	38
Average	mg/kg	2.5	2.5	2.7	2.6
Standard Deviation	mg/kg	1.7	1.9	1.6	1.8
Median	mg/kg	2.3	2.3	2.5	2.4
90th Percentile	mg/kg	3.6	3.6	4.0	3.8
95th Percentile	mg/kg	4.2	4.4	4.9	4.8
99th Percentile	mg/kg	5.7	6.9	9.3	7.6

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined thorium concentrations using correction factors from Model TH-1A or Mode TH-2A.

3 Laboratory-reported thorium concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).

bgs Below ground surface
ICP-MS Inductively coupled plasma-mass spectrometry
mg/kg Milligrams per kilogram
XRF X-ray fluorescence

4.6.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported thorium concentrations in the bulk soil samples, as summarized in Section 4.6.1, led to selection of two models to appropriately bracket the concentrations of interest at the site. Model TH-2A was selected as the optimal model to best predict laboratory thorium concentrations by use of XRF analyzers when thorium concentrations are near background levels (< 12 ppm), and Model TH-1A was selected as the optimal model when thorium concentrations equal or exceed 12 ppm. These models were both used to post-process the in situ XRF measurements to correct them to a more accurate representation of the measurement technique applied to evaluate thorium via laboratory analysis (ICP-MS after acid partial digestion), and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining thorium concentrations by use of XRF analyzers (Model TH-2A only), the correlation coefficient (r = 0.84), in situ XRF measurement precision (RSD = 14 percent), and corrected ex situ XRF bulk sample comparability (15 percent) all meet the criteria for thorium data reported by XRF analyzers to be considered at a definitive level. The inferential statistics indicate that the two data sets are equal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparing the corrected XRF thorium data set to the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model TH-1A) and for Mobilization #7 through Mobilization #9 (not used in model development). For both analyses, the inferential statistics indicate that the mean of corrected XRF data is equal to that of the laboratory confirmatory data at a 99 percent confidence level.

Comparison of results from the soil cup method to results from the bulk sample method indicates that the bulk sample method is more conservative at estimating thorium concentrations (Figure B-46). Also, application of the bulk sample method tends to reflect site conditions more closely with regarding particle size, moisture content, and concentration. Therefore, Model TH-2A and Model PB-1A are the final models selected, and were used to correct and post-process in situ XRF measurements to predicted laboratory thorium concentrations for the RSE reports. Equation 8 and Equation 9 express the resulting linear regression model calculated for thorium by use of the 264 data pairs of ex situ XRF bulk sample thorium measurements and laboratory-reported thorium concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 through Mobilization #6:

Equation 8 (< 12 ppm): $[Th]_{lab} = (0.5189 * [Th]_{XRF}) - 0.0333$

Equation 9 (≥ 12 ppm): $[Th]_{lab} = (0.6955 * [Th]_{XRF}) - 0.8443$

Figure B-50 shows both primary bulk sample thorium regression models (Model TH-1A and Model TH-2A) with respect to unity. Model TH-2A (shown in blue) is used for predicting thorium concentration when XRF measurements are less than 12 ppm, and Model TH-1A (shown in green) is used when XRF measurements exceed or equal 12 ppm. These lines are shown with respect to the unity line (shown in black—that is, if the model was perfect [XRF to lab]). The thorium regression models all fall below unity, indicating requirement for a correction factor to improve comparability of the XRF data to predicted laboratory-determined thorium concentrations. Figure B-51 shows the final selected XRF regression model for thorium for both concentration ranges.

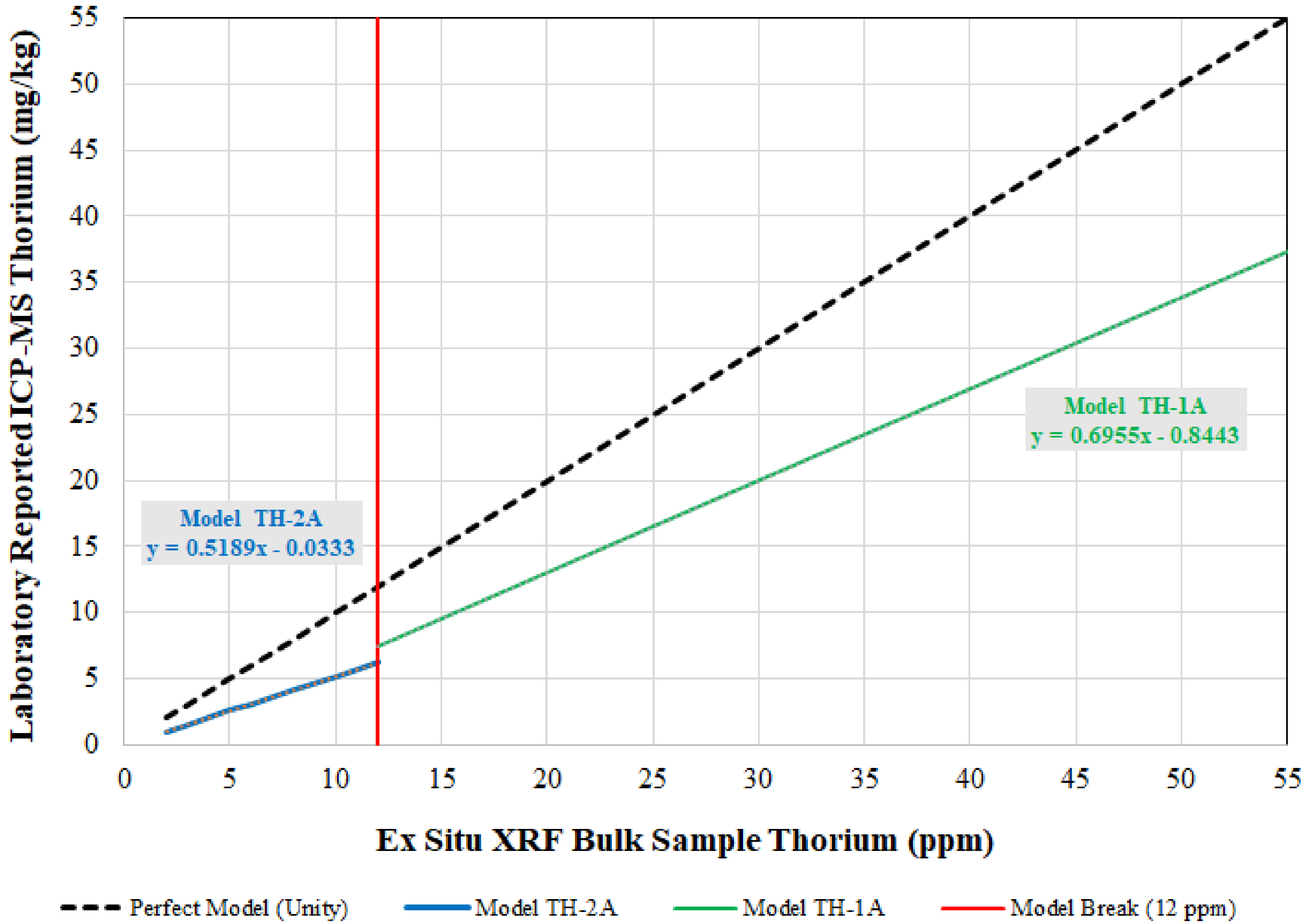


Figure B-50. Final Thorium Regression Models– Unity Comparison

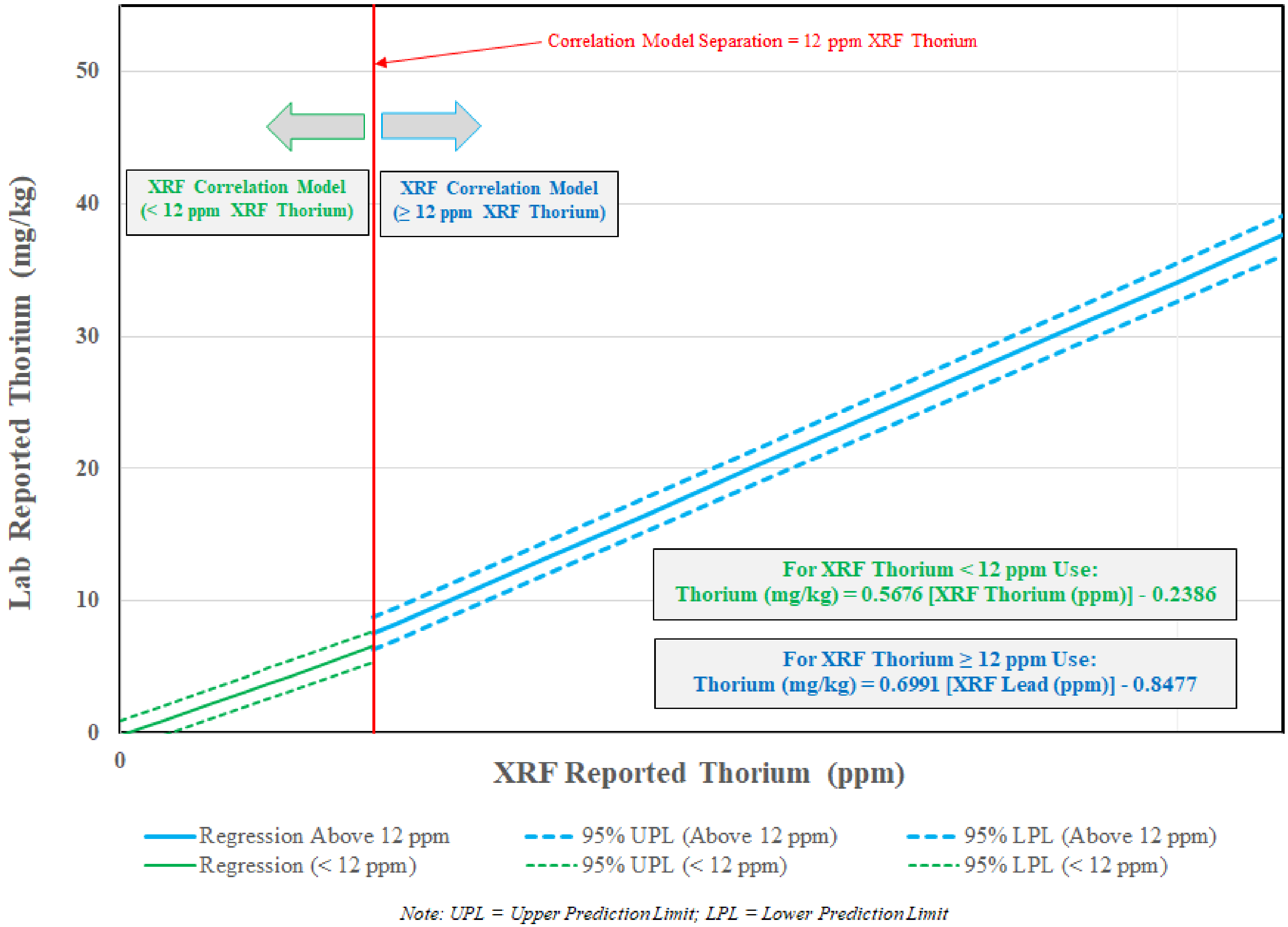


Figure B-51. Final Selected XRF Regression Model for Thorium

4.7 URANIUM

4.7.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Because of the large range of uranium concentrations within the complete data set, an evaluation of the complete data set (Model U-1) occurred, along with an evaluation of the data set restricted only to XRF-measured uranium concentrations less than 95 ppm.

The first model, referred to as Model U-1, upon removal of 47 nondetects, included 217 of 264 data pairs with uranium concentrations. For Model U-1, a linear regression least squares analysis was applied on the 217 uranium data pairs. For these data pairs, the laboratory reported uranium concentrations from the data set ranging from 0.46 to 370 mg/kg, with an average of 38 mg/kg. Upon visual inspection of the regression model and evaluation of the standardized residuals of Model U-1, four data pairs appeared as obvious outliers with the four largest residuals.

Table B-64 summarizes the data pairs with the four largest residuals. For three of these samples (M21-XS302-02-060918, M4-XS63-01-050718, and M6-XS269-01-04262018), RSDs were all low but RPDs were abnormally high. Suspicion is that either laboratory error occurred or the "nugget" effect was responsible. One of the samples was rerun and digested again by the laboratory (M21-XS302-02-060918), and the rerun yielded 97 mg/kg (previously it had been 350 mg/kg). The fourth sample, M28-XS148-01-062018, had a lower RPD but was a visual outlier that did not represent the population. A decision to remove the four samples identified in Table B-64 occurred prior to reanalysis of any more models. These four samples would be removed from all future regression models and flagged as outliers.

Model U-2 is the second regression model evaluated for uranium, including the full data set excluding nondetects and any data pair with average ex situ XRF uranium measurement exceeding 95 ppm (27 data pairs identified for exclusion). This model included 190 data pairs with laboratory-reported uranium concentrations ranging from 0.46 to 100 mg/kg. The correlation coefficient decreased from Model U-1 (r = 0.86) to Model U-2 (r = 0.83) as the slope increased (from 0.7378 to 0.8396), indicating a distinction between the bracketed concentrations. Upon visual inspection of the Model U-2 regression and of the standardized residuals, more data pairs with large residuals were evident. Six of the data pairs with the six highest standardized residuals were also identified via visual inspection (listed in Table B-65). These six data pairs were flagged as outliers and removed from all future regression models.

Upon removal of the six outliers listed in Table B-65, the lower bracketed concentrations were reevaluated in Model U-2A. This model consisted of 184 data pairs and had a slope of 0.8031, y-intercept of -2.266, and the correlation coefficient (r = 0.94) was significantly improved. Visual inspection and evaluation of the standardized residuals identified no additional outliers. Model U-2A was the final model selected to represent the data in the lower bracket or uranium concentrations, that is for data pairs with XRF uranium measurements less than 95 ppm. A final regression model was evaluated, Model U-1A, which reevaluated the complete data set less outliers, and excluded the data pairs listed in Table B-64 and Table B-65. This model involved 207 data pairs and had a high correlation coefficient (r = 0.96). The slope of Model U-1A was not much different than that of Model U-2A. Visual inspection of the Model U1-A regression model and the associated standardized residuals identified no additional outliers, and Model U1-A was selected as the final model to best represent any XRF measurements exceeding 95 ppm. Table B-66 summarizes the parameters of the uranium regression models evaluated for uranium.

Figure B-52 shows the final selected data pairs included in Model U-2A with the 95 percent prediction limits and the uranium data pairs with outliers removed. The final regression model for the lower XRF concentrations of uranium (< 95 ppm) is Model U-2A, and the final regression model for any XRF concentration of uranium above 95 ppm is Model U-1A. Both of these models with the respective prediction limits and primary linear regression models tied together are shown on Figure B-53.

Attachment B3 presents statistical analyses of all regression models evaluated for uranium (Model U-1, Model U-1A, Model U-2, and Model U-2A). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residuals, normal probability plot of standardized residuals, and histogram of standardized residuals for each regression model. Attachment B4 presents all data, in tabular format, either included or excluded in the final uranium models: Model U-1A and Model U-2A, and also presents the data pairs from Mobilization #7 through Mobilization #9. The following subsection conveys results of the soil cup comparability study for uranium. That subsection compares Model U-2A to the various soil cup regression models (lower concentration models only).

Table B-64. Summary of Data Pairs with Large Residuals for Uranium in Model U-1

Sample ID	Average Ex Situ XRF Uranium Value (ppm)[1]	RSD of Ex Situ XRF Values[2]	Laboratory Uranium Result (ppm)[3]	RPD of Data Pairs
M21-XS302-02-060918	48	16%	350	152%
M4-XS63-01-050718	127	18%	320	86%
M6-XS269-01-04262018	20	10%	240	169%
M28-XS148-01-062018	477	70%	240	66%

Notes:

1 Average of six ex situ XRF uranium measurements taken on the bulk sample.
2 RSDs of the six ex situ XRF uranium measurements taken on the bulk sample.
3 Laboratory-reported uranium concentration via partial digestion (3050B) and ICP-MS (6020A).
ICP-MS Inductively coupled plasma-mass Spectrometry
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

Table B-65. Summary of Outliers Identified in Model U-2 and Removed for Model U-2A

Sample ID	Average Ex Situ XRF Uranium Value (ppm)[1]	RSD of Ex Situ XRF Values[2]	Laboratory Uranium Result (ppm)[3]	RPD of Data Pairs
M16-XS166-01-052118	47	35%	100	71%
M16-XS45-01-052118	31	11%	83	90%
M25-XS16-01-071718	11	17%	74	150%
M22-XS60-01-060418	35	11%	67	63%
M15-XS73-01-052118	21	4%	49	80%
M1-XS31-01-051218	17	11%	38	76%

Notes:

[1] Average of six ex situ XRF uranium measurements taken on the bulk sample.
[2] RSDs of the six ex situ XRF uranium measurements taken on the bulk sample.
[3] Laboratory-reported uranium concentration via partial digestion (3050B) and ICP-MS (6020A).
ICP-MS Inductively coupled plasma-mass spectrometry
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

Table B-66. Summary of Parameters for Ex Situ Bulk Sample Uranium Regression Models

Model Name	Data Pairs	Higher Values Removed	Nondetects Removed	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model U-1	217	-	47	-	0.7378	5.4561	0.74	0.86
Model U-2	190	27	47	-	0.8396	-1.4354	0.69	0.83
Model U-2A	184	27	47	6	0.8031	-2.266	0.89	0.94
Model U-1A	207	-	47	10	0.7677	-0.0998	0.92	0.96

Notes:

[1] Eight other data pairs were removed because of an instrumental error; these were not true outliers.
b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination

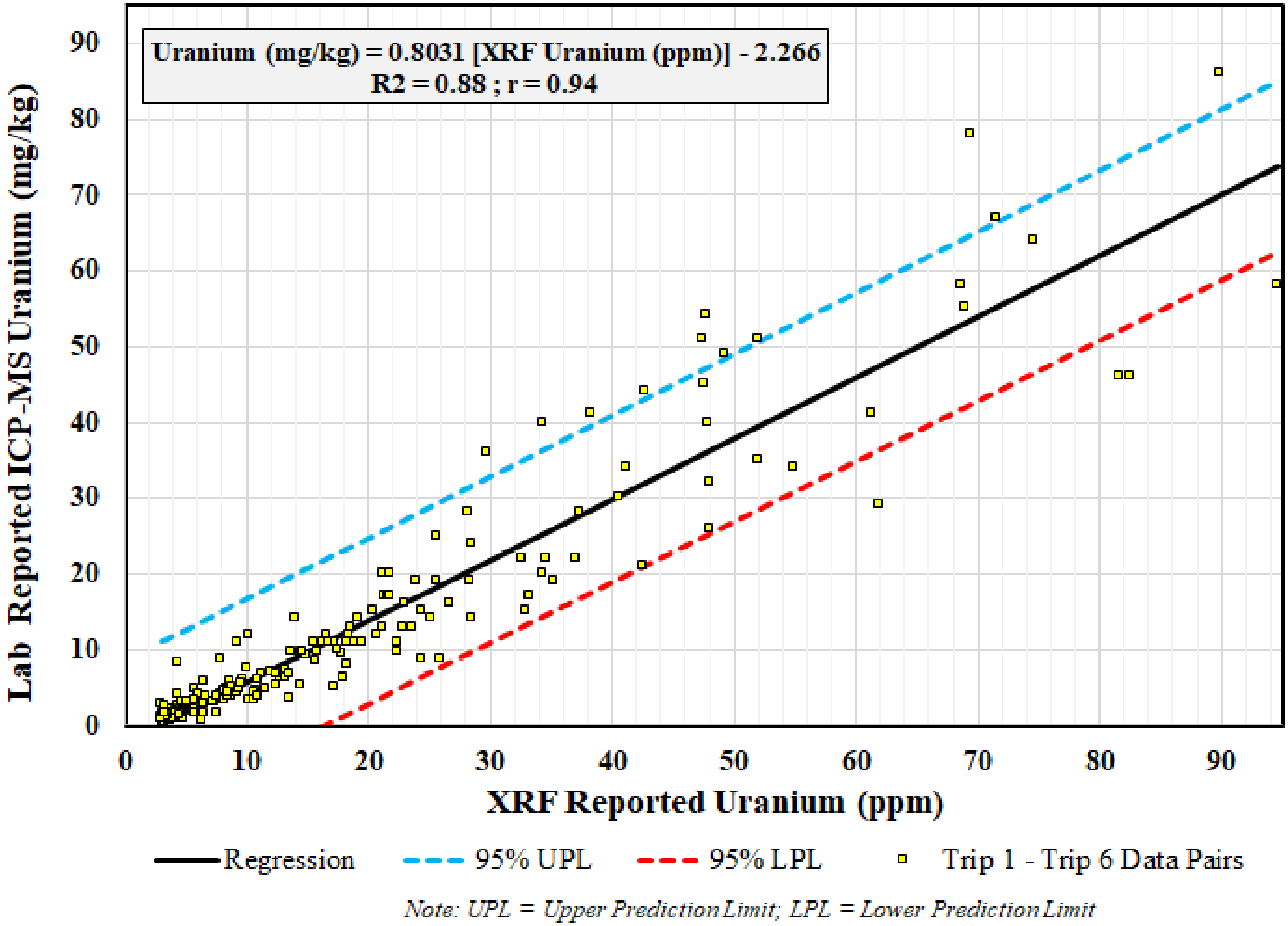


Figure B-52. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model U-2A (Uranium)

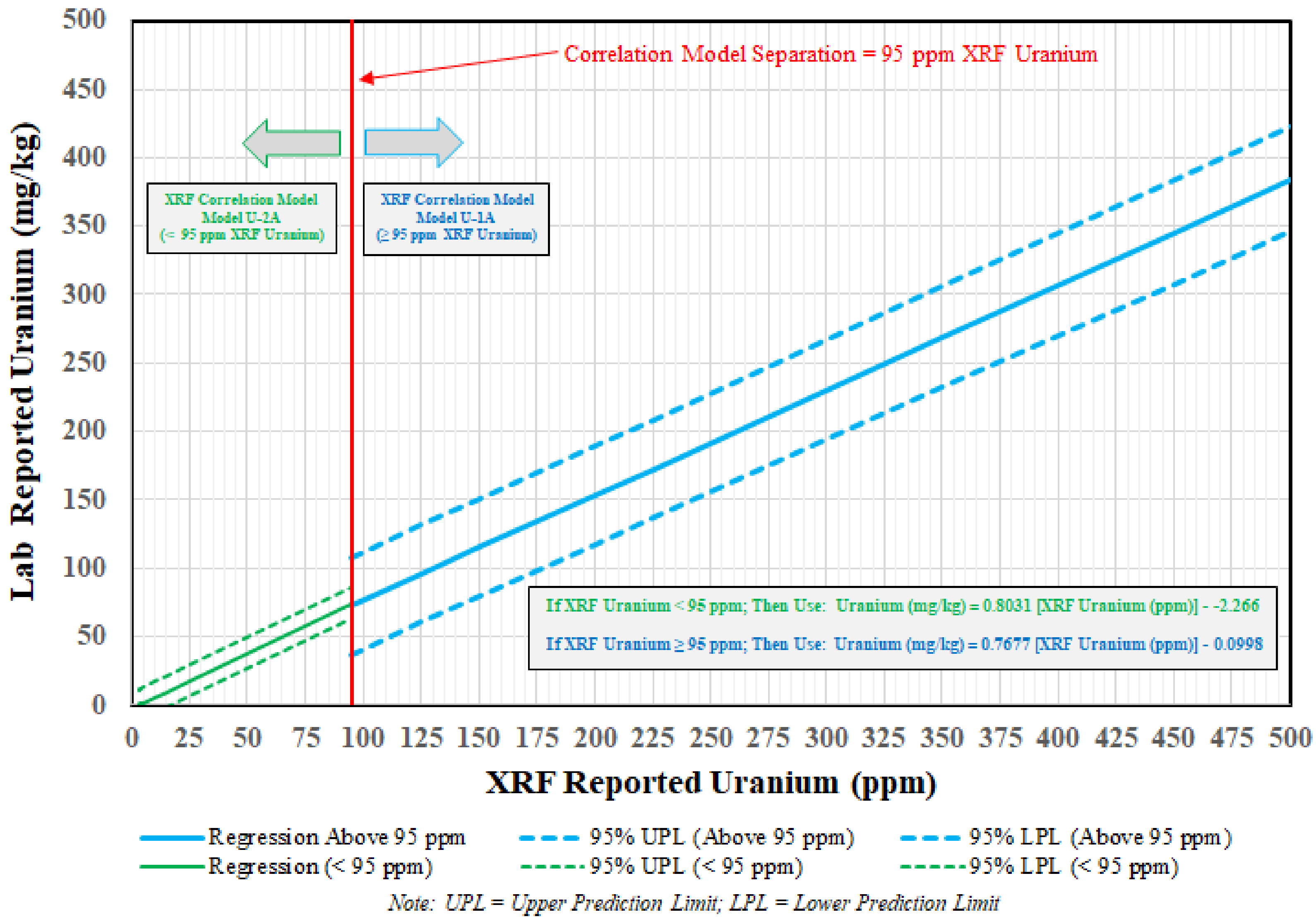


Figure B-53. Final XRF Correlation Models for Prediction of Uranium using XRF (Model U1A and Model U-2A)

4.7.2 Linear Regression Analysis

A comparability study involved ex situ XRF uranium measurements and laboratory-reported uranium concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring uranium using this XRF method are discussed in Section 3.4, and the results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B3. Table B-67 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-67. Summary of Uranium Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.8342	-2.7423	0.87	0.93
Red	0.8431	-3.3273	0.88	0.94
White	0.8702	-4.3499	0.83	0.91
Average	**0.8492**	**-3.4732**	**0.86**	**0.93**

Notes:

1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.

b y-intercept as calculated by the linear regression least squares method

m slope of linear regression line as calculated by the linear regression least squares method

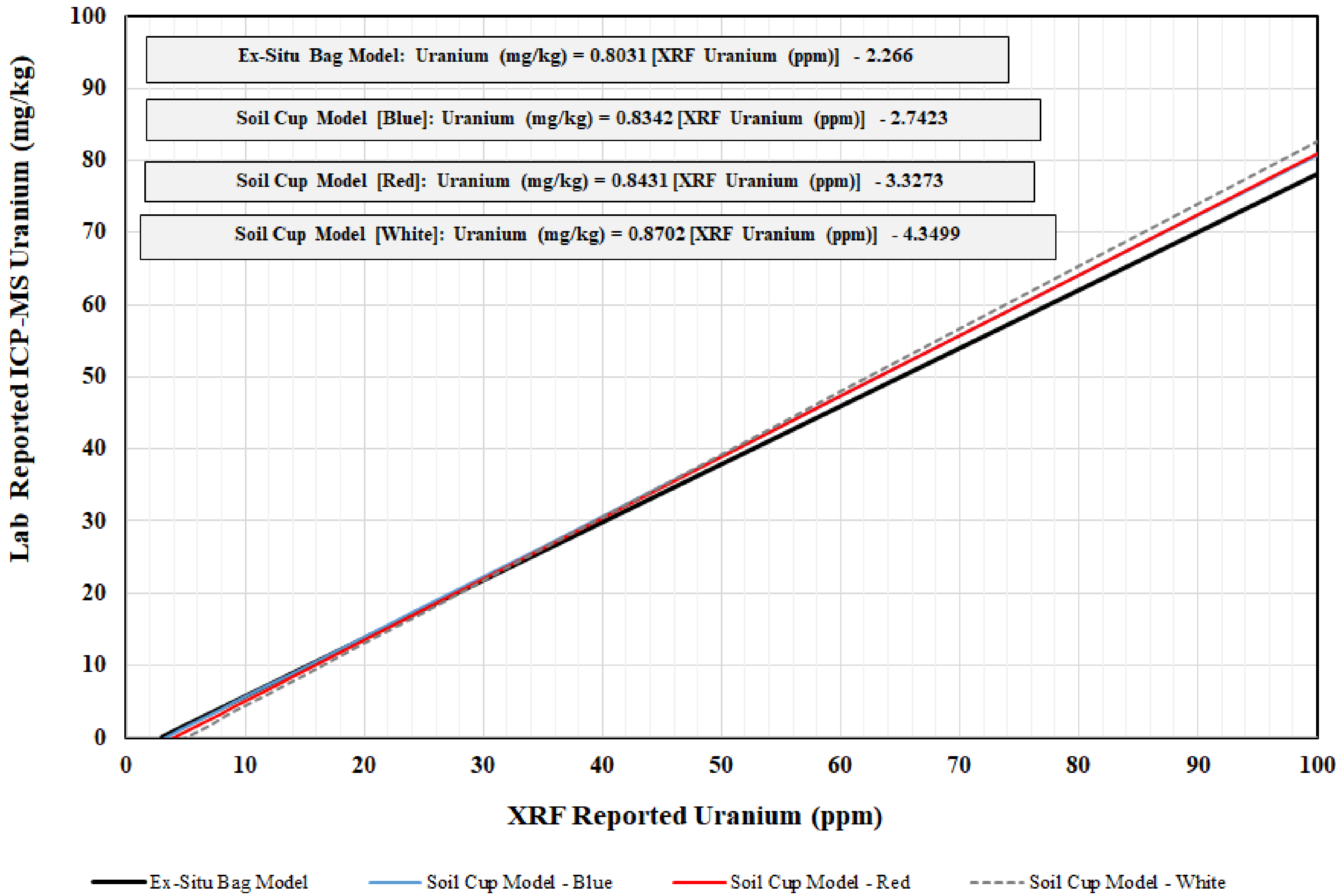
r Pearson's correlation coefficient

R^2 Coefficient of determination

XRF X-ray fluorescence

Results indicate that the slope did not vary much among XRF analyzers (RSD = 2.2 percent). The average R^2 (0.86) for results from application of the soil cup method is lower than the R^2 (0.94) computed from application of the bulk sample method; however, both methods show acceptable correlation coefficients. Figure B-54 compares soil cup method and bulk sample method regression models. At all uranium levels, very little difference among the models appears.

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported uranium concentrations. Figure B-55 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 26 of the 44 samples (59 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 23 percent. The mean of the bulk sample uranium concentration from the 44 samples was 73 mg/kg and decreased to 68 mg/kg in the soil cup samples—an RPD decrease of 10 percent. Further discussion of particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.



Note: UPL = Upper Prediction Limit; LPL = Lower Prediction Limit

Figure B-54. Uranium Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

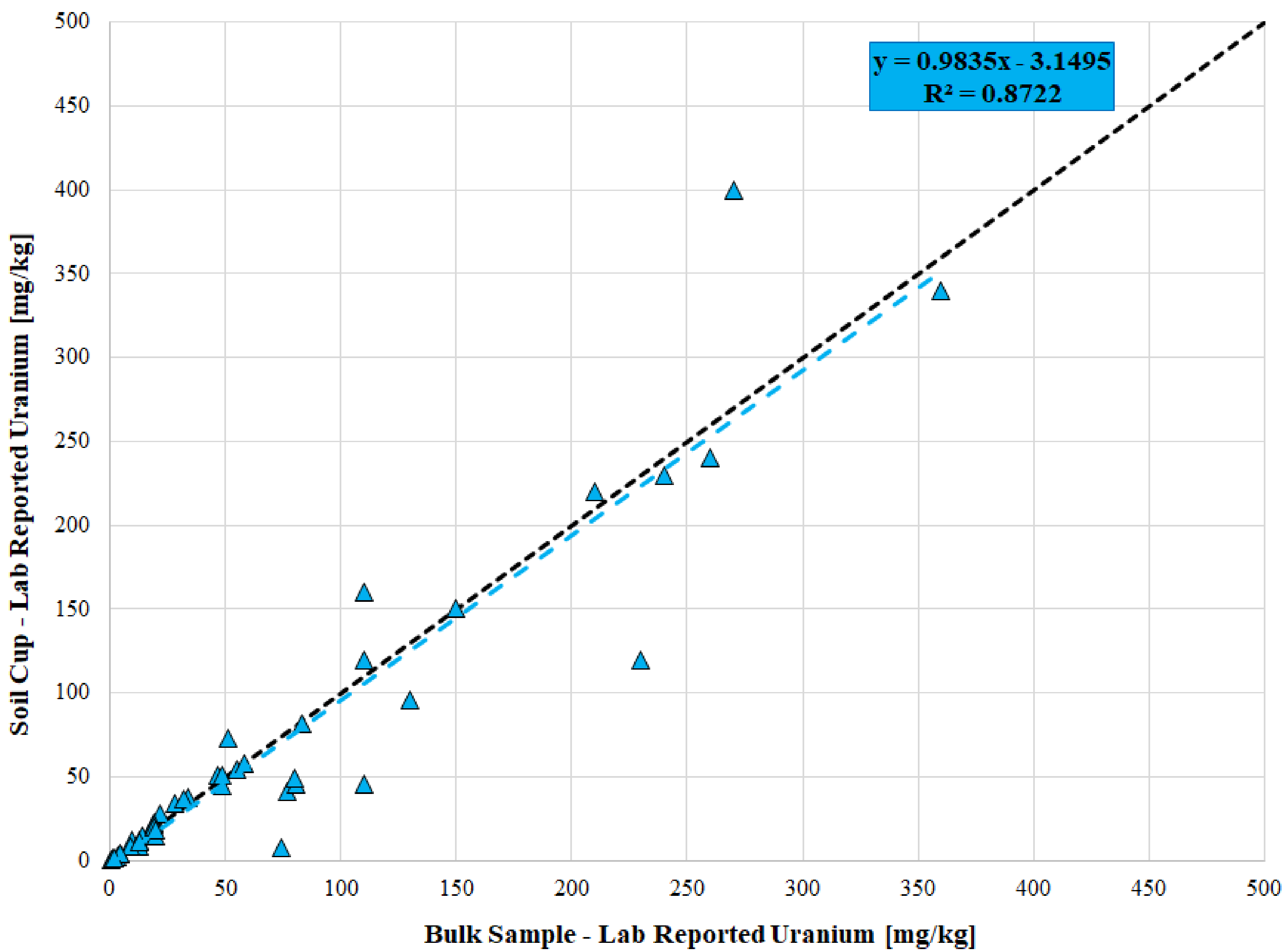


Figure B-55. Bulk Sample versus Soil Cup Uranium Concentration

4.7.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-68. A large number of samples were evaluated in application of each of the ex situ methods, as listed in Table B-68.

Table B-68. Method Detection Limit for Uranium by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	127	2.9
Ex Situ XRF Bulk Sample	109	4.4
Ex Situ XRF Soil Cup	27	4.2

Notes:

Manufacturer reported MDL of 2 mg/kg for uranium using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

[1] MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.

MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.7.4 Precision of XRF Analysis

An evaluation of precision for determination of uranium was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of uranium concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-69 summarizes calculated precisions for the different ranges of concentrations for each method type. For all XRF methods of measuring uranium concentration, precision improved as concentration increased. This was expected and shows the XRF analyzer responded better at higher uranium concentrations in soil. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-69. Summary of Calculated Precision of XRF Method for Uranium

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	21	24%	106	14%	27	8.5%	18	6.7%	172	13%
Ex Situ XRF Bulk Sample	64	19%	45	15%	37	14%	61	13%	207	16%
Ex Situ XRF Soil Cup	9	19%	18	9.3%	17	9.6%	84	9.0%	128	10%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 "Very low" refers to samples with uranium concentrations < 2x manufacturer reported MDL.

3 "Low" refers to samples with uranium concentrations ≥ 2x to < 5x manufacturer reported MDL.

4 "Medium" refers to samples with uranium concentrations ≥ 5x to < 10x manufacturer reported MDL.

5 "High" refers to samples with uranium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit

n Number of samples used for calculating median RSD

RSD Relative standard deviation (presented as median RSD)

XRF X-ray fluorescence

4.7.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-70 lists the RPD between the XRF and confirmatory soil cup data for different uranium soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-67) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined uranium concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 128 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of the criteria used for the concentration ranges is in Table B-11. Similar to the observed precision resulting from application of the soil cup method (Section 4.7.4), comparability tends to increase (that is, RPD decreases) as concentration increases. Overall comparability across all concentration ranges and for all data combined significantly increases with application of a correction factor to the XRF data to estimate a predicted laboratory-determined uranium concentration. With use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

Table B-70. Comparability for Ex Situ XRF Soil Cup Method Uranium

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	9	101%	18	76%	17	51%	84	23%	128	29%
Ex Situ XRF Soil Cup (Corrected)	9	50%	18	37%	17	23%	84	11%	128	16%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with uranium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with uranium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with uranium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with uranium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-71 lists RPDs between XRF and confirmatory bulk sample data for different uranium soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample uranium regression models (Model U-2A and Model U-1A) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined uranium concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 207 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Overall comparability across all concentration ranges and for all data combined improves significantly with application of a correction factor to the XRF data to estimate a predicted laboratory-determined uranium concentration. By use of a correction factor, the comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are 16 percent and 12 percent, respectively. For both methods, comparability is significantly improved to acceptable levels with application of a correction factor for determination of uranium concentration. An RPD of 22 percent is considered good by USEPA (1998 and 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is in the following subsection.

Table B-71. Comparability for Ex Situ XRF Bulk Sample Method for Uranium

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	64	86%	45	60%	37	43%	61	19%	207	56%
Ex Situ XRF Bulk Sample (Corrected)	64	39%	45	21%	37	14%	61	21%	207	22%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with uranium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with uranium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with uranium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with uranium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

4.7.6 Inferential Statistical Analysis

An analysis occurred to compare the XRF and the confirmatory uranium data by way of two-sample hypothesis testing and supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample uranium measurement values were corrected by application of Model U-1A or Model U-2A identified in Section 4.7.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample, size normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of thorium in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis (as in the linear regression). Table B-72 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that both uncorrected and corrected XRF data sets from each mobilization grouping equal the laboratory data set.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed that the lognormal distribution best fits the uranium confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-56 is a lognormal probability plot showing the XRF-corrected uranium data set and the confirmatory uranium data set side by side, indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-57 compares the same two data sets with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-72. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Uranium Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Uranium	1 - 6	XRF = Lab	XRF = Lab
	7 - 9	XRF = Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01).

1 Mobilization #1 – Mobilization #6 was the Baseline Study.
2 Mobilization #7 – Mobilization #9 was the Site Characterization Study.
3 Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.
4 Corrected refers to the XRF data that was converted using Model U-2A or Model U-1A correction factors.

XRF X-ray fluorescence
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

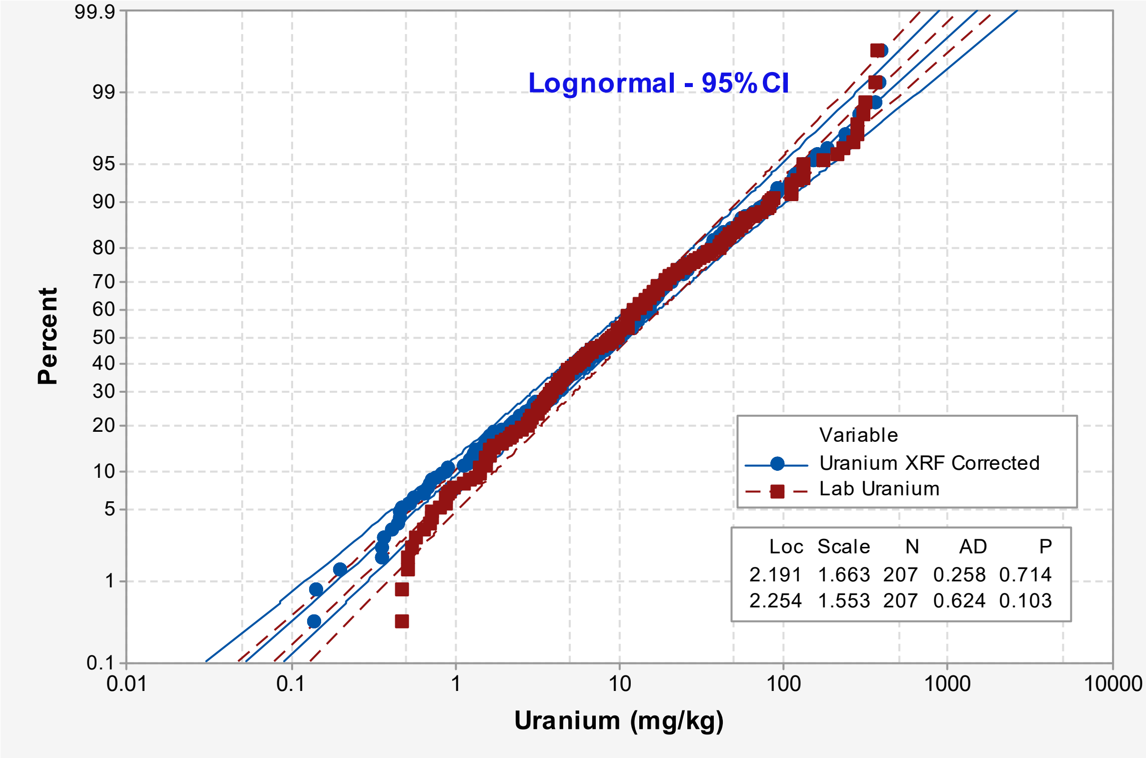


Figure B-56. Probability Plot of XRF Corrected Uranium Data Set and Confirmatory Uranium Data Set (Lognormal)

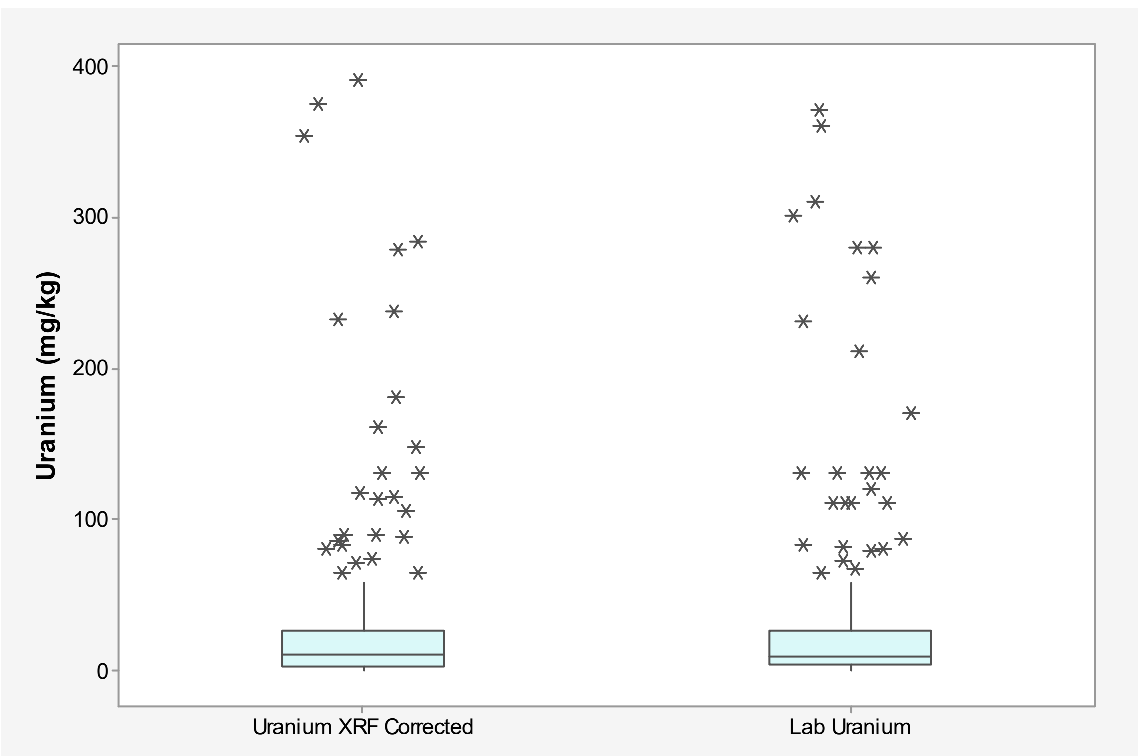


Figure B-57. Boxplot of XRF Corrected Uranium and Laboratory Reported Uranium

4.7.7 Sample Numbers and Descriptive Statistics

Table B-73 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF uranium measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for uranium with use of the XRF analyzer, 1,083 of these were below the MDL and qualified as such. The average detected uranium concentration of in situ XRF measurements after correction is 12 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 24 mg/kg uranium. A total of 292 surface soil samples were collected, averaging 35 mg/kg uranium. Therefore, 794 analytical surficial (XRF confirmation and surface soil) soil samples were collected in total across the sites, averaging 28 mg/kg uranium. The average of the in situ XRF measurements was much lower (RPD = 83 percent) than project-wide uranium concentrations reported in surface soils via laboratory analytical method. XRF-reported average uranium concentration was lower than that from application of laboratory analytical techniques because in situ XRF measurements occurred within large land areas where uranium concentrations were at background levels, whereas surface sampling, while focused on the range of concentrations, was biased toward higher areas of uranium concentrations such as waste piles. Moreover, this shows that as an indicator element for identifying mine waste areas, uranium is superior to some of the other elements (for example, thorium), which exhibit more consistent concentrations even across areas of mining disturbance. Vanadium is similar to uranium in this regard.

Table B-73. Summary of Project Wide Uranium Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	8,457	502	292	794
Nondetects	#	1,083	0	0	0
Minimum	mg/kg	0.08	0.24	0.34	0.24
Maximum	mg/kg	1,264	660	710	710
Average	mg/kg	12	24	35	28
Standard Deviation	mg/kg	36	59	92	73
Median	mg/kg	3.9	3.8	4.4	4.0
90th Percentile	mg/kg	20	64	86	72
95th Percentile	mg/kg	40	120	175	143
99th Percentile	mg/kg	159	280	457	370

Notes:
1 Descriptive statistics presented are of the detected concentrations only.
2 In situ XRF measurements were converted to predicted laboratory-determined uranium concentrations using correction factors from Model U-1A or Model U-2A.
3 Laboratory-reported uranium concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).
mg/kg Milligrams per kilogram
bgs Below ground surface
ICP-MS Inductively coupled plasma-mass spectrometry
XRF X-ray fluorescence

4.7.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported uranium concentrations for the bulk soil samples, as summarized in Section 4.7.1, led to selection of two models to appropriately bracket the concentrations of interest at the site. Model U-2A was selected as the optimal model to best predict laboratory uranium concentrations by use of XRF analyzers when uranium concentration are near background levels (< 95 ppm), and Model U-1A was selected as the optimal model when uranium concentrations equal or exceed 95 ppm. These models were both used to post-process the in situ XRF measurements to correct them to a more accurate representation of the measurement technique applied to evaluate uranium via laboratory analysis (ICP-MS after acid partial digestion), and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining uranium concentrations by use of XRF analyzers (Model U-2A only), the correlation coefficient (r = 0.94), in situ XRF measurement precision (RSD = 13 percent), and corrected ex situ XRF bulk sample comparability (22 percent) all meet the criteria for uranium data reported by XRF analyzers to be considered at a quantitative screening level. The inferential statistics indicate that the two data sets are equal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparing the corrected XRF uranium data set to the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model U-1A) and for Mobilization #7 through Mobilization #9 (not used in model development). For both analyses, the inferential statistics indicate that the mean of corrected XRF data equals that of the laboratory confirmatory data at a 99 percent confidence level.

Comparison of results from the soil cup method to results from the bulk sample method indicates that the bulk sample method is more conservative at estimating uranium concentrations (Figure B-54). Also, application of the bulk sample method tends to reflect the site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model U-2A and Model U-1A are the final models selected, and were used to correct and post-process in situ XRF measurements to predicted laboratory uranium concentrations for the RSE reports. Equation 10 and Equation 11 express the resulting linear regression model calculated for uranium by use of the 264 data pairs of ex situ XRF bulk sample uranium measurements and laboratory-reported uranium concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 through Mobilization #6:

Equation 10 (< 95 ppm): $[U]_{lab} = (0.8031 * [U]_{XRF}) - 2.266$

Equation 11 (≥ 95 ppm): $[U]_{lab} = (0.7677 * [U]_{XRF}) - 0.099$

For Model U-2A (Equation 10), the coefficient of determination (R^2) is 0, and the correlation coefficient (r) is 0.79, indicating the regression model is significant (that is, r ≥ 0.9). Figure B-58 shows the primary bulk sample regression models, which differ depending on concentration of uranium. Model U-2A (shown in blue) is used for predicting uranium concentration when XRF measurements are less than 95 ppm, and Model U-1A (shown in green) is used when XRF measurements exceed or equal 95 ppm. These lines are shown with respect to the unity line (dashed and shown in black—that is, if the model was perfect [XRF to lab]. Both models fit well with unity and provide general agreement with the laboratory data without any correction.

However, based on multiple reasons conveyed above, the 9,540 in situ XRF measurement data were corrected for the RSE investigation using either Equation 10 or Equation 11 because these models provide a more protective approach. Furthermore, Equation 10 is more accurate at low uranium concentrations.

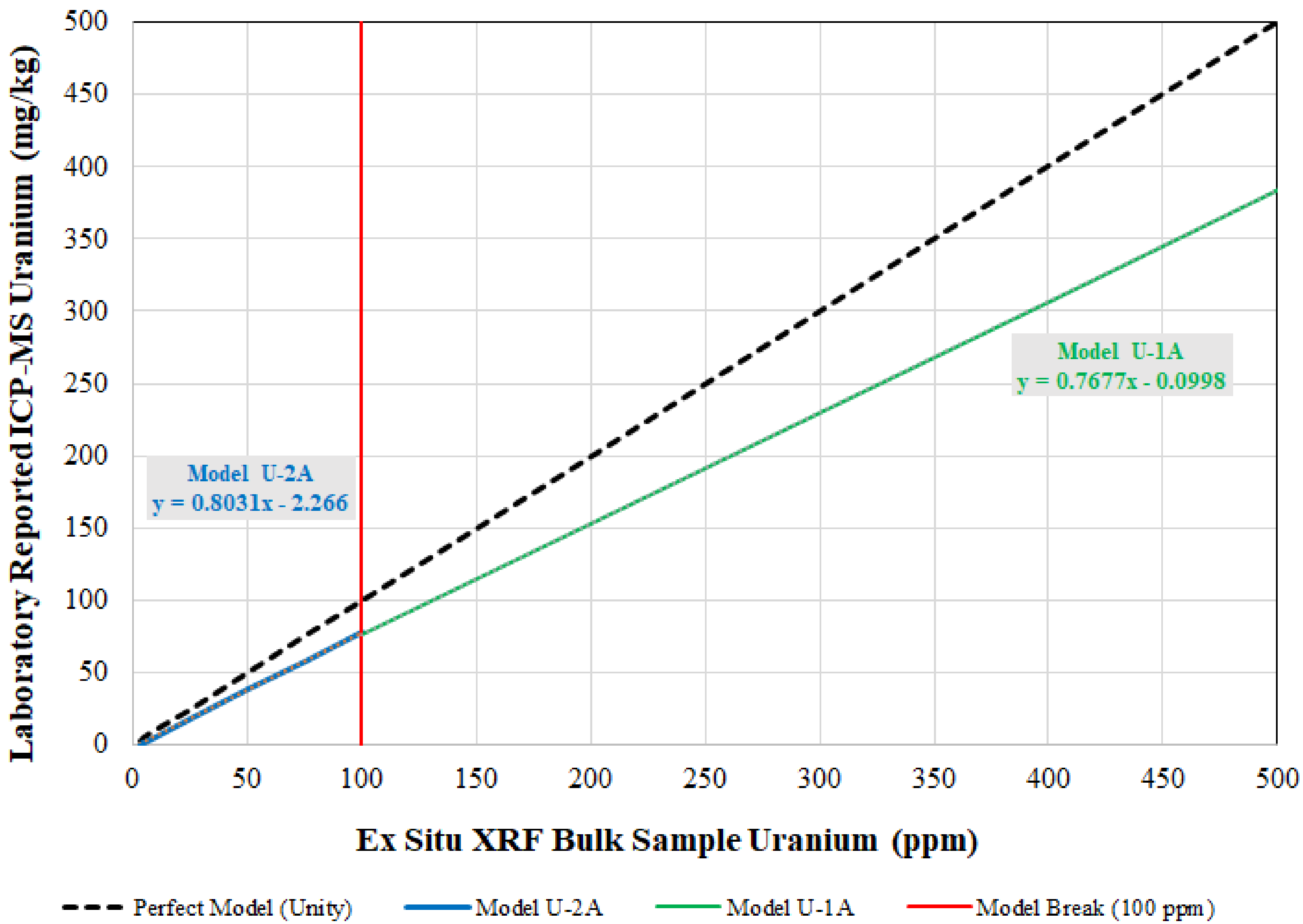


Figure B-58. Final Uranium Regression Models– Unity Comparison

4.8 VANADIUM

4.8.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 vanadium data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the vanadium comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis, but instead were used for inferential statistics and model validation purposes. A total of eight of 264 data pairs contained nondetects and were therefore removed from the dataset prior to the initial linear regression least squares analysis. All eight nondetect vanadium data pairs were removed because of issues with XRF instrument detection capabilities, not presence in the laboratory data of nondetects (that is, all results from confirmatory samples were detected results). Following the removal of these data pairs, a linear regression least squares analysis was applied on the remaining 256 vanadium data pairs. For these remaining data pairs, the laboratory reported vanadium concentrations from the data set ranging from 4.6 mg/kg to 1,900 mg/kg, with an average of 120 mg/kg.

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the vanadium data set, conclusion was that the range of vanadium data pairs warranted a single model with one scale. Two different regression scenarios were evaluated and documented for this report as described below.

Model VA-1 involved linear regression least squares analysis. This model included the entire vanadium dataset (without nondetects), totaling 256 data pairs. Visual inspection of a fitted line plot revealed four apparent influential outliers, obvious not only via visual inspection of the linear regression model but also identified in the statistical evaluation of standardized residuals. Table B-74 summarizes the data pairs with the four largest standardized residual errors corresponding to the four outliers identified via visual inspection. Three of these samples (M4-XS63-01-050718, M4-XS63-02-050718, and M11-XS11-01-071118) had the three highest vanadium concentrations, and the fourth sample (M6-XS285-01-04272018) had the fifth highest.

Model VA-1 had a high correlation coefficient (r = 0.88), slope of 0.9859, and y-intercept of -34.08. After identification of the outliers, decision was to rerun the linear regression analysis on the data set with these outliers excluded. Model VA-2 was developed to exclude the four samples (M4-XS63-01-050718, M4-XS63-02-050718, M11-XS11-01-071118, and M6-XS285-01-04272018). A linear regression least squares analysis was rerun on the data set for Model VA-2 that contained 252 data pairs. Results indicated an improvement in correlation coefficients between Model VA-1 and Model VA-2 from 0.88 to 0.96, a reduction in slope (0.9859 to 0.7963), and positive increase in y-intercept (-34.08 to -18.33). Table B-75 summarizes the parameters for the two ex-situ regression models evaluated for vanadium.

Table B-74. Summary of Data Pairs with Large Residuals for Vanadium in Model VA-1

Sample ID	Average Ex Situ XRF Vanadium Value (ppm)[1]	RSD of Ex Situ XRF Values[2]	Laboratory Vanadium Result (ppm)[3]	RPD of Data Pairs
M4-XS63-02-050718	820	9.2%	1,900	79%
M4-XS63-01-050718	1,113	25%	1,900	52%
M11-XS11-01-071118	982	9%	1,500	42%
M6-XS285-01-04272018	369	5.3%	820	76%

Notes:

1 Average of six ex situ XRF vanadium measurements taken from the bulk sample.
2 RSDs of the six ex situ XRF vanadium measurements taken from the bulk sample.
3 Laboratory-reported vanadium concentration obtained via partial digestion (3050B) and ICP-MS (6020A).

ICP-MS Inductively coupled plasma-mass spectrometry
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

Table B-75. Summary of Parameters for Ex Situ Bulk Sample Vanadium Regression Models

Model Name	Data Pairs	Nondetects Removed	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model VA-1	256	8	0	0.9859	-34.08	0.78	0.88
Model VA-2	252	8	4	0.7963	-18.33	0.91	0.96

Notes:

A total of 131 data pairs removed because they contained a nondetect.

b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 coefficient of determination

Model VA-2 is the final model selected to best represent the relationship between ex situ XRF bulk sample vanadium measurements and laboratory-reported vanadium concentrations from the XRF confirmation soil samples. This model omits nondetects and outliers, and is the most meaningful representation of the data. Figure B-59 shows the final selected data pairs, excluding nondetects and outliers, that were used in the final development of Model VA-2 and are plotted within the 95 percent prediction limits.

Attachment B3 presents statistical analyses of both ex situ XRF bulk sample regression models evaluated for vanadium (Model VA-1 and Model VA-2). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residuals, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 presents, in tabular format, all included or excluded in the final vanadium model: Model VA-2. The attachment also presents the data pairs from Mobilization #7 through Mobilization #9. The following subsection conveys results of the soil cup comparability study for vanadium, and compares Model VA-2 to the different soil cup regression models. A discussion on final model selection for determination of vanadium by use of XRF analyzers appears in Section 4.8.8, including an evaluation of data quality criteria by use of the final vanadium model presented in this report.

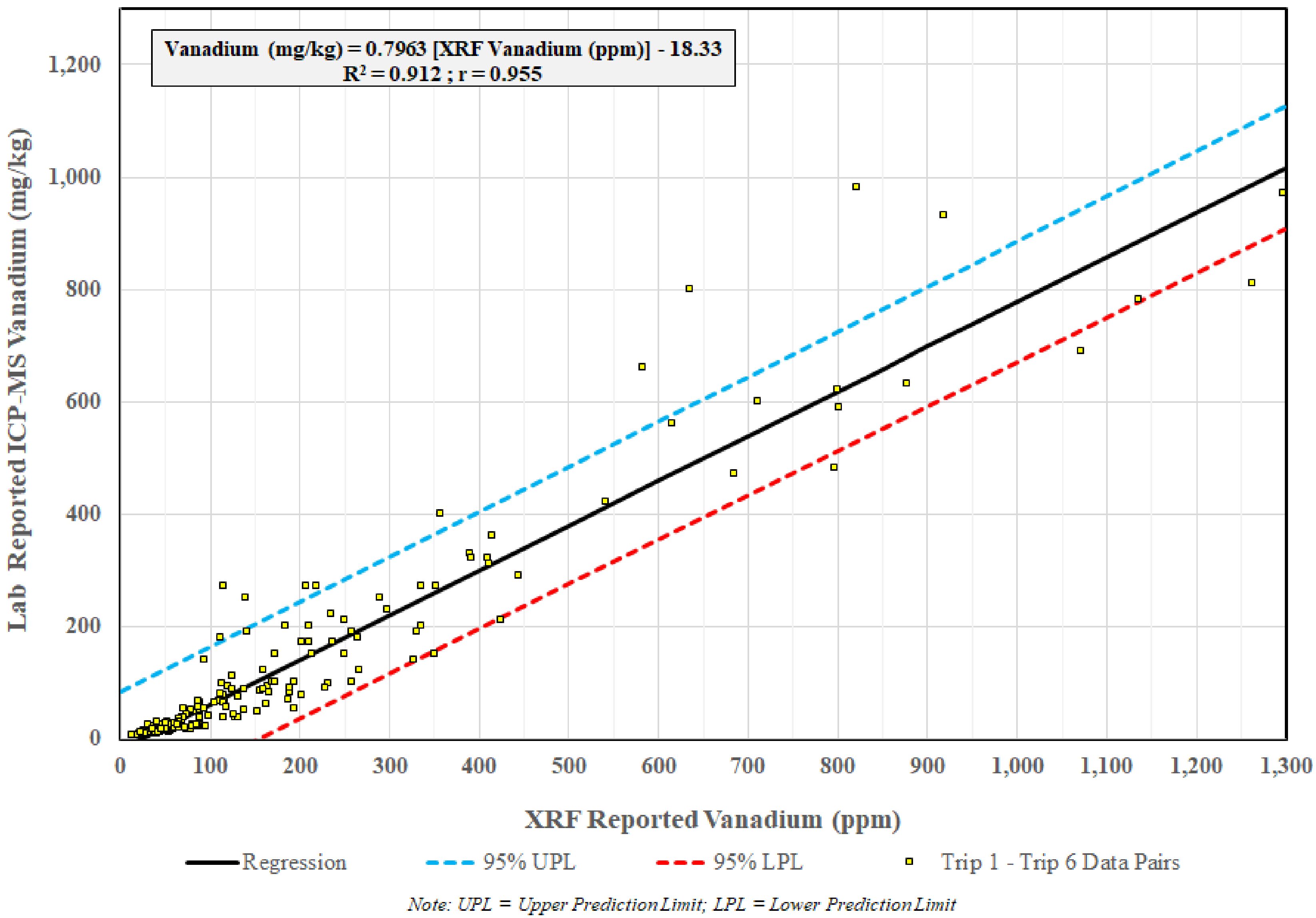


Figure B-59. Ex Situ Bulk Soil Sample vs. Lab Concentrations Regression Model (Vanadium)

4.8.2 Linear Regression Analysis

A comparability study involved ex situ XRF vanadium measurements and laboratory-reported vanadium concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring vanadium using this XRF method are discussed in Section 3.4, and results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B4. Table B-76 lists x ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-76. Summary of Vanadium Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.784	-49.411	0.96	0.98
Red	0.8298	-53.5250	0.96	0.98
White	0.7705	-52.8470	0.95	0.98
Average	**0.7948**	**-51.9277**	**0.96**	**0.98**

Notes:

1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.

b y-intercept as calculated by the linear regression least squares method

m Slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

XRF X-ray fluorescence

Results indicate that the slope varies much among XRF analyzers (RSD = 3.9 percent). Average R^2 (0.96) for the soil cup method is the same as computed for bulk sample method, and both methods show acceptable correlation coefficients. Figure B-60 compares soil cup method bulk sample method regression models. At all ranges of vanadium concentrations, very little difference is evident among the soil cup regression models themselves and the ex situ bulk sample regression model. This is because the average slope (m = 0.7948) of the soil cup method is nearly identical to the slope (m = 0.7963) of the ex situ XRF bulk sample method. The only differences in the models are the y-intercepts.

Figure B-61 shows results of the linear regression for the 44 soil cup samples and the bulk sample from which they were processed. In total, 26 of the 44 samples (59 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 26 percent. The mean of the bulk sample vanadium concentration from the 44 samples was 256 mg/kg and decreased to 231 mg/kg in the soil cup samples—an RPD decrease of 10 percent. Further discussion on particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

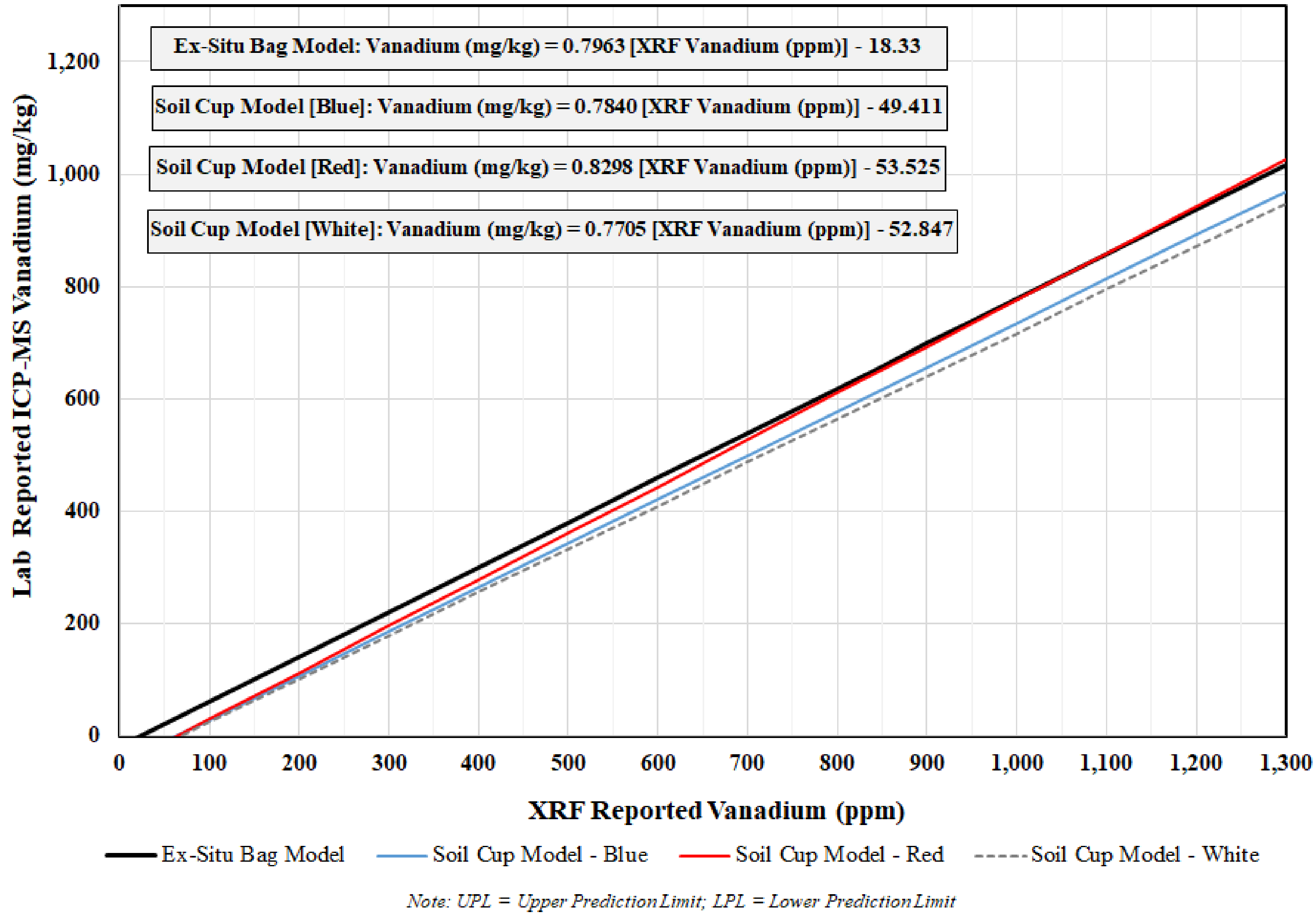


Figure B-60. Vanadium Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

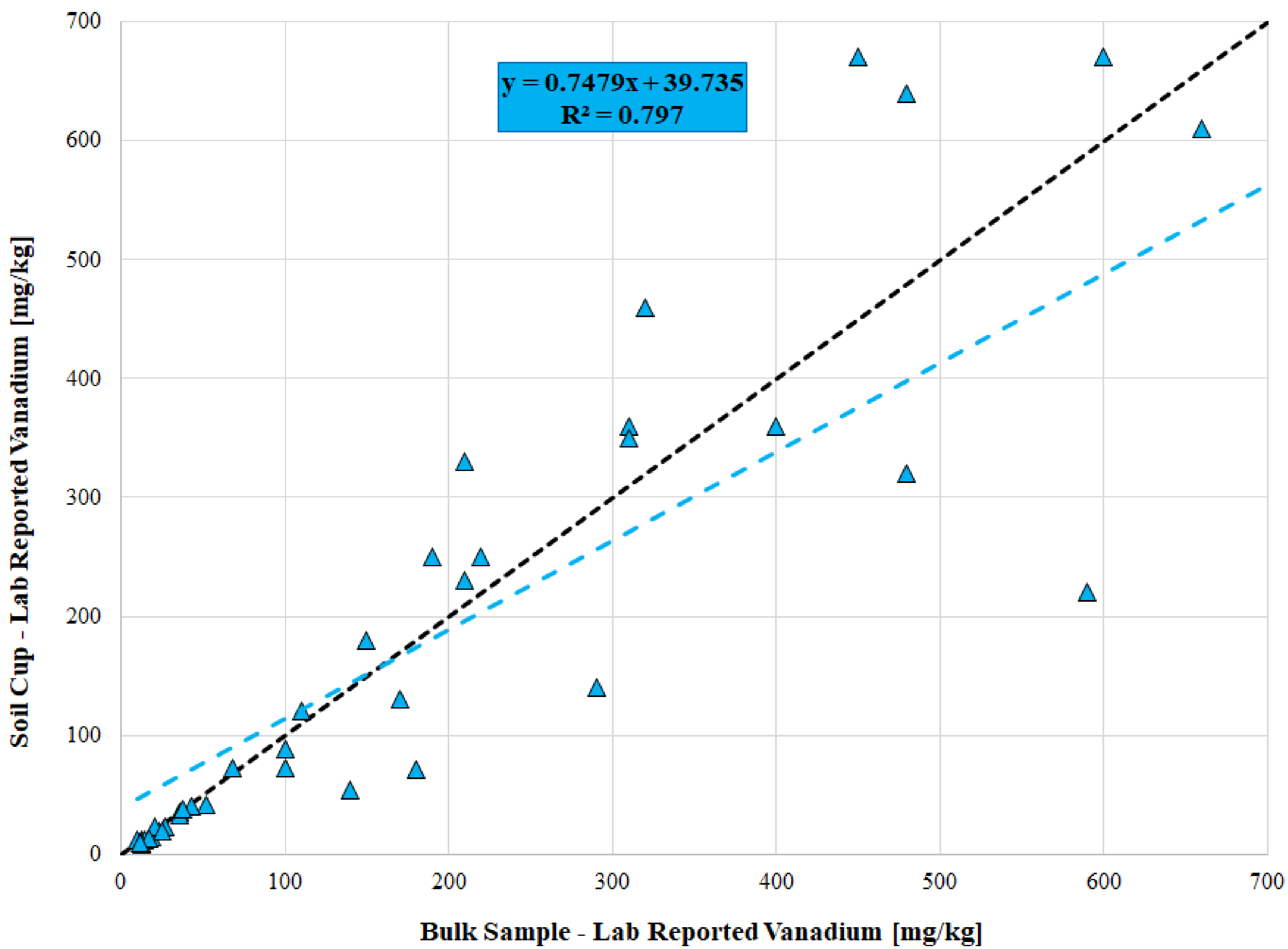


Figure B-61. Bulk Sample versus Soil Cup Vanadium Concentration

4.8.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-77. A large number of samples were evaluated in application of for each of the ex situ methods, as listed in Table B-77.

Table B-77. Method Detection Limit for Vanadium by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	10	9.4
Ex Situ XRF Bulk Sample	88	13
Ex Situ XRF Soil Cup	21	21

Notes:

Manufacturer reported MDL of 2 mg/kg for vanadium using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

[1] MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.

MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.8.4 Precision of XRF Analysis

An evaluation of precision for determination of vanadium was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of vanadium concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-78 summarizes calculated precisions for the different ranges of concentrations for each method type. For all XRF methods of measuring vanadium concentration, precision improved as concentration increased. This was expected and shows the XRF analyzer responded better at higher vanadium concentrations in soil. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-78. Summary of Calculated Precision of XRF Method for Vanadium

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	0	-	0	-	29	14%	160	8.3%	189	9.0%
Ex Situ XRF Bulk Sample	10	15%	78	13%	54	10%	110	7.9%	252	10%
Ex Situ XRF Soil Cup	0	-	21	12%	15	9.3%	96	6.2%	132	8.2%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with vanadium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with vanadium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with vanadium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with vanadium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.8.5 Comparability of XRF Analysis to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-79 lists the RPD between the XRF and confirmatory soil cup data for different vanadium soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-76) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined vanadium concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. Prior to correction of the XRF data, 132 soil cups had detectable data pairs, and these were evaluated for comparability based on the range of concentrations observed within the data set. After application of the correction factor, some XRF data (n = 21) became negative and were removed from the evaluation. A description of the criteria for the concentration ranges is in Table B-11. Similar to observed precision of the soil cup method (Section 4.8.4), comparability tends to increase (that is, RPD decreases) as concentration increases. Overall comparability across all concentration ranges and for all data combined increases significantly with application of a correction factor to the XRF data to estimate a predicted laboratory-determined vanadium concentration. With use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

Table B-79. Comparability for Ex Situ XRF Soil Cup Method Vanadium

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	0	-	21	129%	15	112%	96	46%	132	67%
Ex Situ XRF Soil Cup (Corrected)	0	-	6	37%	9	14%	96	13%	111	15%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with vanadium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with vanadium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with vanadium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with vanadium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-80 lists RPDs between XRF and confirmatory bulk sample data for different vanadium soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparability with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample vanadium regression model (Model VA-2) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined vanadium concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. Prior to correction of the XRF data, 252 bulk samples had detectable data pairs, and these were evaluated for comparability based on the range of concentrations observed within the data set. After application of the correction factor, some XRF data (n = 4) became negative and were removed from the evaluation. Similar to precision of the bulk sample method, comparability tends to increase (that is, RPD decreases) as concentration increases. Overall comparability across all concentration ranges and for all data combined is increases significantly by application of a correction factor to the XRF data to estimate a predicted laboratory-determined vanadium concentration. By use of a correction factor, comparability is considered fair according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are an overall RPD of 15 percent and 27 percent, respectively. For both methods, comparability is significantly improved with application of a correction factor to XRF data for determination of vanadium concentration. An RPD of 27 percent is considered fair by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is in the following subsection.

Table B-80. Comparability for Ex Situ XRF Bulk Sample Method for Vanadium

XRF Method	Very Low		Low		Medium		High		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	10	125%	78	111%	54	96%	110	46%	252	91%
Ex Situ XRF Bulk Sample (Corrected)	7	72%	77	34%	54	30%	110	20%	248	27%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with vanadium concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with vanadium concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with vanadium concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with vanadium concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

4.8.6 Inferential Statistical Analysis

An analysis occurred to compare the XRF and the confirmatory vanadium data by way of two-sample hypothesis testing and supported by graphical analysis as recommended in USEPA (2015a). The ex situ XRF bulk sample vanadium measurement values were corrected by application of Model VA-2 identified in Section 4.8.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of vanadium in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis (as done with the linear regression). Table B-81 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that the XRF data set from each mobilization grouping equals the laboratory data set after application of a correction factor.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed the three parameter lognormal distribution best fits the vanadium confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-62 is a three-parameter lognormal probability plot showing the XRF corrected vanadium data set and the confirmatory vanadium data set side by side, indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-63 compares the same two data sets with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are the not unequal at a 99 percent confidence level for XRF and laboratory reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-81. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Vanadium Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Vanadium	1 - 6	XRF <> Lab	XRF = Lab
	7 - 9	XRF <> Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01).

1 Mobilization #1 – Mobilization #6 was the Baseline Study.
2 Mobilization #7 – Mobilization #9 was the Site Characterization Study.
3 Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.
4 Corrected refers to the XRF data that was converted using Model VA-2 correction factors.

XRF X-ray fluorescence
XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

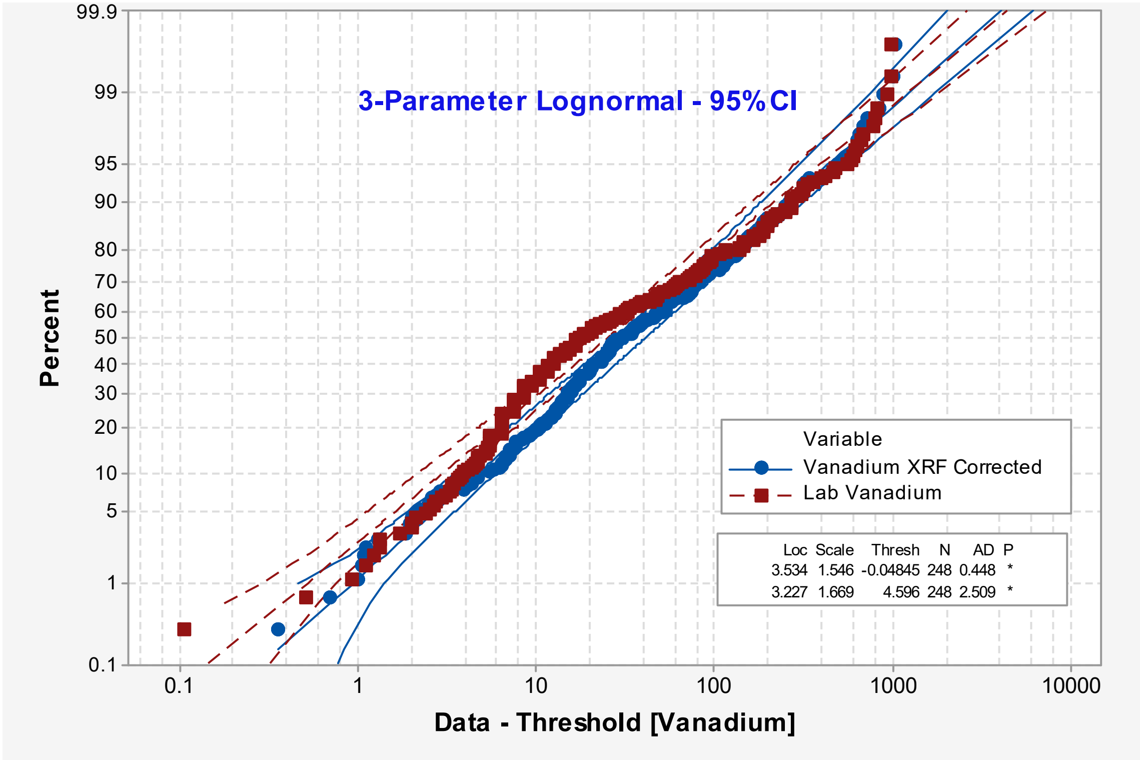


Figure B-62. Probability Plot of XRF Corrected Vanadium Data Set and Confirmatory Vanadium Data Set (3-Parameter Lognormal)

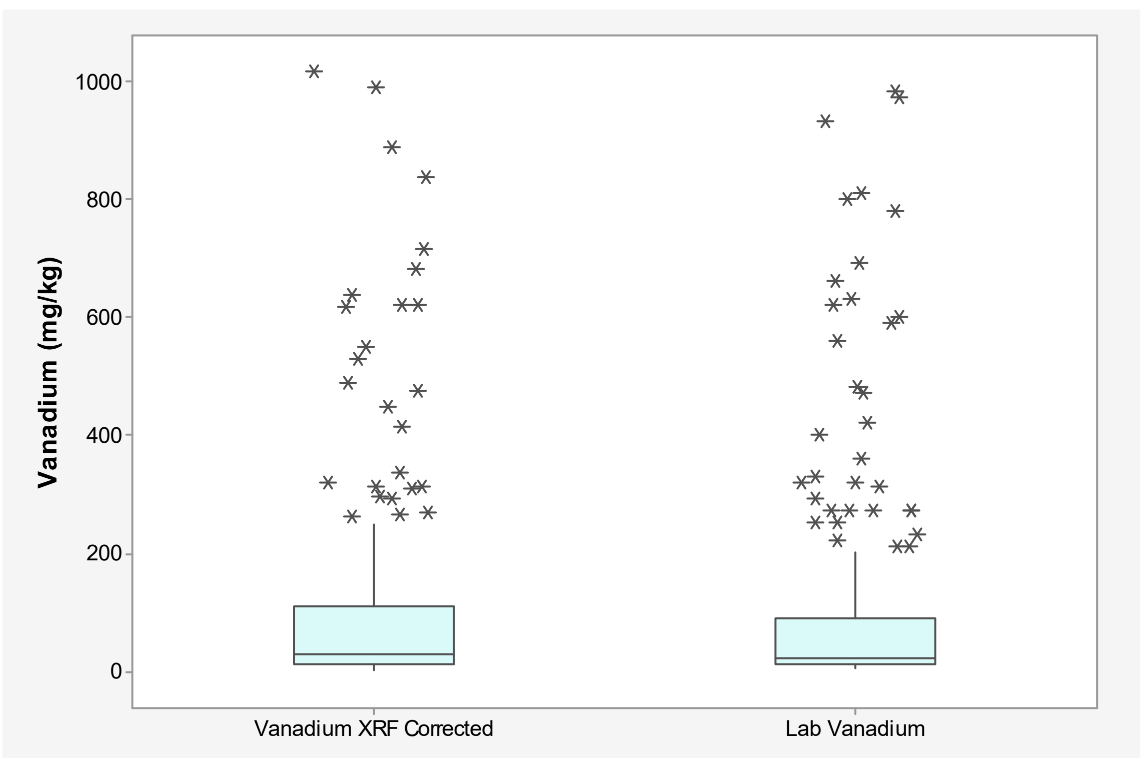


Figure B-63. Boxplot of XRF Corrected Vanadium and Laboratory Reported Vanadium

4.8.7 Sample Numbers and Descriptive Statistics

Table B-82 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF vanadium measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. because of detection limits calculated for vanadium with use of the XRF analyzer, 3,647 of these were below the MDL and qualified as such. The average detected vanadium concentration of in situ XRF measurements after correction is 77 mg/kg. A total of 502 XRF confirmatory soil samples were collected, averaging 91 mg/kg vanadium. A total of 292 surface soil samples were collected, averaging 124 mg/kg vanadium. Therefore, 794 analytical surficial (XRF confirmation and surface soil) soil samples were collected in total across the sites, averaging 103 mg/kg vanadium. The average of in situ XRF measurements was much lower than project-wide vanadium concentrations reported in surface soils via laboratory analytical method (RPD = 29 percent). This is similar to uranium, as XRF analyzers reported lower vanadium concentrations than those resulting from analytical techniques because in situ XRF measurements occurred within large land areas where vanadium concentrations were at background levels, whereas surface soil sampling, while focused on the range of concentrations, was more biased toward areas with higher concentrations of uranium-vanadium, such as waste piles. As uranium, therefore, vanadium is an excellent indicator element for identifying mine waste areas compared to some of the other elements (for example, thorium), which are at more consistent concentrations even across areas of mining disturbance.

Table B-82. Summary of Project Wide Vanadium Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	5,893	502	292	794
Nondetects	#	3,647	0	0	0
Minimum	mg/kg	16.001	4.6	4.6	4.6
Maximum	mg/kg	3,387	1,900	2,700	2,700
Average	mg/kg	77	91	124	103
Standard Deviation	mg/kg	131	194	283	231
Median	mg/kg	37.2	20	23	21
90th Percentile	mg/kg	162	249	320	287
95th Percentile	mg/kg	266	439	555	480
99th Percentile	mg/kg	650	929	1,245	1,100

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined vanadium concentrations using correction factors from Model VA-2.

3 Laboratory-reported vanadium concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).

mg/kg Milligrams per kilogram

bgs Below ground surface

XRF X-ray fluorescence

ICP-MS Inductively coupled plasma-mass spectrometer

4.8.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported vanadium concentrations in the bulk soil samples, as summarized in Section 4.8.1, led to selection of Model VA-2 as the optimal model to best predict laboratory vanadium concentrations by use of XRF analyzers. This model can be used to post-process in situ XRF measurements to correct them to a more accurate representation of vanadium concentrations reported from laboratory application of ICP-MS after acid partial digestion, and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining vanadium concentrations by use of XRF analyzers, the correlation coefficient (r = 0.96), in situ XRF measurement precision (RSD = 9.0 percent), and corrected ex situ XRF bulk sample comparability (27 percent) all meet the criteria for vanadium data reported by XRF analyzers to be considered at a quantitative screening level. The correlation coefficient is greater than 0.9, and inferential statistics indicate the two data sets are equal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparison of the corrected XRF vanadium data set and the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model VA-2) and for Mobilization #7 through Mobilization #9 (not used in model development). In both analyses, the inferential statistics indicate the mean of corrected XRF data equal to the mean of laboratory confirmatory data.

Comparison of results from the soil cup method to results from the bulk sample method indicate that the bulk sample method is essentially as dependable or at least more conservative at estimating vanadium concentrations (Figure B-60). Furthermore, application of the ex situ XRF bulk sample method tends to reflect site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model VA-2 is the final model selected and is used to correct and post-process in situ XRF measurements to predicted laboratory vanadium concentrations for the RSE reports. Equation 12 expresses the resulting linear regression model calculated for vanadium by use of the 264 data pairs of ex situ XRF bulk sample vanadium measurements and laboratory-reported vanadium concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 – Mobilization #6:

Equation 12: $$[V]_{lab} = (0.7963 * [V]_{XRF}) - 18.33$$

Figure B-64 depicts the primary bulk sample vanadium regression model (shown in blue) as it compares to unity line (as shown in black—that is, if the model was 1:1 [XRF to lab]). The model is lower than unity, indicating requirement for application of a correction factor to the XRF data to increase comparability between data derived from XRF analyzers and confirmatory methods.

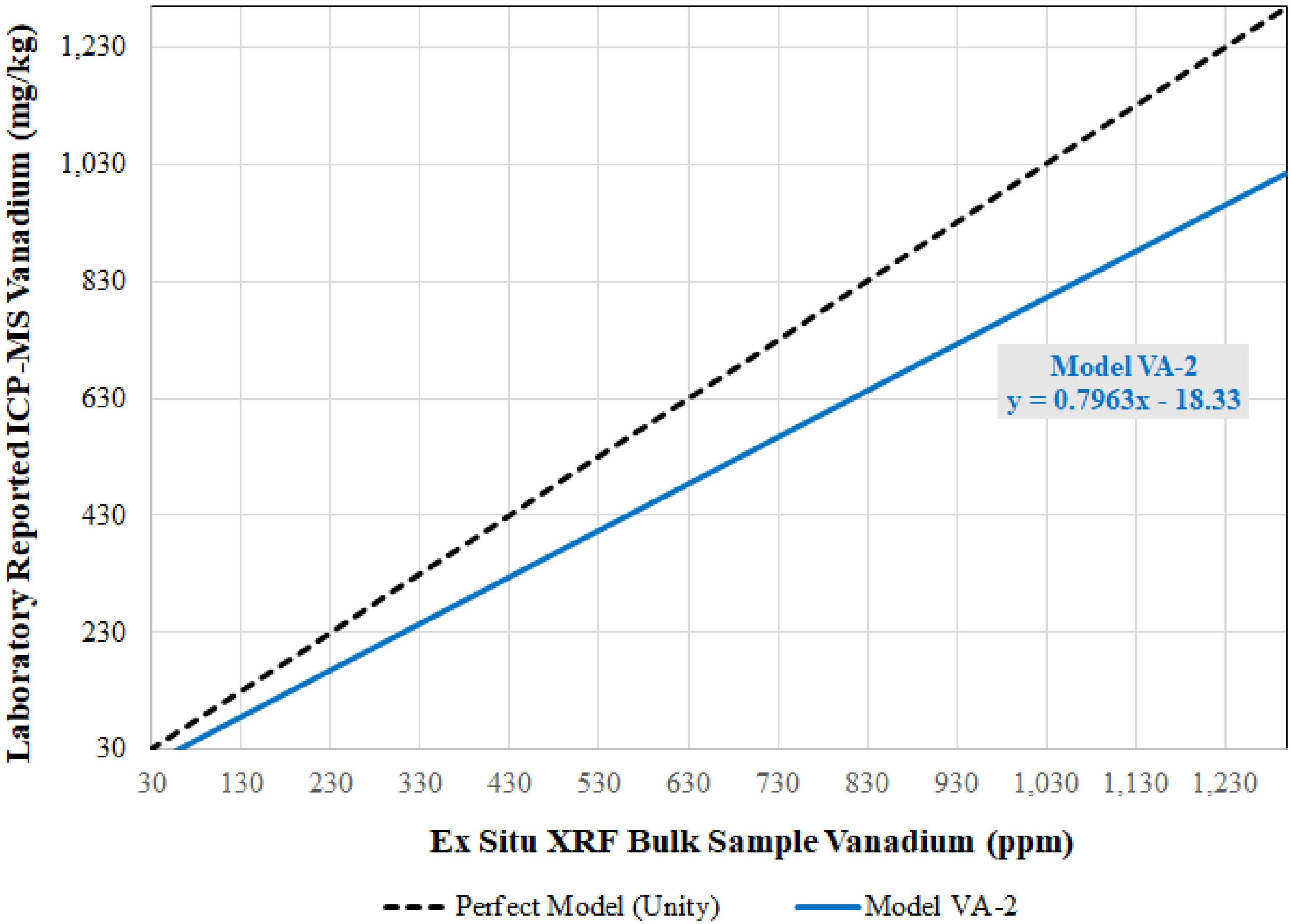


Figure B-64. Final Vanadium Regression Model – Unity Comparison

4.9 ZINC

4.9.1 Comparison of Ex Situ XRF Bulk Sample to Laboratory Results

Results from 264 zinc data pairs obtained from soil samples collected during Mobilization #1 through Mobilization #6 were evaluated as part of the zinc comparability study. Samples collected during Mobilization #7 though Mobilization #9 were not used in the linear regression least squares analysis but, instead, used for inferential statistics and model validation purposes. A total of 10 of 264 data pairs contained nondetects and were therefore removed from the dataset prior to the initial linear regression least squares analysis. Following removal of these data pairs, a linear regression least squares analysis was applied on the remaining 254 zinc data pairs. For these remaining data pairs, the laboratory reported zinc concentrations from the data set ranging from 6.3 to 120 mg/kg, with an average of 19 mg/kg.

An analysis to identify potential outliers and to bracket the action levels occurred. Regression results were plotted as a visual aid to determine the significance of the linear model to help identify potential outliers, and an analysis of standardized residuals was conducted by use of regression analysis tools in the Minitab statistical software. An additional evaluation of effects of the different bracketed concentration ranges involved inclusion and exclusion of higher and lower data pairs. Upon completion of this evaluation of the zinc data set, conclusion was that the range of zinc data pairs observed warranted a single model with one scale. Several different regression scenarios were evaluated and documented for this report as described below.

Model ZN-1 was the first in a series of models involving linear regression least squares analysis. This model included the entire zinc dataset (without nondetects), totaling 254 data pairs. The correlation coefficient was poor ($r = 0.33$) because of the presence of a number of outliers identified via visual inspection and evaluation of the standardized residuals. Six obvious outliers were identified through visual inspection of the linear regression model, and these data pairs did not represent the data well. Eight data pairs, including the six visual outliers, were flagged by the statistical software as having large residuals. Table B-83 summarizes the data pairs flagged as having unusually large residuals. Seven of these data pairs (all data pairs in Table B-83 except for T17-XS144-01-042618) were valid outliers and were removed prior to a second analysis.

Model ZN-2 was the second model evaluated, involving exclusion of nondetects and the seven outliers identified from Model ZN-1. Model ZN-2 included 247 data pairs and had a high correlation coefficient ($r = 0.78$), slope of 0.7301, and y-intercept of 3.8676. After removal of the outliers, the correlation coefficient improved from Model ZN-1 ($r = 0.57$) to Model ZN-2 ($r = 0.89$). The slope from Model ZN-1 ($m = 0.6936$) increased slightly in Model ZN-2 ($m = 0.7301$). A visual inspection of the linear regression model and evaluation of standardized residuals of Model ZN-2 resulted in four primary data pairs flagged as potential outliers, as listed in Table B-84.

Table B-83. Summary of Data Pairs with Large Residuals for Zinc in Model ZN-1

Sample ID	Average Ex Situ XRF Zinc Value (ppm)[1]	RSD of Ex Situ XRF Values[2]	Laboratory Zinc Result (ppm)[3]	RPD of Data Pairs
T17-XS304-01-042818	11	5.5%	120	166%
T13-XS12-01-050818	20	11%	88	128%
T23-XS40-01-052118	19	6.6%	92	131%
T17-XS317-01-04272018	15	12%	56	116%
T17-XS1-01-04262018	7.4	18%	43	141%
M4-XS4-01-050718	9.9	11%	41	122%
T17-XS273-01-042818	18	7.1%	41	79%
T17-XS144-01-042618	63	6.7%	73	14%

Notes:

1 Average of six ex situ XRF zinc measurements taken from the bulk sample.
2 RSDs of the six ex situ XRF zinc measurements taken from the bulk sample.
3 Laboratory reported zinc concentration via partial digestion (3050B) and ICP-MS (6020A).

ICP-MS Inductively coupled plasma-mass spectrometry
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

Table B-84. Summary of Data Pairs with Large Residuals for Zinc in Model ZN-2

Sample ID	Average Ex Situ XRF Zinc Value (ppm)[1]	RSD of Ex Situ XRF Values[2]	Laboratory Reported Zinc (mg/kg)[3]	RPD of Data Pairs
T17-XS144-01-04262018	63	6.7%	73	14%
T17-XS251-01-04272018	17	3.6%	38	74%
T17-XS369-01-043018	18	8.7%	33	57%
M30-XS222-01-062218	25	5.7%	37	39%

Notes:

1 Average of six ex situ XRF zinc measurements taken from the bulk sample.
2 RSDs of the six ex situ XRF zinc measurements taken from the bulk sample.
3 Laboratory-reported zinc concentration via partial digestion (3050B) and ICP-MS (6020A).

ICP-MS Inductively coupled plasma-mass spectrometry
mg/kg Milligrams per kilogram
ppm Parts per million
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

The four data pairs listed in Table B-84 were evidently skewing the data, and these were flagged as outliers and removed prior to a final analysis in Model ZN-3. Model ZN-3 involved linear regression least squares analysis on 243 data pairs, excluding the nondetects and outliers identified above. This model resulted in a slight improvement in the correlation coefficient ($r = 0.91$), and the slope ($m = 0.6936$) decreased slightly to magnitude similar to that in Model ZN-1. In general, very little difference was evident among the three zinc regression models. Table B-85 summarizes the various parameters associated with the three regression models evaluated as part of the zinc comparability study. Model ZN-3 is the final model selected to best represent the relationship between ex situ XRF bulk sample zinc measurements and laboratory-reported zinc concentrations from the XRF confirmation soil samples. This model omits nondetects and outliers, and is the most meaningful representation of the data.

Table B-85. Summary of Parameters for Ex Situ Bulk Sample Zinc Regression Models

Model Name	Data Pairs	Nondetects Removed	Outliers Removed	Slope (m)	y-intercept (b)	R^2	r
Model ZN-1	254	10	0	0.6936	6.2256	0.33	0.57
Model ZN-2	248	10	7	0.7301	3.8676	0.78	0.89
Model ZN-3	243	10	11	0.6919	4.2593	0.82	0.91

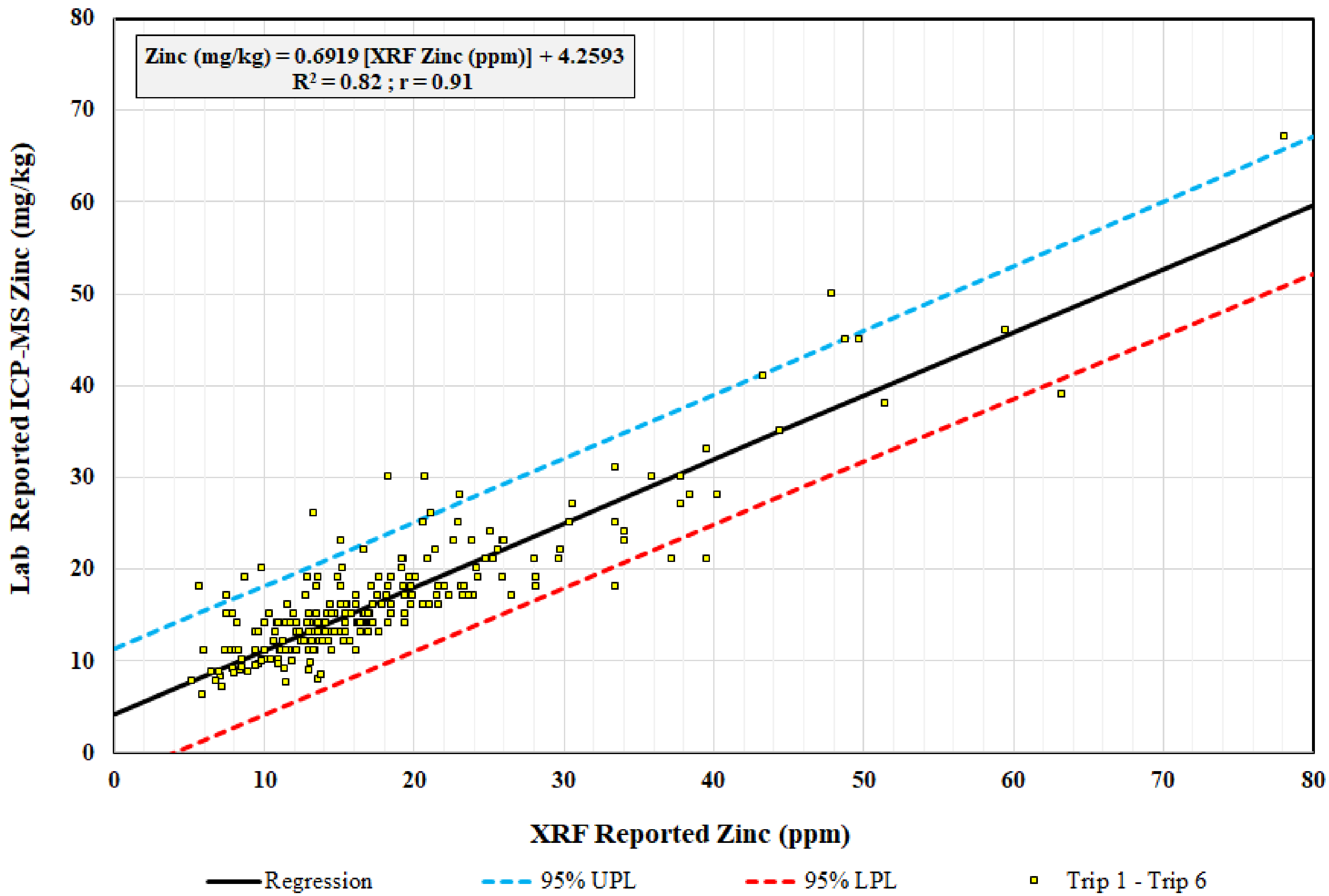
Notes:

A total of 131 data pairs were removed because they contained nondetects.

b y-intercept as calculated by the linear regression least squares method.
m Slope of linear regression line as calculated by the linear regression least squares method
r Pearson's correlation coefficient
R^2 Coefficient of determination

Figure B-65 shows the final selected data pairs, excluding nondetects and outliers, that were used in the final development of Model ZN-3 and are plotted within the 95 percent prediction limits.

Attachment B3 presents statistical analysis for both ex situ XRF bulk sample regression models evaluated for zinc (Model ZN-1 and Model ZN-2). This attachment includes, for each regression model, a prediction report, residual diagnostics report, fitted line plot, versus order analysis of standardized residual, normal probability plot of standardized residuals, and histogram of standardized residuals. Attachment B4 presents, in tabular format, all data included or excluded in the final zinc model: Model ZN-3. The attachment also presents the data pairs from Mobilization #7 through Mobilization #9. The following subsection conveys results of the soil cup comparability study for zinc, and compares Model ZN-3 to the various soil cup regression models. A discussion on final model selection for determination of zinc concentrations with use of XRF analyzers is in Section 4.9.8, including an evaluation of data quality criteria by use of the final zinc model presented in this report.



Note: UPL = Upper Prediction Limit; LPL = Lower Prediction Limit

Figure B-65. Ex Situ Bulk Soil Sample versus Lab Concentrations Regression Model ZN-3 (Zinc)

4.9.2 Linear Regression Analysis

A comparability study involved ex situ XRF zinc measurements and laboratory-reported zinc concentrations from the soil cup samples. The preparation method for the soil cup sample and the procedures followed for the XRF and laboratory data sources are presented in Section 3.3. Each soil cup was measured in replicate (six ex situ XRF measurements) by three XRF analyzers (Blue XRF, Red XRF, and White XRF). Precision and accuracy of measuring zinc using this XRF method are discussed in Section 3.4, and results are compared to those resulting from application of the ex situ XRF bulk sample method. A complete graphical presentation for each of the linear regression models for each instrument is in Attachment B4. Table B-86 lists ex situ XRF soil cup method linear regression model parameters for each XRF analyzer.

Table B-86. Summary of Zinc Soil Cup Linear Regression Model Parameters

XRF Analyzer[1]	Slope (m)	y-intercept (b)	R^2	r
Blue	0.7449	-0.801	0.97	0.98
Red	0.7249	0.9051	0.96	0.98
White	0.694	-3.7665	0.98	0.99
Average	**0.7213**	**-1.2208**	**0.97**	**0.99**

Notes:

1 Each XRF analyzer has a distinct serial number, as presented in Section 3.3.2.

b y-intercept as calculated by the linear regression least squares method

m slope of linear regression line as calculated by the linear regression least squares method

r Pearson's correlation coefficient

R^2 Coefficient of determination

XRF X-ray fluorescence

Results indicate that the slope does not vary much among XRF analyzers (RSD = 3.6 percent). Average R^2 (0.97) for results from application of the soil cup method is higher than R^2 (0.82) computed for results from application of the bulk sample method; however, both methods show acceptable correlation coefficients. Figure B-66 compares soil cup method and bulk sample method regression models. At all zinc levels, the bulk sample regression model deviates upward compared to the soil cup regression models, indicating the bulk sample model generates a conservative estimate of predicted laboratory-determined zinc concentrations. This is because the y-intercept of the soil cup method is lower than the y-intercept of the bulk sample method, because both of these slopes are similar.

To evaluate concentration effects from particle size, a regression and statistical analysis was performed on the bulk sample and soil cup laboratory-reported zinc concentrations. Figure B-67 shows results of the linear regression for the 42 soil cup samples and the bulk sample from which they were processed. In total, 40 of the 42 samples (95 percent) decreased in concentration from the bulk sample to the soil cup sample, with an average percent decrease of 26 percent. The mean of the bulk sample zinc concentration from the 42 samples was 21 mg/kg and decreased to 16 mg/kg in the soil cup samples—an RPD decrease of 27 percent. Further discussion of particle size effects on concentration is in Section 5.3. The following subsection evaluates data quality criteria for both methods.

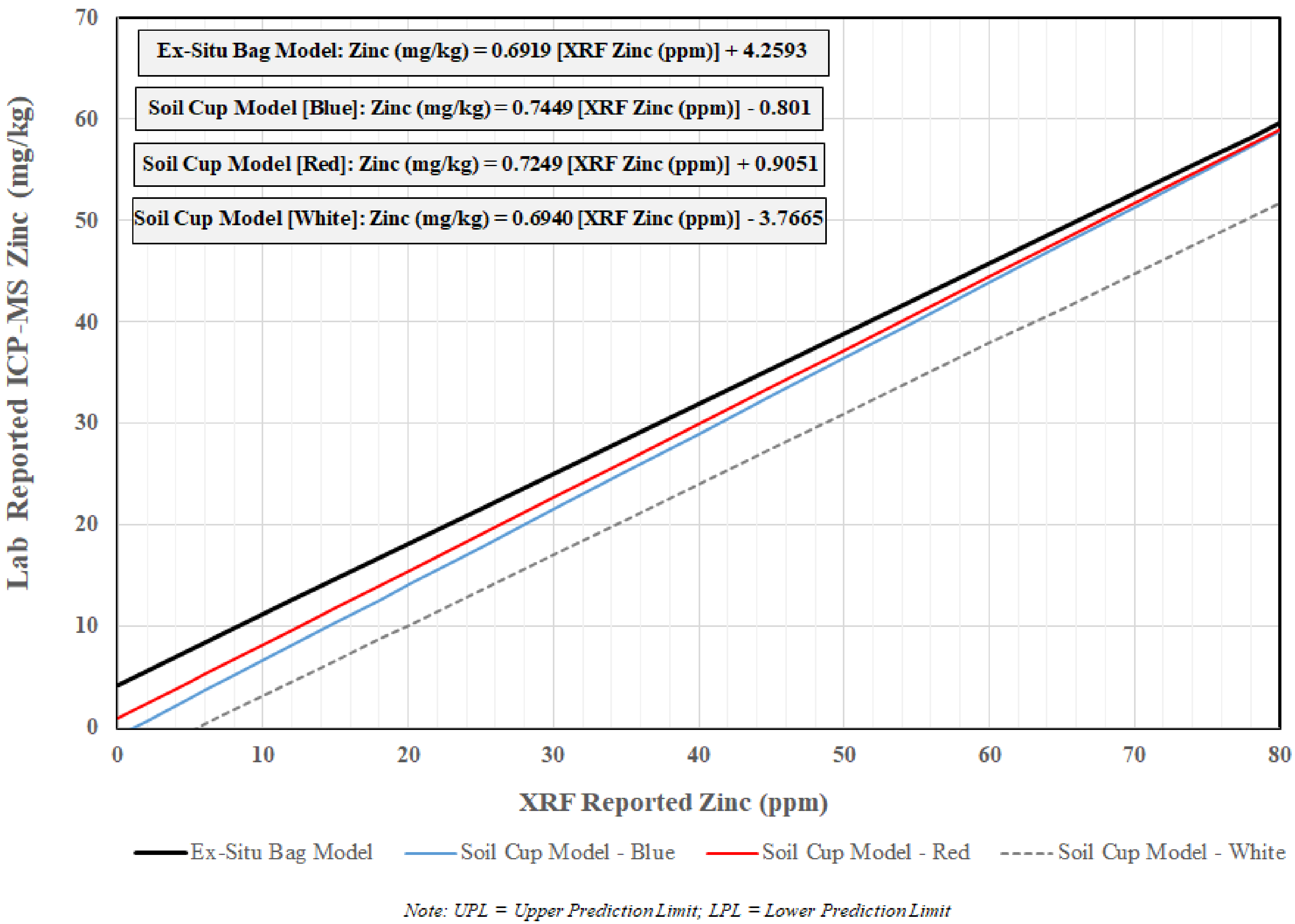


Figure B-66. Zinc Linear Regression: Ex Situ Bulk Sample versus Ex Situ Cup Sample Models

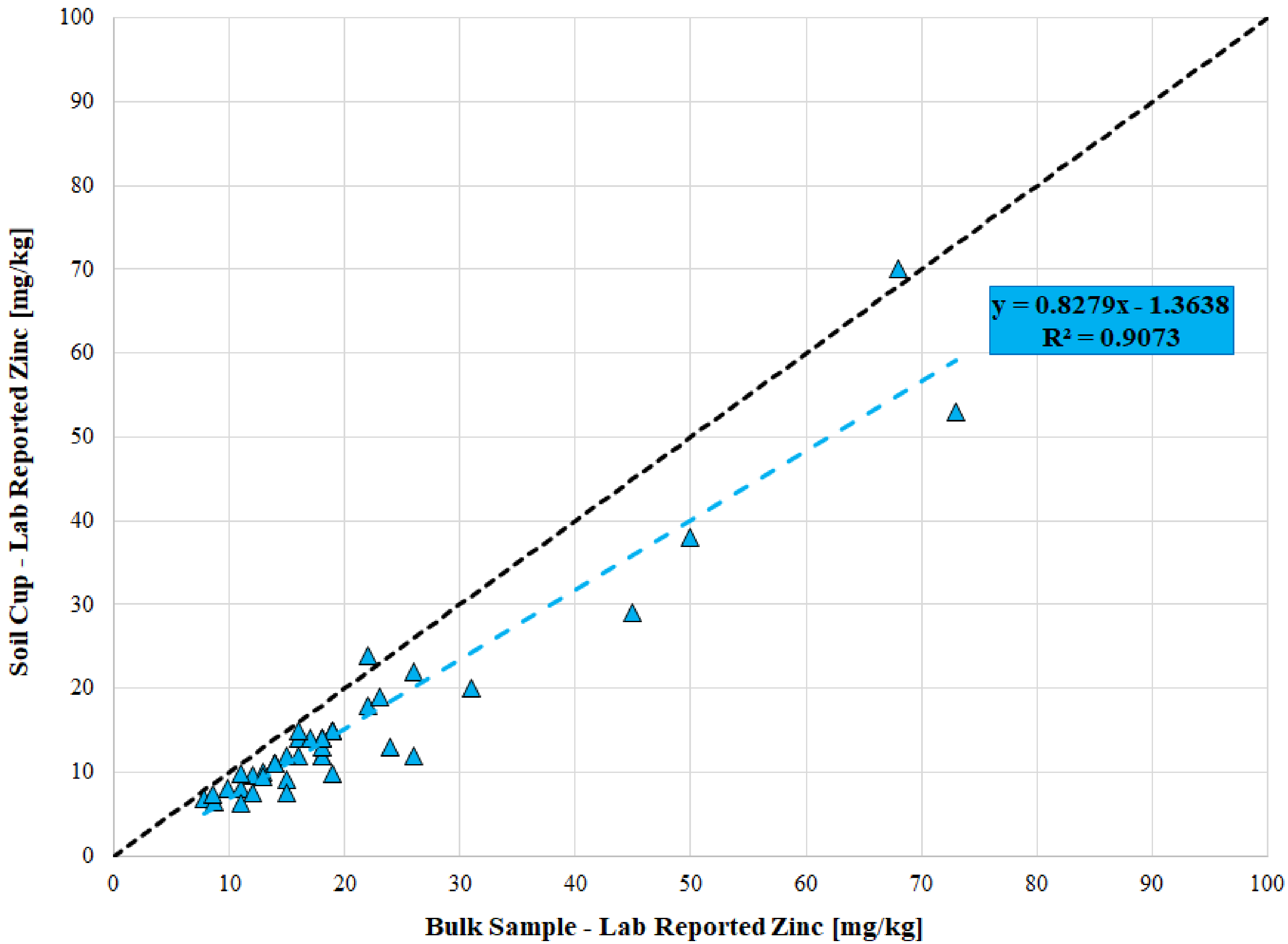


Figure B-67. Bulk Sample versus Soil Cup Zinc Concentration

4.9.3 Method Detection Limit of XRF Analysis

MDLs were calculated for each of the three XRF soil preparation methods: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. These calculations followed the approach described in Section 3.4.8. The average of the individual MDLs calculated for each method is reported as the MDL for the given method, as listed in Table B-87. A large number of samples were evaluated in application of for each of the ex situ methods, as listed in Table B-87, the in situ XRF method had fewer samples (n = 12) within the range of interest (that is, < 5 times the MDL).

Table B-87. Method Detection Limit for Zinc by XRF Method

XRF Method	Number of Samples Evaluated (n)	MDL[1] (ppm)
In Situ XRF	12	5.1
Ex Situ XRF Bulk Sample	23	4.0
Ex Situ XRF Soil Cup	45	4.9

Notes:

Manufacturer reported MDL of 2 mg/kg for zinc using 60 second count on each filter.
MDL calculated by three times the standard deviation of replicate sample.
Average MDL of all samples calculated for samples less than five times the manufacturer MDL.
All XRF methods used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

[1] MDL presents the XRF uncorrected MDL directly presented as a detect result by the analyzer.
MDL Method detection limit
n Number of samples evaluated to determine the MDL
ppm Parts per million
XRF X-ray fluorescence

4.9.4 Precision of XRF Analysis

An evaluation of precision for determination of zinc was performed by calculating the RSD as described in Section 3.4.6 for each of the different types of XRF methods where replicate measurements were taken. Method 6200 recommends that for an XRF method to be valid, the median RSD must be less than 20 percent. Precision was calculated for different ranges of zinc concentrations for each XRF method as recommended in Method 6200. Criteria for ranking concentration ranges used for evaluative processes are listed in Table B-11.

Table B-88 summarizes calculated precisions for the different ranges of concentrations for each method type. In all XRF methods of evaluating zinc, precision improved as concentration increased. This was expected, and indicates that the XRF analyzer responded better at higher zinc concentrations in soil. All three of the XRF methods evaluated had an overall median RSD of less than 20 percent, and therefore meet the criteria set forth in Method 6200.

Table B-88. Summary of Calculated Precision of XRF Method for Zinc

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RSD	n	RSD	n	RSD	n	RSD	n	RSD
In Situ XRF	0	-	12	18%	84	8.8%	88	5.7%	184	7.4%
Ex Situ XRF Bulk Sample	0	-	23	14%	167	11%	53	9.3%	243	11%
Ex Situ XRF Soil Cup	0	-	45	13%	66	7.9%	21	4.2%	132	8.9%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with zinc concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with zinc concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with zinc concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with zinc concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RSD
RSD Relative standard deviation (presented as median RSD)
XRF X-ray fluorescence

4.9.5 Comparability of XRF to Laboratory Results

An evaluation of comparability involved XRF and confirmatory data for the two types of applicable methods: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Table B-89 lists the RPD between the XRF and confirmatory soil cup data for different zinc soil concentration ranges. For this analysis, the soil cup data sets for the three XRF analyzers were combined into one data set. This table compares effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory soil cup data. For the corrected samples, the average of the soil cup slopes and y-intercepts (listed in Table B-86) were used to convert the average of the replicate ex situ XRF soil cup measurements to a predicted laboratory-determined zinc concentration which was then compared to the confirmatory soil cup sample result, and an RPD was recalculated. A total of 132 soil cups had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. A description of the criteria used for the concentration ranges is in Table B-11. Similar to observed precision of the soil cup method (Section 4.9.4), comparability tends to increase (that is, RPD decreases) as concentration of zinc in the sample increases. Overall comparability across all concentration ranges and for all data combined slightly improves with application of a correction factor to the XRF data to estimate a predicted laboratory-determined zinc concentration. By use of a correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

Table B-89. Comparability for Ex Situ XRF Soil Cup Method Zinc

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Soil Cup (Uncorrected)	0	-	45	33%	66	39%	21	39%	132	37%
Ex Situ XRF Soil Cup (Corrected)	0	-	45	27%	66	17%	21	7%	132	19%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with zinc concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with zinc concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with zinc concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with zinc concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

Table B-90 lists RPDs between XRF and confirmatory bulk sample data for different zinc soil concentration ranges. For this method, multiple XRFs were used interchangeably. This table shows the effects of uncorrected and corrected average XRF measurements on comparisons with confirmatory bulk sample data. For the corrected samples, the slope and y-intercept calculated from the final bulk sample zinc regression model (Model ZN-3) were used to convert the average of the replicate ex situ XRF measurements from a given bulk sample to a predicted laboratory-determined zinc concentration, which was then compared to the confirmatory sample result, and an RPD was recalculated. A total of 243 bulk samples had detectable data pairs, and all were evaluated for comparability based on the range of concentrations observed within the data set. Overall comparability across all concentration ranges and for all data combined improved slightly, except at low zinc soil concentrations, by applying a correction factor to the XRF data to estimate a predicted laboratory-determined zinc concentration. With and without application of correction factor, comparability is considered good according to the criteria of USEPA (1998, 2006a), and indicated in Table B-12.

To conclude, comparabilities of both soil cup and bulk sample methods, with correction of XRF data, are an overall RPD of 19 percent and 12 percent, respectively. For both methods, application of a correction factor improves comparability for determination of zinc concentration. An RPD of 12 percent is considered good by USEPA (1998, 2006a). However, Method 6200 does not specify a criterion for RPD but specifies the XRF data set and the confirmatory sample data set by way of inferential statistics must not be unequal at a 99 percent confidence interval. Further evaluation to determine if this criterion is met is described in the following subsection.

Table B-90. Comparability for Ex Situ XRF Bulk Sample Method for Zinc

XRF Method[1]	Very Low[2]		Low[3]		Medium[4]		High[5]		All	
	n	RPD	n	RPD	n	RPD	n	RPD	n	RPD
Ex Situ XRF Bulk Sample (Uncorrected)	0	-	23	14%	167	15%	53	19%	243	17%
Ex Situ XRF Bulk Sample (Corrected)	0	-	23	15%	167	12%	53	14%	243	12%

Notes:

1 XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
2 "Very low" refers to samples with zinc concentrations < 2x manufacturer reported MDL.
3 "Low" refers to samples with zinc concentrations ≥ 2x to < 5x manufacturer reported MDL.
4 "Medium" refers to samples with zinc concentrations ≥ 5x to < 10x manufacturer reported MDL.
5 "High" refers to samples with zinc concentrations ≥ 10x manufacturer reported MDL.

MDL Method detection limit
n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)
XRF X-ray fluorescence

4.9.6 Inferential Statistical Analysis

An analysis occurred to compare the XRF and the confirmatory zinc data by way of two-sample hypothesis testing and supported by graphical analysis, as recommended in USEPA (2015a). The ex situ XRF bulk sample zinc measurement values were corrected by application of Model ZN-3 identified in Section 4.9.1. The hypothesis testing method selected was the Student's t-test in ProUCL. The Student's two-sample t-test was used to compare the means of the two independently distributed normal populations that include the XRF data set and the confirmatory data set. This method assumes normality of each population, but given the large sample size, normality is not an issue based on the central limit theorem (USEPA 2015a). A 99 percent ($\alpha = 0.01$) confidence interval was used for the evaluation. The analysis was performed between Mobilization #1 through Mobilization #6 data sets and between Mobilization #7 through Mobilization #9 data sets. Only samples with detected concentrations of zinc in both XRF and laboratory data were used in the analysis—that is, nondetect data pairs were removed from the analysis (as in the linear regression). Table B-91 lists results of comparing uncorrected and corrected XRF data sets with the laboratory-reported concentrations under both mobilization grouping scenarios. Results indicate that both corrected and uncorrected XRF data sets from each mobilization grouping equal the laboratory data set.

An individual distribution analysis was performed in Minitab to identify the best fitting parametric distribution of the confirmatory data set. This analysis showed the three-parameter lognormal distribution best fits the zinc confirmatory data set from Mobilization #1 through Mobilization #6. Figure B-68 is a three-parameter lognormal probability plot showing the XRF-corrected zinc data set and the confirmatory zinc data set side by side, and indicating a strong match between the two populations. A boxplot showing a side-by-side analysis on Figure B-69 compares the same two data sets with one another. Results of the hypothesis testing and graphical analysis indicate the means of the two populations are not unequal at a 99 percent confidence level for XRF and laboratory-reported concentrations. Inferential statistics indicate the two populations are from the same distribution as specified as a criterion in Method 6200.

Table B-91. Summary of Student's t-test Hypothesis Testing Results of XRF and Confirmatory Zinc Data

Analyte	Mobilization[1,2]	Uncorrected[3] Test Result	Corrected[4] Test Result
Zinc	1 - 6	XRF = Lab	XRF = Lab
	7 - 9	XRF = Lab	XRF = Lab

Notes:

Student's two-sample t-test was used with a 99 percent significance level (α = 0.01).

1 Mobilization #1 – Mobilization #6 was the Baseline Study.
2 Mobilization #7 – Mobilization #9 was the Site Characterization Study.
3 Uncorrected refers to the raw XRF data used to represent the XRF population of the t-test.
4 Corrected refers to the XRF data that was converted using Model ZN-3 correction factors.

XRF X-ray fluorescence
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

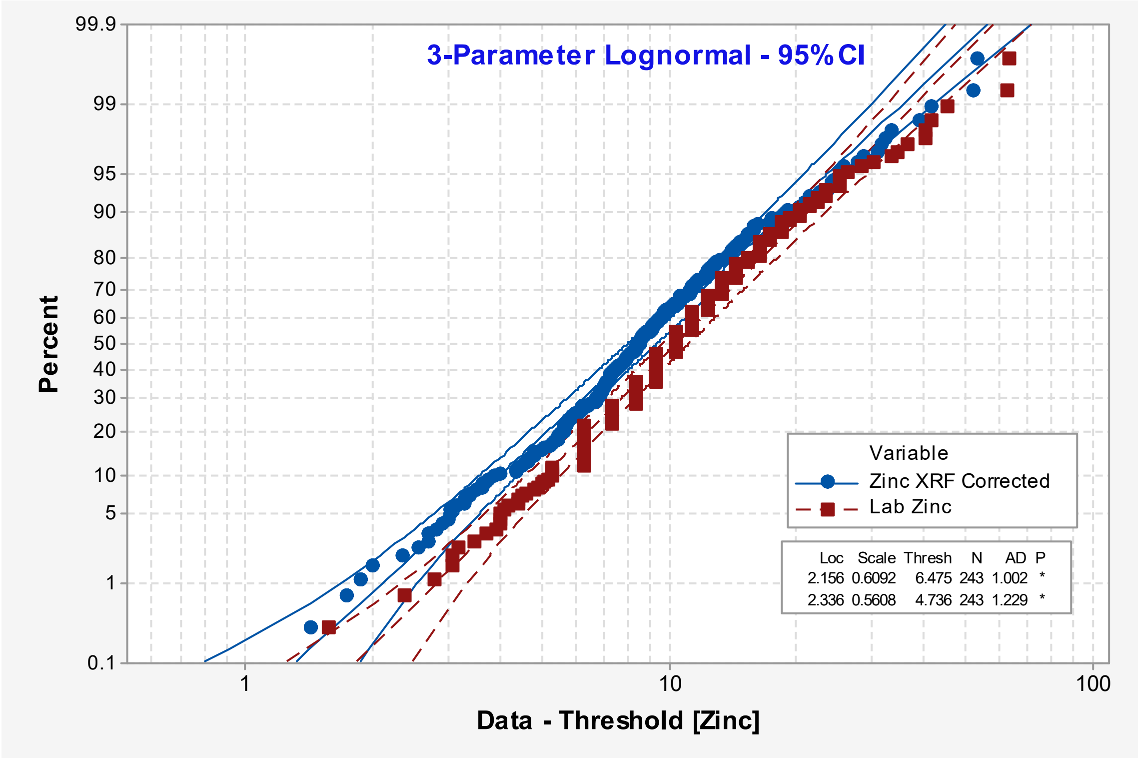


Figure B-68. Probability Plot of XRF Corrected Zinc Data Set and Confirmatory Zinc Data Set (3-Parameter Lognormal)

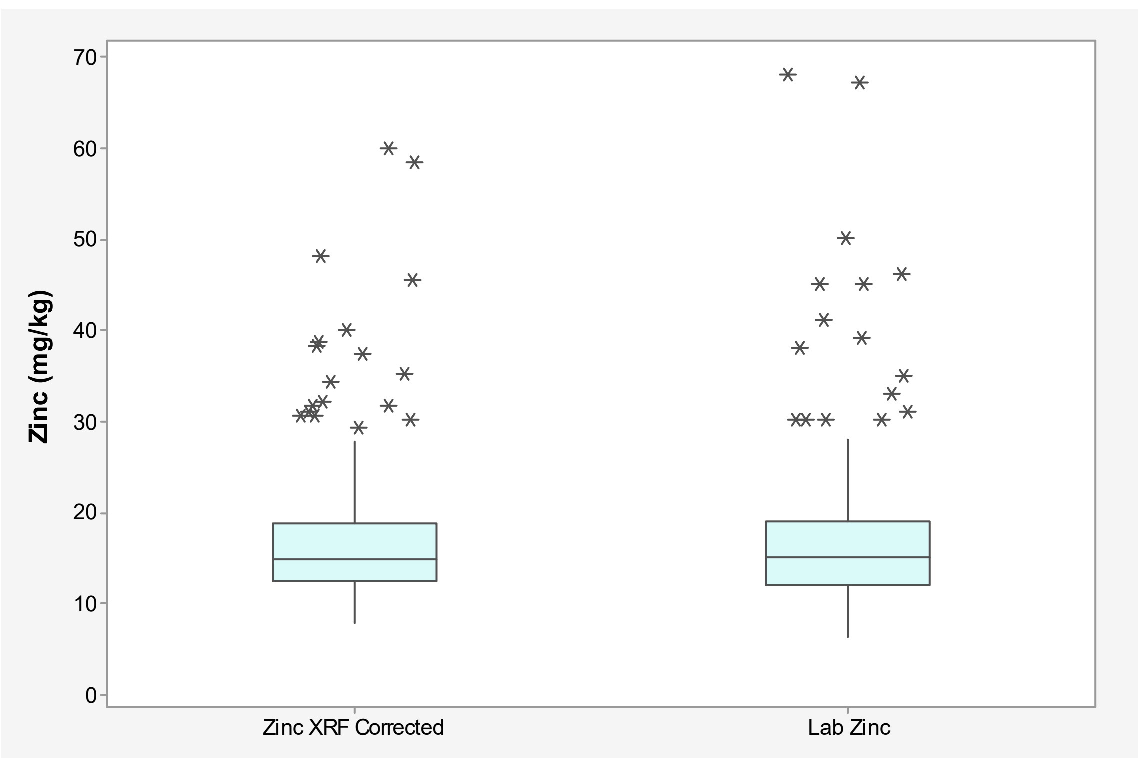


Figure B-69. Boxplot of XRF Corrected Zinc and Laboratory Reported Zinc

4.9.7 Sample Numbers and Descriptive Statistics

Table B-92 summarizes sample numbers and descriptive statistics for the three different surface soil sampling methods used for the project: (1) in situ XRF measurements (corrected), (2) XRF confirmation soil samples, and (3) surface soil samples. A total of 9,540 in situ XRF zinc measurements were taken across the Northern Agency Tronox Mines, which included AUM sites and Target sites. Because of detection limits calculated for zinc with use of the XRF analyzer, 160 of these were below the MDL and qualified as such. The average detected zinc concentration of in situ XRF measurements after correction is 20 mg/kg. A total of 485 detected XRF confirmatory soil sample results averaged 18 mg/kg zinc (detects only). A total of 280 detected surface soil sample results averaged the same 18 mg/kg zinc (detects only). Therefore, 765 detected analytical surficial (XRF confirmation and surface soil) soil sample results averaged 18 mg/kg (detects only). Generally, the average of in situ XRF measurements was very close to project-wide zinc concentrations reported in surface soils via laboratory analytical method (RPD = 12 percent).

Table B-92. Summary of Project Wide Zinc Results by Surface Sampling Method

Summary Statistic[1]	Units	In Situ XRF (Corrected)[2]	XRF Confirmation Samples (0 to 3 inches bgs)[3]	Surface Soil Samples (0 to 6 inches bgs)[3]	Combined Analytical[3]
Detected Results	#	9,380	485	280	765
Nondetects	#	160	17	12	29
Minimum	mg/kg	7.8	5.5	4.8	4.8
Maximum	mg/kg	234	120	290	290
Average	mg/kg	20	18	18	18
Standard Deviation	mg/kg	9.0	12	19	15
Median	mg/kg	18	15	16	15
90th Percentile	mg/kg	29	26	25	26
95th Percentile	mg/kg	35	37	31	33
99th Percentile	mg/kg	50	75	61	78

Notes:

1 Descriptive statistics presented are of the detected concentrations only.

2 In situ XRF measurements were converted to predicted laboratory-determined zinc concentrations using correction factors from Model ZN-3.

3 Laboratory-reported zinc concentrations were analyzed via partial digestion (3050B) and ICP-MS (6020A).

bgs Below ground surface

ICP-MS Inductively coupled plasma-mass spectrometry

mg/kg Milligrams per kilogram

XRF X-ray fluorescence

4.9.8 Final Model Selection

A comparison of ex situ XRF bulk sample measurements to laboratory-reported zinc concentrations in the bulk soil samples, as summarized in Section 4.9.1, led to selection of Model ZN-3 as the optimal model to best predict laboratory zinc concentrations by use of XRF analyzers. This model can be used to post-process in situ XRF measurements to correct them to a more accurate representation of zinc concentrations reported from laboratory application of ICP-MS after acid partial digestion, and thus meet project DQOs. Criteria for characterizing data quality for this project are listed in Table B-3. For determining zinc concentrations by use of XRF analyzers, the correlation coefficient (r = 0.91), in situ XRF measurement precision (RSD = 7.4 percent), and corrected ex situ XRF bulk sample comparability (12 percent) all meet the criteria for zinc data reported by XRF analyzers to be considered at a definitive level. The correlation coefficient exceeds 0.9, and inferential statistics indicate the two data sets are equal at a 99 percent confidence level, as specified in Method 6200. The inferential statistics involved comparison of the corrected XRF zinc data set and the laboratory data set for Mobilization #1 through Mobilization #6 (used in development of Model ZN-3) and for Mobilization #7 through Mobilization #9 (not used in model development). In both of these analyses, the inferential statistics indicate the mean of corrected XRF data equal to the mean of the laboratory confirmatory data.

Comparison of the soil cup method to the bulk sample method indicated that the bulk sample method is essentially as dependable or at least more conservative at estimating zinc concentrations (Figure B-66). Furthermore, application of the ex situ XRF bulk sample method tends to reflect site conditions more closely regarding particle size, moisture content, and concentration. Therefore, Model ZN-3 is the final model selected, and is applied to correct and post-process in situ XRF measurements to predicted laboratory zinc concentrations for the RSE reports. Equation 13 expresses the resulting linear regression model calculated for zinc by use of the 264 data pairs of ex situ XRF bulk sample zinc measurements and laboratory-reported zinc concentrations (via ICP-MS after partial digestion) obtained during Mobilization #1 through Mobilization #6:

Equation 13: $$[Zn]_{lab} = (0.6919 * [Zn]_{XRF}) + 4.2593$$

Figure B-70 compares the primary bulk sample zinc regression model (shown in blue) to unity line (as shown in black—that is, if the model was 1:1 [XRF to lab]). The model is lower than unity, indicating requirement to apply a correction factor to the XRF data in order to increase comparability between XRF and confirmatory methods.

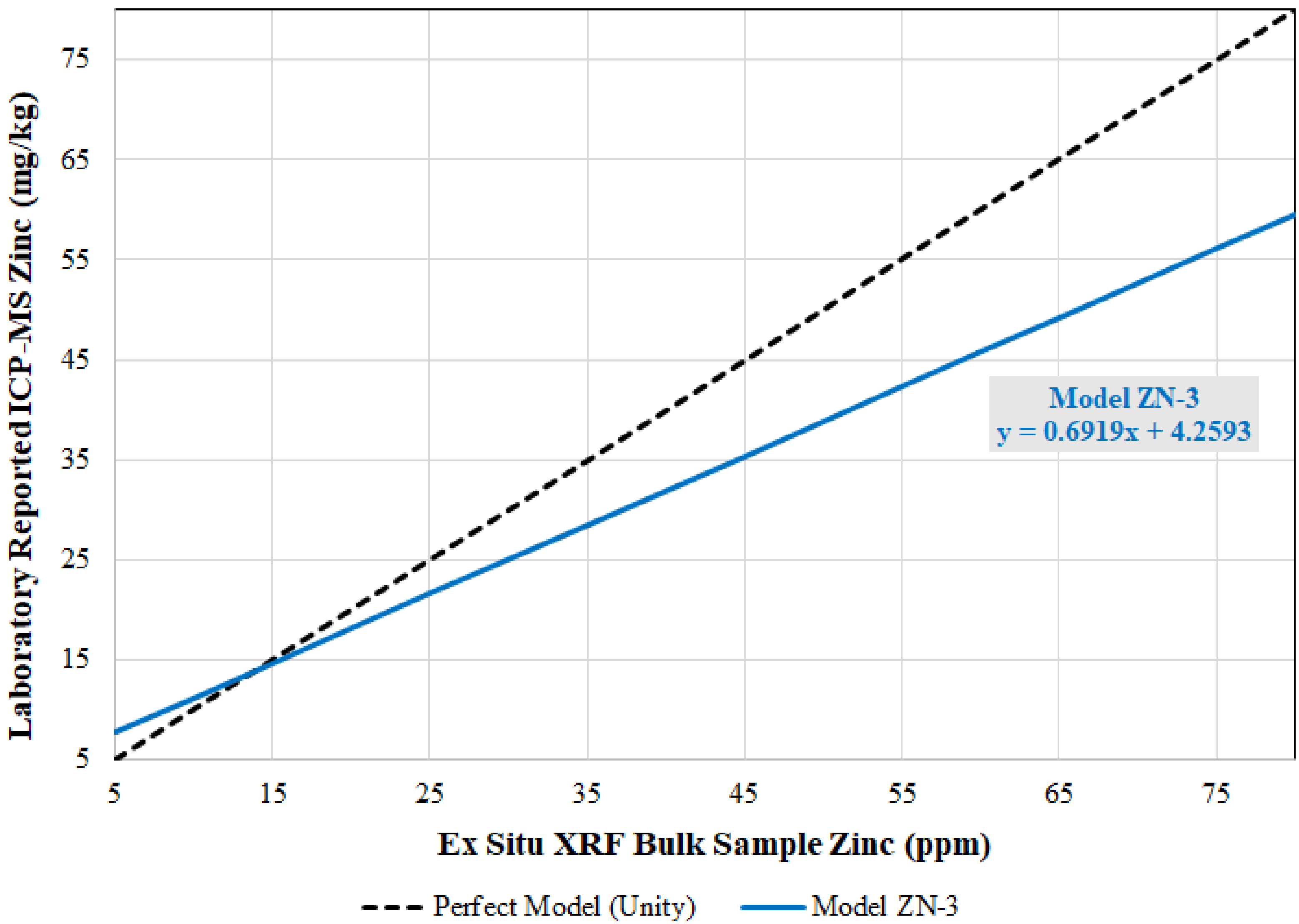


Figure B-70. Final Zinc Regression Model – Unity Comparison

5.0 DATA QUALITY ASSESSMENT

The data quality assessment of the XRF field survey program in this section includes a presentation of data quality indicators, summary of results of a pilot study, and a brief particle size analysis.

5.1 DATA QUALITY INDICATORS

The measurement performance criteria presented in Section 3.0 are evaluated in this study for data quality indicators (DQI). DQIs as part of systematic planning typically include precision, accuracy, representativeness, comparability, and completeness (USEPA 2014a). This program included several measures used as DQIs to monitor analytical quality of the different methods applied in the XRF field survey program. These measures are used to objectively quantify, where possible, how well the data can be used to achieve project DQOs. These DQIs are related to performances of the various XRF methods, including in situ XRF method in the field, ex situ XRF bulk sample method, and ex situ XRF soil cup method. The indicators include detection limits, accuracy, precision, data qualifiers, inferential statistics (through two-sample hypothesis testing), and evaluation of prediction limits of the regression models. Many results of these indicators have been presented earlier in the report for each target element, but this section provides the reader an opportunity to evaluate those results in a single section, allowing easier comparison across the multiple target elements. Some of these indicators are discussed for the first time in this section. Nonetheless, all of these measures provide a snapshot of performances of the different XRF methods, and how well the data can be used to meet project DQOs.

5.1.1 METHOD DETECTION LIMIT

The XRF field survey report includes information on an attempt to quantify detection capabilities of the Niton XL5 analyzer for use in applications of the various XRF analysis methods. The three methods of XRF analysis were: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup sample method. MDLs were calculated for each method for each of the nine target elements following federal guidance (Title 40 *Code of Federal Regulations* [CFR] Part 136, Appendix B, Revision 1.11), as described in Section 3.4.8. Resulting MDL values for each method for each of the nine target elements are conveyed within the respective elemental discussion subsections in Section 4.0.

Calculated MDLs for the three different XRF methods are shown for comparison purposes only, along with manufacturer-reported MDLs, in Table B-93, Table B-94, and Table B-95. Calculated MDLs for the in situ XRF method were used subsequently only during the data qualification process described in Section 3.6. All corrected measurements in the in situ XRF database that became negative values or measurements below the instrument LOD were set as nondetects as less than (<) corrected in situ XRF MDLs. These are the calculated MDLs listed in Table B-95 for the in situ XRF method, which then were converted by application of ex situ XRF bulk sample correction factors. For molybdenum and vanadium, *corrected* in situ XRF MDLs were negative values, and therefore any data qualified as nondetect were then set to less than (<) maximum reported laboratory MDLs for those analytes rather than the *corrected* in situ XRF MDLs. Also, and notably, the in situ MDL for uranium, when converted to a predicted laboratory-determined value, was less than the laboratory MDL of 0.10 mg/kg. Nonetheless, all uranium nondetect data were set less than (<) the in situ XRF MDL (lab-converted) of 0.080 mg/kg. Furthermore, a small subset of corrected in situ XRF measurements considered detect are between the 0.080 mg/kg (laboratory-converted in situ XRF MDL for uranium) and 0.10 mg/kg (maximum laboratory-reported MDL for uranium).

Table B-93. Summary of In Situ XRF Method Detection Limits

Analyte	Niton MDL (ppm)[1]	In Situ XRF MDL (ppm)[2]	Corrected In Situ XRF MDL (ppm)[3]	Maximum Lab MDL (where applicable) (ppm)[4]
Arsenic	2.0	2.3	1.8	-
Iron	9.0	2,030	768	-
Lead	1.0	1.8	0.27	-
Manganese	13	21	81	-
Molybdenum	1.0	1.6	-0.39	0.038
Thorium	1.0	2.0	1.0	-
Uranium	2.0	2.9	0.08	0.10
Vanadium	3.0	9.4	-10.8	16
Zinc	2.0	5.1	7.8	-

Notes:

1 Niton MDL refers to 60 second count on all three filters; in situ XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 In Situ XRF MDL calculated according to Title 40 CFR Part 136, Appendix B, Revision 1.11.

3 Corrected in situ XRF MDL was converted by application of final model for ex situ XRF bulk sample method.

4 This value is used only for molybdenum and vanadium because corrected MDL is negative.

CFR *Code of Federal Regulations*
MDL Method detection limit
ppm Parts per million
XRF X-ray fluorescence

Table B-94. Summary of Ex Situ XRF Bulk Sample Method Detection Limits

Analyte	Niton MDL (ppm)[1]	Ex Situ XRF Bulk Sample Method MDL (ppm)[2]
Arsenic	2.0	3.3
Iron	9.0	1,254
Lead	1.0	2.2
Manganese	13	34
Molybdenum	1.0	2.1
Thorium	1.0	2.1
Uranium	2.0	4.4
Vanadium	3.0	13
Zinc	2.0	4.0

Notes:

1 Niton MDL refers to 60 second count on all three filters; in situ XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 Ex situ XRF Bulk Sample Method MDL calculated according to Title 40 CFR Part 136, Appendix B, Revision 1.11.

CFR *Code of Federal Regulations*
MDL Method detection limit
ppm Parts per million
XRF X-ray fluorescence

Table B-95. Summary of Ex Situ XRF Soil Cup Method Detection Limits

Analyte	Niton MDL (ppm)[1]	Ex Situ XRF Soil Cup Method MDL (ppm)[2]
Arsenic	2.0	2.3
Iron	9.0	1,118
Lead	1.0	2.5
Manganese	13	31
Molybdenum	1.0	9.8
Thorium	1.0	2.1
Uranium	2.0	4.2
Vanadium	3.0	21
Zinc	2.0	4.9

Notes:

1 Niton MDL refers to 60 second count on all three filters; In Situ XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.

2 Ex Situ XRF Bulk Sample Method MDL calculated according to Title 40 CFR Part 136, Appendix B, Revision 1.11.

CFR *Code of Federal Regulations*
MDL Method detection limit
ppm Parts per million
XRF X-ray fluorescence

5.1.2 COMPARABILITY

Comparability was evaluated by calculating the RPD between XRF data and confirmatory data. The RPD can help determine how well an XRF-reported measurement corresponds to the counterpart laboratory-reported concentration of a target element. Further discussion on this is in Section 3.0. Part of this study evaluated comparabilities between laboratory data and XRF data generated by applications of: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method. Method 6200 does not specify an acceptable RPD for an XRF method to be considered acceptable or included in the data quality criteria process; however, for the proposed data quality criteria described for this project (Section 2.3.3), a measure of acceptable RPD has been presented. Resultant RPD values for each method are conveyed for each of the nine target elements within the respective elemental discussion subsections in Section 4.0. Previous evaluation studies have used a categorical rating system to identify how well an XRF method achieves comparability (USEPA 1998, 2006a). Table B-12 lists those categorical ratings. A performance evaluation appears later in the report to show which target elements fall into which categorical ratings in order to determine comparabilities of the different XRF methods.

Table B-96 and Table B-97 summarize uncorrected and corrected comparabilities for the ex situ XRF soil cup method across concentration ranges. “Corrected comparabilities” refers to analyses of RPDs between corrected ex situ XRF soil cup data and confirmatory data. The median RPD ranges between 10 and 19 percent. Table B-98 and Table B-99 summarize uncorrected and corrected comparabilities for the ex situ XRF bulk sample method across concentration ranges. Here “corrected comparabilities” refers to analyses of RPDs between corrected ex situ XRF bulk sample data and confirmatory data. The median RPD for corrected results ranges between 12 and 44 percent. Comparabilities of corrected data from application of the ex situ XRF bulk sample method are parameters used to characterize data quality specified in Section 6.0.

For this project, comparabilities of data from the ex situ XRF bulk sample method and the ex situ XRF soil cup method are generally good for all analytes after application of method-specific correction factors. Comparability for molybdenum data from the ex situ XRF bulk sample method showed an RPD of 44 percent, but this was weighted heavily by poor comparability measured in the very low concentration ranges. However, for the rest of the analytes, both XRF ex situ methods provided fair to excellent estimation metrics, depending on the analyte of interest and concentration range.

Table B-96. Summary of Comparabilities (Uncorrected XRF Soil Cup Method)

Analyte	Very Low		Low		Medium		High		All	
	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD
Arsenic	53	33%	21	18%	3	10%	15	16%	92	24%
Iron	0	-	0	-	0	-	132	82%	132	82%
Lead	0	-	54	56%	48	44%	30	24%	132	45%
Manganese	0	-	3	13%	57	21%	72	16%	132	19%
Molybdenum	3	111%	16	10%	12	35%	0	-	31	30%
Thorium	57	67%	47	62%	6	66%	3	32%	113	65%
Uranium	9	101%	18	76%	17	51%	84	23%	128	29%
Vanadium	0	-	21	129%	15	112%	96	46%	132	67%
Zinc	0	-	45	33%	66	39%	21	39%	132	37%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)

Table B-97. Summary of Comparabilities (Corrected Ex Situ XRF Soil Cup Method)

Analyte	Very Low		Low		Medium		High		All	
	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD
Arsenic	53	14%	21	10%	3	5%	15	7%	92	10%
Iron	0	-	0	-	0	-	132	11%	132	11%
Lead	0	-	54	19%	48	12%	30	7%	132	13%
Manganese	0	-	3	30%	57	19%	72	13%	132	17%
Molybdenum	3	86%	16	19%	12	9%	0	-	31	14%
Thorium	57	13%	47	14%	6	33%	3	2.9%	113	13%
Uranium	9	50%	18	37%	17	23%	84	11%	128	16%
Vanadium	0	-	6	37%	9	14%	96	13%	111	15%
Zinc	0	-	45	27%	66	17%	21	7%	132	19%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)

Table B-98. Summary of Comparabilities (Uncorrected Ex Situ XRF Bulk Sample Method)

Analyte	Very Low		Low		Medium		High		All	
	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD
Arsenic	46	15%	61	11%	12	10%	12	14%	131	13%
Iron	0	-	0	-	0	-	256	63%	256	63%
Lead	1	36%	82	49%	136	25%	36	12%	255	29%
Manganese	0	-	1	28%	45	52%	205	29%	251	31%
Molybdenum	118	167%	14	59%	9	45%	5	34%	146	155%
Thorium	91	76%	155	63%	8	46%	2	35%	256	68%
Uranium	64	86%	45	60%	37	43%	61	19%	207	56%
Vanadium	10	125%	78	111%	54	96%	110	46%	252	91%
Zinc	0	-	23	14%	167	15%	53	19%	243	17%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)

Table B-99. Summary of Comparabilities (Corrected Ex Situ XRF Bulk Sample Method)

Analyte	Very Low		Low		Medium		High		All	
	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD	n	Median RPD
Arsenic	46	17%	12	10%	12	10%	12	15%	131	13%
Iron	0	-	0	-	0	-	256	12%	256	12%
Lead	1	52%	82	21%	136	14%	36	12%	255	15%
Manganese	0	-	1	50%	45	20%	205	13%	251	13%
Molybdenum	88	66%	14	24%	9	14%	5	2.1%	116	44%
Thorium	91	16%	155	15%	8	19%	2	2.9%	256	15%
Uranium	64	39%	45	21%	37	14%	61	21%	207	22%
Vanadium	7	72%	77	34%	54	30%	110	20%	248	27%
Zinc	0	-	23	15%	167	12%	53	14%	243	12%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RPD
RPD Relative percent difference (presented as median RPD)

5.1.3 PRECISION

Analytical precision was estimated by replicate sampling during the in situ XRF field survey and by ex situ analyses of bulk samples and soil cup samples. Repeated measurements are important because they provide estimates of measurement precision (Johnson and others 2005) and these data can also be used to estimate MDLs for the XRF analyzer (see Section 5.1.1). XRF replicate measurements occurred as specified in Section 4.4.1.2 of the QAPP (Appendix C to the RSE Work Plan, Tetra Tech 2018) and in accordance with Method 6200. A discussion of the methodology for evaluating and calculating precision is in Section 3.4.6.

As specified in Section 9.5 of Method 6200, precision of a method is monitored by analyzing a sample with low, moderate, or high concentrations of target elements. Precision of the different XRF methods was calculated for target analytes over a range of concentrations: very low, low, medium, and high. Definitions of these concentration ranges are listed in Table B-11. Resultant RPD values for each method are conveyed for each of the nine target elements within the respective elemental discussion subsections in Section 4.0; all of these are repeated here in one place to facilitate cross elemental precision analysis. Table B-100 summarizes precisions of the in situ XRF method across four concentration ranges.

Table B-101 summarizes precision of the ex situ XRF soil cup method across four concentration ranges. Table B-102 summarizes precision of the XRF bulk sample method across four concentration ranges. Except for molybdenum in application of the ex situ XRF bulk sample method, acceptable precision requirements (RSD < 20 percent) were achieved for all target elements for all XRF methods across all levels of concentration ranges.

Table B-100. Summary of Precisions (In Situ XRF Method)

Scenario	Very Low		Low		Medium		High		All	
	n	Median RSD	n	Median RSD	n	Median RSD	n	Median RSD	n	Median RSD
Arsenic	62	21%	29	16%	8	9.6%	3	6.1%	102	19%
Iron	0	-	0	-	0	-	190	1.5%	190	1.5%
Lead	1	21%	10	19%	146	10%	32	6.5%	189	9.7%
Manganese	0	-	5	13%	48	11%	133	6.3%	186	7.5%
Molybdenum	11	18%	36	19%	10	13%	1	35%	58	18%
Thorium	1	31%	110	17%	63	12%	1	5.8%	175	14%
Uranium	21	24%	106	14%	27	8.5%	18	6.7%	172	13%
Vanadium	0	-	0	-	29	14%	160	8.3%	189	9.0%
Zinc	0	-	12	18%	84	8.8%	88	5.7%	184	7.4%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RSD
RSD Relative standard deviation difference (presented as median RSD)

Table B-101. Summary of Precisions (Ex Situ XRF Soil Cup Method)

Scenario	Very Low		Low		Medium		High		All	
	n	Median RSD	n	Median RSD	n	Median RSD	n	Median RSD	n	Median RSD
Arsenic	53	19%	21	12%	3	7.7%	15	4.6%	92	14%
Iron	0	-	0	-	0	-	132	3.6%	132	3.6%
Lead	0	-	54	12%	48	10%	30	6.1%	132	9.2%
Manganese	0	-	3	20%	57	17%	72	9.3%	132	12%
Molybdenum	3	21%	16	23%	12	6.3%	0	-	31	15%
Thorium	57	21%	47	16%	6	7.5%	3	2.9%	113	18%
Uranium	9	19%	18	9.3%	17	10%	84	9.0%	128	9.6%
Vanadium	0	-	21	12%	15	9.3%	96	6.2%	132	8.2%
Zinc	0	-	45	13%	66	7.9%	21	4.2%	132	8.9%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RSD

RSD Relative standard deviation difference (presented as median RSD)

Table B-102. Summary of Precisions (Ex Situ XRF Bulk Sample Method)

Scenario	Very Low		Low		Medium		High		All	
	n	Median RSD	n	Median RSD	n	Median RSD	n	Median RSD	n	Median RSD
Arsenic	46	23%	61	16%	12	12%	12	10%	131	17%
Iron	0	-	0	-	0	-	256	6%	256	6%
Lead	1	16%	82	12%	136	11%	36	10%	255	11%
Manganese	0	-	1	40%	45	19%	205	13%	251	14%
Molybdenum	118	23%	14	15%	9	12%	5	8%	146	22%
Thorium	91	17%	155	14%	8	10%	2	5.6%	256	15%
Uranium	64	19%	45	15%	37	14%	61	13%	207	16%
Vanadium	10	15%	78	13%	54	10%	110	8%	252	10%
Zinc	0	-	23	14%	167	11%	53	9%	243	11%

Notes:

XRF method used a 30 second Main filter, 15 second Low filter, and 15 second High filter.
Criterion for different concentration ranges are listed in Table B-11.

n Number of samples used for calculating median RSD

RSD Relative standard deviation difference (presented as median RSD)

5.1.4 DATA QUALIFIERS

A total of 9,540 in situ XRF measurements were taken during the Baseline Study and Site Characterization Study of the RSE investigation. Determination was that the XRF analyzer can adequately estimate trace concentrations of nine target elements, as discussed in Section 4.0. The in situ XRF measurements were corrected by use of correction factors (slope and y-intercept) developed from the ex situ XRF bulk sample comparability study for each of the nine target elements. The data qualification scheme in Section 3.6 takes into account MDLs and uncertainties within the limits of the regression models (that is, lower and upper limits of the data set used in development of the regression model). Table B-103 summarizes numbers and types of data qualifiers used to qualify the in situ XRF measurement geodatabase for the project.

Table B-103. Summary of Data Qualifiers in XRF Geodatabase

Target Element	# of Total Values	# of Qualified Data	# of QL Qualifiers	# of QH Qualifiers	# of QU Qualifiers
Arsenic	9,540	4,002	0	15	3,987
Iron	9,540	121	9	11	101
Lead	9,540	107	56	3	48
Manganese	9,540	455	49	336	70
Molybdenum	9,540	6,304	0	0	6,304
Thorium	9,540	506	0	2	504
Uranium	9,540	1,143	50	10	1,083
Vanadium	9,540	3,661	0	14	3,647
Zinc	9,540	204	4	40	160

Notes:
LOD Limit of detection
MDL Method detection limit
QH Detected, but XRF measurement above maximum XRF value used in regression model.
QL Detected, but XRF measurement below minimum XRF value used in regression model.
QU Not detected—XRF measurement below either the LOD or calculated in situ XRF MDL of instrument.
XRF X-ray fluorescence

5.1.5 SUMMARY OF HYPOTHESIS TESTING

Two-sample hypothesis testing approaches were applied to compare XRF data and confirmatory data, and to evaluate whether the means of the two populations are unequal. This analysis involved use of USEPA statistical software ProUCL 5.1.00.2 (USEPA 2015a). Results of the population testing for each element are conveyed in Section 4.0. The student's t-test was used to compare the raw and uncorrected ex situ XRF bulk sample data set to laboratory results from the same bulk samples. This analysis occurred after correction of the XRF data. A 99 percent confidence level was used, as specified in Section 9.7 of Method 6200. The analysis was performed on the Mobilization #1 through Mobilization #6 data sets (uncorrected and corrected), and on the Mobilization #7 through Mobilization #9 data sets. Table B-104 lists results of the two-sample hypothesis testing of XRF data set and confirmatory data set for Mobilization #1 through Mobilization #6. Table B-105 lists results of the two-sample hypothesis testing of XRF data set and confirmatory data set for Mobilization #7 through Mobilization #9. Results of these analyses are useful to determine if two data sets originating from two different analytical methods (XRF and laboratory) are statistically similar. For all target elements, it was determined that the mean and variance of each of the two data sets acquired during the study were equal after application of the ex situ XRF bulk sample method correction factor. It was also found that for arsenic, uranium, and zinc, no correction factor was required, as the data sets are equal. Nonetheless, recommendation is to apply correction factors to XRF data to best represent predicted laboratory concentrations, and to follow a conservative approach protective of human health and the environment. Attachment B6 includes the ProUCL output files from the analyses of hypothesis testing.

Table B-104. Results of Two Sample Hypothesis Testing of XRF Data Set and Confirmatory Data Set (Mobilization #1 – Mobilization #6)

Test:	**Student's t-test**	
Data Set:	**Mobilization #1 - Mobilization #6**	
Type:	**Uncorrected[1]**	**Corrected[2]**
Analyte	**Result**	
Arsenic	XRF = Lab	XRF = Lab
Iron	XRF <> Lab	XRF = Lab
Lead	XRF <> Lab	XRF = Lab
Manganese	XRF <> Lab	XRF = Lab
Molybdenum	XRF <> Lab	XRF = Lab
Thorium	XRF <> Lab	XRF = Lab
Uranium	XRF = Lab	XRF = Lab
Vanadium	XRF <> Lab	XRF = Lab
Zinc	XRF = Lab	XRF = Lab

Notes:
1 Uncorrected indicates raw ex situ XRF bulk sample measurements.
2 Corrected indicates that final model(s) correction factors were applied to XRF data before the analysis.
XRF X-ray fluorescence
XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

Table B-105. Results of Two Sample Hypothesis Testing of XRF Data Set and Confirmatory Data Set (Mobilization #7 – Mobilization #9)

Test:	Student's t-test	
Data Set:	Mobilization #7 - Mobilization #9	
Type:	Uncorrected	Corrected
Analyte	Result	
Arsenic	XRF = Lab	XRF = Lab
Iron	XRF <> Lab	XRF = Lab
Lead	XRF <> Lab	XRF = Lab
Manganese	XRF <> Lab	XRF = Lab
Molybdenum	XRF <> Lab	NA
Thorium	XRF <> Lab	XRF = Lab
Uranium	XRF = Lab	XRF = Lab
Vanadium	XRF <> Lab	XRF = Lab
Zinc	XRF = Lab	XRF = Lab

Notes:
[1] Uncorrected indicates the raw ex situ XRF bulk sample measurements.
[2] Corrected indicates the final model(s) correction factors were applied to XRF before running analysis.
NA Not applicable (no correction of original molybdenum XRF data occurred)
XRF X-ray fluorescence
XRF <> Lab Indicates the null hypothesis that the sample means are equal was rejected.
XRF = Lab Indicates the null hypothesis that sample means are equal was not rejected.

5.1.6 EVALUATION OF PREDICTION LIMITS

The ex situ XRF bulk sample models are presented throughout Section 4.0 for each of the target elements. These models are shown with upper and lower prediction limits at a 95 percent level. An analysis was performed to evaluate the data pairs generated from Mobilization #1 through Mobilization #6, as well as the data pairs generated from Mobilization #7 through Mobilization #9 to see how well these distinct data sets fall within the main model 95 percent prediction limits. Another analysis occurred to combine all data pairs and evaluate how many data pairs fell within the prediction limits. In general, the percentage of points that fell outside of prediction limits ranged from 3.9 to 6.1 percent. Ideally, 95 percent of the data pairs would fall within the prediction limits. Table B-106 summarizes this analysis. Applying this validation method showed that generally, the models were good at predicting laboratory concentrations with use of the ex situ XRF bulk sample correction factors developed for each target element.

Table B-106. Evaluation of Prediction Limits for Target Element Regression Models

Analyte	Model Name	Mobilization #1 - Mobilization #6		Mobilization #7 - Mobilization #9		All	
		Data Pairs	% of Points Outside Prediction Limits	Data Pairs	% of Points Outside Prediction Limits	Data Pairs	% of Points Outside Prediction Limits
Arsenic	Model AS-3	131	3.8%	86	4.7%	217	4.1%
Iron	Model FE-1	256	5.9%	272	4.4%	528	5.1%
Manganese	Model MN-2	251	6.0%	257	6.2%	508	6.1%
Molybdenum	Model MO-1	146	5.5%	-	-	146	5.5%
Vanadium	Model VA-2	252	6.0%	265	5.3%	517	5.6%
Zinc	Model ZN-3	243	6.6%	244	4.5%	487	5.5%
Uranium	Model U-2A	184	7.6%	206	4.4%	390	5.9%
Thorium	Model TH-2A	254	3.9%	-	-	254	3.9%
Lead	Model PB-2A	254	5.5%	266	5.3%	520	5.4%

Note:

- No data available for Mobilization #7 through Mobilization #9.

5.2 PILOT STUDY

A small pilot study in the field evaluated a Target site via in situ XRF measurements on a grid system and then collection of soil samples at the same approximate locations within the grid system. Ex situ XRF bulk sample regression correction factors were applied to the in situ XRF measurements to predict laboratory concentrations of the target elements. Then the corrected XRF data set for each element was compared to the counterpart laboratory data set. A comparison of RPDs to typical ranges of RPDs from this study occurred over a given concentration range for a given element. All RPDs calculated for each element were within the expected range of RPDs for a given concentration range of that element. Three of the eight elements had RPDs lower than the median RPDs expected within the given concentration ranges, and the other five had RPDs above the median RPDs expected within the given concentration ranges.

Comparisons of XRF data sets to confirmatory data sets were better than expected for arsenic, iron, and thorium. Within given concentration ranges of the remaining five elements, where RPDs were higher than the median RPDs, average concentrations were higher than those of the confirmatory data set. Thus, corrected XRF data were consistently more conservative on average than laboratory-reported concentrations. This result was expected, and supports use of corrected XRF data for human health and ecological risk assessment because of the protectiveness of this prediction mechanism.

Table B-107 summarizes the corrected XRF data set and laboratory data set pertaining to Target T12.

Table B-108 summarizes statistics of corrected XRF versus laboratory XRF data sets pertaining to Target T12.

Table B-107. Summary of Corrected XRF Data Set and Laboratory Data Set for Target T12

Analyte	XRF Corrected Data Set[1]					Confirmation Samples[3]				
	n	Detects	Average (mg/kg)	Standard Deviation (mg/kg)	RSD[2]	n	Detects	Average (mg/kg)	Standard Deviation (mg/kg)	RSD[4]
Arsenic	12	11	2.7	0.84	31%	12	12	2.4	0.2	7.9%
Iron	12	12	7,602	981	13%	12	12	7,033	474	6.7%
Lead	12	12	9.6	1.8	19%	12	12	7.4	1.4	20%
Manganese	12	12	377	57	15%	12	12	283	30	11%
Molybdenum	12	9	0.70	0.62	88%	12	12	0.19	0.02	12%
Thorium	12	12	2.9	0.59	20%	12	12	2.8	0.4	13%
Uranium	12	12	1.2	0.63	53%	12	12	0.43	0.09	21%
Vanadium	12	12	18	4.0	22%	12	12	11	1.2	10%
Zinc	12	12	26	4.4	17%	12	12	19	3.7	19%

Notes:
[1] Average of six ex situ XRF arsenic measurements taken from the bulk sample.
[2] RSDs of 12 corrected in situ XRF measurements taken at the Target site (calculated from detects only).
[3] Laboratory-reported concentrations via partial digestion (3050B) and ICP-MS (6020A).
[4] RSDs of 12 laboratory-reported concentrations in samples collected at the Target site.

ICP-MS Inductively coupled plasma-mass spectrometry
mg/kg Milligrams per kilogram
n Number of XRF measurements or confirmation samples collected
RSD Relative standard deviation
XRF X-ray fluorescence

Table B-108. Summary Statistics of Corrected XRF vs. Laboratory XRF Data Sets for Target T12

Analyte	Expected Performance				
	RPD of XRF and Lab	Range	Low RPD for Range	High RPD for Range	Typical Median RPD for Range
Arsenic	13%	Very Low	2.0%	76%	17%
Iron	7.8%	High	0.0%	50%	12%
Lead	26%	Medium	0.0%	59%	14%
Manganese	28%	High	0.0%	58%	13%
Molybdenum	115%	Very Low	2.0%	177%	66%
Thorium	3.7%	Low	0.0%	60%	15%
Uranium	93%	Very Low	1.0%	181%	39%
Vanadium	47%	Medium	2.0%	108%	30%
Zinc	32%	Medium	0.0%	75%	12%

Notes:
RPD Relative percent difference
XRF X-ray fluorescence

5.3 PARTICLE SIZE ANALYSIS

An evaluation occurred to evaluate effects of particle size on XRF measurements of target elements. The XRF confirmation soil sample is a bulk sample evaluated by application of the ex situ XRF bulk sample method. This bulk sample has geotechnical properties similar to what would be encountered in the field, with little to no alteration of original particle size. A soil cup sample evaluated by application of the ex situ XRF soil cup method is a more processed soil sample that has been sieved to contain only particles below a 60-mesh sieve size, and is considered to contain the fine soil particles from within the bulk sample only. A total of 44 bulk samples were further processed to generate soil cup samples. These were selected to represent the ranges of concentrations of respective target elements. Both samples were sent to the laboratory for analysis for a suite of metals. An evaluation of impacts of particle size and homogenization of soil samples on XRF correlation results ensued.

The evaluation of particle size for each target element in Section 4.0 indicates a linear relationship between the elements' respective concentrations in soil bulk samples and soil cup samples. It was evident that soil concentration decreased as particle size decreased. Table B-109 summarizes laboratory analytical results from the two sample sets. Mean concentrations of all target elements were higher in the bulk sample population than in the soil cup population. An important implication of this study of effects of particle size on determinations of metals and radionuclide concentrations is that the results do not align with the assumption that higher concentrations are expected in the finer particles of soil and sediment found at a typical AUMs. This is significant in that the established view that only the finer fractions of soil or sediment are of concern regarding metals contamination is not necessarily correct. The relationship between particle size and metal content conveyed in this report indicates an overall decrease in soil metals concentrations as particle size becomes finer. Further study may be necessary to evaluate different size fractions and respective concentrations in stream sediments.

Table B-109. Summary of Bulk Sample and Soil Cup Sample Results for Target Elements

Analyte[1]	Bulk Sample - Bulk Fraction		Soil Cup - Fine Fraction		Summary Statistics				
	Mean (mg/kg)	Standard Deviation (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	n	# of Samples that Decrease	% of Samples that Decrease	Average % Decrease of Samples that Decreased	RPD of Means
Arsenic	7.3	10	6.2	9.4	44	43	98%	23%	16%
Iron	6,598	3,941	5,184	3,991	44	42	95%	25%	24%
Manganese	196	99	165	106	44	38	86%	24%	17%
Molybdenum	1.87	2.59	1.60	2.15	43	31	72%	19%	15%
Thorium	3.3	6	3.0	6.6	44	38	86%	21%	11%
Uranium	73	86	68	91	44	26	59%	23%	6.2%
Vanadium	256	324	231	271	44	26	59%	26%	10%
Zinc	21	14	16	12	42	40	95%	26%	27%

Notes:

[1] Laboratory-reported concentrations are via partial digestion (3050B) and ICP-MS (6020A). Mean and standard deviations are of all detectable samples.

ICP-MS Inductively coupled plasma-mass spectrometer

mg/kg Milligrams per kilogram

n Number of data pairs from bulk sample and soil cup that indicate element at detectable concentration in both the bulk sample and soil cup

RPD Relative percent difference

6.0 FINAL MODEL SELECTION

Table B-110 summarizes the final models selected for each target element, based on results of the comparability study of the ex situ XRF bulk sample method. This study showed good correlation between data from XRF analyzers and from application of the confirmatory method. Except for manganese and arsenic, the XRF method overestimates elemental soil concentration, indicating a distinct difference between the two methods that may be related to partial digestion of the sample prior to ICP-MS. Because of these differences between the laboratory method (partial digestion) and the XRF method (total analysis), relationship of unity (1 to 1) was evident only for arsenic, and not for any of the other target elements. Therefore, recommendation is to apply a correction factor to XRF data to better predict concentrations determined via the confirmatory method— the same method used in the background investigation and at AUM sites and Target sites during the RSE investigation.

For three elements (lead, thorium, and uranium), a bracketed analysis occurred, meaning two models were developed for those elements depending on concentrations measured by XRF analyzers. In these cases, a model used to predict lower concentrations below specific thresholds of the XRF analyzer differed from the model used to predict higher concentrations above specific thresholds of the XRF analyzer. Figure B-26 and Figure B-31 present the final regression models and correction factors for both measurement thresholds for determination of lead. Figure B-45 and Figure B-50 present the final regression models and correction factors for both measurement thresholds for determination of thorium. Figure B-53 and Figure B-58 present the final regression models and correction factors for both measurement thresholds for determination of uranium. For the remaining elements (arsenic, iron, lead, manganese, molybdenum, vanadium, and zinc), one primary model was selected to represent the full range of elemental concentrations that would be encountered in the field.

Table B-110 summarizes the final XRF model selection and data quality selected for each element based on criteria specified in Section 2.3.3. For all elements, it was determined that correction factors should be applied to the XRF data, because this would categorize quality of measured concentrations of all elements as definitive or quantitative screening—and, thus, permit use of XRF data acquired during the RSE investigation for risk assessment purposes.

Table B-110. Summary of Final XRF Model Selection and Data Quality Criteria for Each Target Element

Target Element	Final Model Name[1]	Correlation Coefficient (r)	Slope (m)	y-intercept (b)	Median RSD[2]	Median RPD[3]	Inferential Statistics[4]	Data Quality Criteria[5]
Arsenic (As)	Model AS-3	1.0	1.0407	-0.5494	19%	13%	Equal	Definitive
Iron (Fe)	Model FE-1	0.9	0.5179	283.36	1.5%	12%	Equal	Definitive
Lead (Pb)	Model PB-1A	0.9	0.9519	-1.476	9.7%	15%	Equal	Definitive
Manganese (Mn)	Model MN-2	0.9	0.8912	62.274	7.5%	13%	Equal	Definitive
Molybdenum (Mo)	Model MO-1B	1.0	0.7964	-1.6827	18%	44%	Equal	Quantitative Screening
Thorium (Th)	Model TH-2A	0.8	0.5189	-0.0333	14%	15%	Equal	Quantitative Screening
Uranium (U)	Model U-2A	0.9	0.8031	-2.266	13%	22%	Equal	Definitive
Vanadium (V)	Model VA-2	1.0	0.7963	-18.33	9.0%	27%	Equal	Definitive
Zinc (Zn)	Model ZN-3	0.9	0.6919	4.2593	7.4%	12%	Equal	Definitive

Notes:

Definitive data quality requires the following criteria to be true: r ≥ 0.9, RSD ≤ 20 percent, RPD ≤ 30 percent, and inferential statistics are equal.
Quantitative screening data quality requires the following criteria to be true: r ≥ 0.8, RSD ≤ 20 percent, RPD ≤ 50 percent, and inferential statistics are equal.

[1] Final models presented are primary models; lead, thorium, and uranium have two regressions based on concentration (one primary model and one high model).
[2] Median RSD of the in situ XRF method for each target element.
[3] Median RPD from the ex situ XRF method for each target element using corrected data.
[4] Inferential statistics refers to two-sample population test Student's t-test between corrected XRF data and confirmatory data at a 99 percent confidence level.
[5] Data quality criteria refers to project-specific data quality criteria listed in Table B-3.

b y-intercept of ex situ XRF data versus confirmatory data regression line
m Slope of ex situ XRF data versus confirmatory data regression line
r Pearson's correlation coefficient of ex situ XRF data versus confirmatory data regression line
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

7.0 CONCLUSIONS

An XRF field survey program occurred as part of the Northern Agency RSE investigation. This report summarizes a data evaluation study of the performance of a field-portable (hand-held) XRF analyzer (Niton XL5) for detection and quantification of trace element concentrations in surface soils at AUM sites and Target sites within the Northern Agency region of the Navajo Nation. Three different XRF methods were evaluated as part of the XRF field survey: (1) in situ XRF method, (2) ex situ XRF bulk sample method, and (3) ex situ XRF soil cup method. Two comparability studies of the following XRF methods occurred: (1) ex situ XRF bulk sample method, and (2) ex situ XRF soil cup method.

Several objectives were accomplished during this study, confirming that this model of XRF analyzer could be used for quantitative analysis to meet select project DQOs at the Northern Agency Tronox Mines. This report presented results of data quality indicators used to evaluate performances of different XRF methods and soil preparation techniques. These data were also used to characterize data quality based on project-specific criteria. Results of various statistical tests and a pilot study presented in this report further substantiate findings of the study. A summary of conclusions is as follows:

- Correction factors for the ex situ XRF bulk sample method are comparable to those for the ex situ XRF soil cup method; however, the ex situ XRF soil cup method has better correlation, better precision, and better comparability than the ex situ XRF bulk sample method. Both methods can achieve a quantitative level prediction of trace elements after application of a correction factor.
- Precisions of all three XRF methods evaluated meet the criteria for use specified in Method 6200 (that is, median RSD less than or equal to 20 percent).
- Except for manganese, the XRF technology estimates higher concentrations of target elements than concentrations determined via the confirmatory method.
- Correction factors determined from the ex situ XRF bulk sample method comparability study best represent true field conditions, and are used to convert the 9,540 in situ XRF measurements taken during the field investigation into predicted laboratory confirmatory soil concentrations for the RSE investigation.
- For all target elements, effects of particle size appear to be relevant—soils or sediments with smaller particle sizes (in this study, in cup soil samples) contain concentrations of those elements lower than in soils or sediments with larger particle sizes (in this study, in bulk soil samples).

The primary conclusion of the study is that the XRF analyzer, with application of a correction factor to data it reports, can be used as a quantitative tool for detecting nine target elements in the surface soils at AUM sites and Target sites investigated during the study. Corrected XRF analyzer results compared well with confirmatory laboratory concentrations. A series of element-specific final models were developed, and can be used to correct XRF data into a useable quantitative data set well comparable to data resulting from application of laboratory confirmatory methods. Therefore, the XRF technology evaluated during this study can be used to quantitatively to determine concentrations of nine target elements for future removal actions and/or final status surveys if a correction factor is applied to data therefrom.

8.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. Toxicological Profile for Thorium. U.S. Department of Health and Human Services.

ATSDR. 2013. Toxicological Profile for Uranium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Bertin, E. 1975. *Principles and Practice of X-Ray Spectrometric Analysis*. Second edition. Plenum Press, New York.

Bullock, L. A., and J. Parnell. 2017. "Selenium and molybdenum enrichment in uranium roll-front deposits of Wyoming and Colorado, USA." *Journal of Geochemical Exploration*. Volume 180. Pages 101 through 112.

Canadian Mining Industry Research Organization (CAMIRO) Exploration Division. 2013. Quality Control Assessment of Portable XRF Analyzers; Development of Standard Operating Procedures, Performance on Variable Media and Recommended Uses. October.

DeKosky, R. 2009. "Developing Chemical Instrumentation for Environmental Use in the Late Twentieth Century: Detecting Lead in Paint Using Portable X-Ray Fluorescence Spectrometry." *Ambix*. Volume 56, Number 2. Pages 138-162.

Guitouni, M. 2016. "Determination of Uranium and Thorium in the Industrial Phosphoric Acid Using X-Ray Fluorescence Spectrometry with Wavelength Dispersive (WDXRF)." *International Journal of Chemistry*. Volume 8, Number 4. Pages 15 through 27.

International Atomic Energy Agency (IAEA). 1997. Sampling, storage, and sample preparation procedures for X ray fluorescence analysis of environmental materials. June.

IAEA. 2005. In Situ Applications of X Ray Fluorescence Techniques. Final report of a coordinate research project 2000-2003. September

Jenkins, R., and J. V. Gilfrich. 1992. *X-Ray Spectrometry* Volume 21, Page 263.

Johnson, R. L., L. A. Durham, C. R. Rieman, H. L. Spector, and J. E. Hummel. 2005. X-Ray Fluorescence Applied to Total Uranium Soil Characterization at the FUSRAP Rattlesnake Creek Site. March.

Kalnicky, D. J., and R. Singhvi. 2001. "Field Portable XRF Analysis of Environmental Samples." *Journal of Hazardous Materials*. Volume 83. Pages 93 through 122.

Lambert, I. B., and K. S. Heir. 1968. "Estimates of the Crustal abundances of thorium, uranium, and potassium." *Chemical Geology* Volume 3 Issue 4. December.

Mamatha, P., K. Aruna, T. Mohammad Munawar, and A. V. N. Swamy. 2016. “Heavy Metal Analysis in Soil Samples of Some Villages near Uranium Corporation of India Limited Thummalapalle Using Wavelength-Dispersive X-Ray Fluorescence Spectrometry.” *International Journal of Advanced Research*. Volume 4, Issue 7. Pages 1 through 6.

Melquiades, F., and C. Appoloni. 2004. Application of XRF and field portable XRF for environmental analysis. Journal of Radioanalytical and Nuclear Chemistry. Volume 262. Pages 533-541.

Parsons, C., E. Margui Grabulosa, E. Pili, G.H. Floor, G. Roman-Ross, and L. Charlet. 2012. “Quantification of Trace Arsenic in Soils by Field-Portable X-Ray Fluorescence Spectrometry: Considerations for Sample Preparation and Measurement Conditions.” *Journal of Hazardous Materials*. Volume 262. Pages 1,213 to 1,222.

PRC Environmental Management, Inc. 1995. Final Demonstration Plan for Field Portable X-Ray Fluorescence Analyzers.

Radu, T., and D. Diamond. 2009. “Comparison of soil pollution concentrations determined using AAS and portable XRF techniques.” *Journal of Hazardous Materials*. Volume 171. Pages 1,168 to 1,171.

Shefsky, S. 1997. “Comparing Field Portable X-Ray Fluorescence (XRF) to Laboratory Analysis of Heavy Metals in Soil.” Niton Corporation. *The International Symposium of Field Screening Methods for Hazardous Wastes and Toxic Chemicals*. Las Vegas, Nevada. January 29 through 31.

Tetra Tech, Inc. (Tetra Tech). 2015. Final Verification Sampling Plan Riley Pass Uranium Mines Site (North Cave Hills) Harding County, South Dakota. November.

Tetra Tech. 2018. Northern Agency Tronox Mines Removal Site Evaluation Work Plan. Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0001. May 14.

Thermo Fisher Scientific. 2016. XL5 Factory Operational Specifications. Protocol ID: 105-00042. Revision: February 26.

Thermo Fisher Scientific. 2017. Niton XL5 Analyzer User’s Guide. Version 1.4.1. November.

University of Florida (UF). 2013. Letter Regarding the Review of Applications and Guidance on the Measurement of Arsenic in Soil Using XRF. From Roxana E. Weil, Leah D. Stuchal, and Stephen M. Roberts, Center for Environment & Human Toxicology. To Ligia Mora-Applegate, Bureau of Waste Cleanup, Florida Department of Environmental Protection. June 20.

U.S. Environmental Protection Agency (USEPA). 1990. Quality Assurance/Quality Control Guidance for Removal Activities. Sampling QA/QC Plan and Data Validation procedures. Interim Final. EPA/540/G-90/004. Office of Solid Waste and Emergency Response (OSWER) Directive 9360.4-01. April.

USEPA. 1993. Data Quality Objectives Process for Superfund-Interim Final Guidance. OSWER. Washington, D.C. EPA/540/R-03-071.

USEPA. 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. EPA/540/S-96-500. December.

USEPA. 1997. Test Methods for Evaluating Solid Waste/Chemical Methods (SW-846).

USEPA. 1998. Environmental Technology Verification Report Field Portable X-ray Fluorescence Analyzer Niton XL Spectrum Analyzer. EPA/600/R-97/150. March.

USEPA. 2005. Uniform Federal Policy for Quality Assurance Project Plans. Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities. EPA-505-B-04-900B. Final. Version 1. March.

USEPA. 2006a. Innovative Technology Verification Report XRF Technologies for Measuring Trace Elements in Soil and Sediment Innov-X XT400 Series XRF Analyzer. EPA/540/R-06/002. February.

USEPA. 2006b. Innovative Technology Verification Report XRF Technologies for Measuring Trace Elements in Soil and Sediment Niton Xli 700 Series XRF Analyzer. EPA/540/R-06/003. February.

USEPA. 2006c. Innovative Technology Verification Report XRF Technologies for Measuring Trace Elements in Soil and Sediment Niton Xlt 700 Series XRF Analyzer. EPA/540/R-06/004. February.

USEPA. 2006d. Innovative Technology Verification Report XRF Technologies for Measuring Trace Elements in Soil and Sediment Oxford X-Met 3000TX XRF Analyzer. EPA/540/R-06/008. February.

USEPA. 2007. Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment. SW-846 Test Method 6200.

USEPA. 2008. X-ray Fluorescence (XRF) Session 1 through Session 8. Sponsored by: U.S. EPA Technology Innovation and Field Services Division. August. Accessed May 23, 2019. https://clu-in.org/conf/tio/xrf_080408/.

USEPA. 2014a. SW-846 Test Methods for Evaluating Solid Waste. Revision 2. SW-846 Update V. With promulgated revisions. July.

USEPA. 2014b. Laboratory Data Review for the Non-Chemist. Region 9. October.

USEPA. 2015a. ProUCL Version 5.1.002 Technical Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. EPA/600/R-07/041. October.

USEPA. 2015b. Navajo Nation Aerial Radiological Survey. Draft Final. May.

USEPA 2019. Regional Screening Level Summary Table (TR = 1 E-06, HQ=1). April. https://semspub.epa.gov/work/HQ/199432.pdf.

U.S. Geological Survey (USGS). 2017. Mineral Commodities Summaries.

Waikato Regional Council. 2015. Guidance for Analysis of Soil Contamination Using a Portable X-Ray Fluorescence Spectrometer. Technical Report 2016/22. September.

Weston Solutions, Inc. (Weston). 2016. Mine Category Assessment Protocol Summary Report. Final. December.

Wu, C.-M., H.-T. Tsai, K.-H. Yang, and J.-C. Wen. 2012. "How Reliable Is X-Ray Fluorescence (XRF) Measurement for Different Metals in Soil Contamination?" *Environmental Forensics*. Volume 13. Pages 110 through 121.

ATTACHMENT B1

XRF QUALITY CONTROL ANALYSIS

TABLE OF CONTENTS

Section **Page**

1.0 PRECISION ANALYSIS B1-1

1.1 BLUE XRF (S/N X500939) B1-1
1.2 GREEN XRF (S/N X500870) B1-2
1.3 ORANGE XRF (S/N X500872) B1-3
1.4 PINK XRF (S/N X500940) B1-4
1.5 YELLOW XRF (S/N X500941) B1-5
1.6 PURPLE XRF (S/N X500530) B1-6
1.7 BLACK XRF (S/N X500939) B1-7
1.8 RED XRF (S/N X500875) B1-8
1.9 WHITE XRF (S/N X500946) B1-9
1.10 ALL XRF INSTRUMENTS COMBINED B1-10

2.0 QUALITY CONTROL CHARTS B1-11

2.1 NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST) QUALITY CONTROL CHARTS B1-11
2.1.1 Arsenic B1-11
2.1.2 Thorium B1-12
2.2 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) QUALITY CONTROL CHARTS B1-13
2.2.1 Arsenic B1-13
2.2.2 Lead B1-14
2.3 NATURAL URANIUM (UNAT) QUALITY CONTROL CHARTS B1-15
2.3.1 Arsenic B1-15
2.3.2 Lead B1-16
2.3.3 Uranium B1-17

LIST OF TABLES

Table B1-1. Summary of Field Replicates XRF Measurements for Blue XRF B1-1
Table B1-2. Summary of Field Replicates XRF Measurements for Green XRF B1-2
Table B1-3. Summary of Field Replicates XRF Measurements for Orange XRF B1-3
Table B1-4. Summary of Field Replicates XRF Measurements for Pink XRF B1-4
Table B1-5. Summary of Field Replicates XRF Measurements for Yellow XRF B1-5
Table B1-6. Summary of Field Replicates XRF Measurements for Purple XRF B1-6
Table B1-7. Summary of Field Replicates XRF Measurements for Black XRF B1-7
Table B1-8. Summary of Field Replicates XRF Measurements for Red XRF B1-8
Table B1-9. Summary of Field Replicates XRF Measurements for White XRF B1-9
Table B1-10. Summary of Field Replicates XRF Measurements for All XRF Instruments .. B1-10

LIST OF FIGURES

Figure B1-1. Arsenic NIST Quality Control Chart B1-11
Figure B1-2. Thorium NIST Quality Control Chart B1-12
Figure B1-3. Arsenic RCRA Quality Control Chart B1-13
Figure B1-4. Lead RCRA Quality Control Chart B1-14
Figure B1-5. Arsenic UNAT Quality Control Chart B1-15
Figure B1-6. Lead UNAT Quality Control Chart B1-16
Figure B1-7. Uranium UNAT Quality Control Chart B1-17

1.0 PRECISION ANALYSIS

1.1 BLUE XRF (S/N X500939)

Table B1-1. Summary of Field Replicates XRF Measurements for Blue XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	26	52	20%	144	204	16%
Iron	51	52	1.9%	204	204	1.6%
Manganese	51	52	10%	201	204	7.7%
Molybdenum	9	52	17%	63	204	13%
Lead	51	52	10%	201	204	9.4%
Thorium	49	52	15%	201	204	16%
Uranium	46	52	14%	194	204	13%
Vanadium	51	52	8.9%	202	204	10%
Zinc	51	52	7.1%	203	204	8.2%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a "<LOD" measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.2 GREEN XRF (S/N X500870)

Table B1-2. Summary of Field Replicates XRF Measurements for Green XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	13	27	21%	86	117	22%
Iron	27	27	1.6%	116	117	1.8%
Manganese	27	27	8.4%	116	117	9.5%
Molybdenum	11	27	20%	73	117	22%
Lead	27	27	11%	115	117	12%
Thorium	27	27	14%	115	117	13%
Uranium	24	27	13%	107	117	11%
Vanadium	27	27	9.3%	115	117	8.5%
Zinc	27	27	7.8%	116	117	5.3%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a "<LOD" measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.3 ORANGE XRF (S/N X500872)

Table B1-3. Summary of Field Replicates XRF Measurements for Orange XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	8	14	21%	36	52	17%
Iron	14	14	2.1%	52	52	2.0%
Manganese	14	14	6.4%	52	52	5.4%
Molybdenum	3	14	15%	26	52	21%
Lead	14	14	7.9%	52	52	6.1%
Thorium	13	14	12%	52	52	16%
Uranium	12	14	11%	49	52	12%
Vanadium	13	14	11%	52	52	9.4%
Zinc	14	14	6.4%	52	52	6.6%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a “<LOD” measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.4 PINK XRF (S/N X500940)

Table B1-4. Summary of Field Replicates XRF Measurements for Pink XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	1	3	28%	4	7	26%
Iron	3	3	2.2%	7	7	3.0%
Manganese	3	3	5.5%	7	7	22%
Molybdenum	1	3	17%	3	7	25%
Lead	3	3	11%	7	7	13%
Thorium	3	3	18%	7	7	5.4%
Uranium	2	3	18%	4	7	4.4%
Vanadium	3	3	22%	7	7	21%
Zinc	3	3	18%	7	7	22%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a "<LOD" measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.5 YELLOW XRF (S/N X500941)

Table B1-5. Summary of Field Replicates XRF Measurements for Yellow XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	27	39	16%	117	143	19%
Iron	39	39	1.5%	143	143	1.5%
Manganese	38	39	7.4%	142	143	6.3%
Molybdenum	8	39	15%	55	143	15%
Lead	39	39	9.3%	143	143	11%
Thorium	38	39	15%	141	143	14%
Uranium	36	39	14%	138	143	12%
Vanadium	39	39	7.2%	143	143	9.4%
Zinc	38	39	7.2%	142	143	7.3%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a "<LOD" measurement value, it was not included in this column.
2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.6 PURPLE XRF (S/N X500530)

Table B1-6. Summary of Field Replicates XRF Measurements for Purple XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	8	21	17%	49	68	12%
Iron	21	21	1.1%	67	68	2.0%
Manganese	21	21	6.6%	67	68	7.6%
Molybdenum	10	21	14%	44	68	19%
Lead	21	21	12%	67	68	7.9%
Thorium	13	21	16%	63	68	17%
Uranium	20	21	14%	66	68	11%
Vanadium	21	21	9.3%	67	68	6.6%
Zinc	21	21	6.3%	67	68	7.6%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a "<LOD" measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.7 BLACK XRF (S/N X500939)

Table B1-7. Summary of Field Replicates XRF Measurements for Black XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	2	4	24%	1	3	58%
Iron	4	4	1.4%	3	3	1.1%
Manganese	3	4	27%	3	3	37%
Molybdenum	3	4	19%	2	3	38%
Lead	4	4	17%	3	3	27%
Thorium	4	4	14%	2	3	10%
Uranium	3	4	12%	3	3	29%
Vanadium	4	4	17%	3	3	17%
Zinc	3	4	8.2%	3	3	14%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a “<LOD” measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.8 RED XRF (S/N X500875)

Table B1-8. Summary of Field Replicates XRF Measurements for Red XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	8	17	21%	39	60	18%
Iron	17	17	1.1%	60	60	1.2%
Manganese	16	17	9.0%	60	60	6.7%
Molybdenum	8	17	22%	30	60	22%
Lead	17	17	9.2%	60	60	10%
Thorium	14	17	14%	56	60	16%
Uranium	15	17	10%	58	60	10%
Vanadium	17	17	7.7%	60	60	4.6%
Zinc	13	17	8.0%	58	60	8.7%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a "<LOD" measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.9 WHITE XRF (S/N X500946)

Table B1-9. Summary of Field Replicates XRF Measurements for White XRF

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	9	14	15%	51	65	18%
Iron	14	14	0.7%	65	65	0.7%
Manganese	13	14	6.5%	65	65	4.4%
Molybdenum	5	14	24%	37	65	16%
Lead	13	14	11%	65	65	11%
Thorium	14	14	13%	65	65	13%
Uranium	14	14	14%	65	65	10%
Vanadium	14	14	8.8%	65	65	8.3%
Zinc	14	14	10%	65	65	8.2%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a “<LOD” measurement value, it was not included in this column.
2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

1.10 ALL XRF INSTRUMENTS COMBINED

Table B1-10. Summary of Field Replicates XRF Measurements for All XRF Instruments

Analyte	RSD of In Situ XRF Replicates			RPD of In Situ XRF Duplicates		
	# of Replicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RSD	# of Duplicate Measurements (No Nondetects)[1]	# of Replicate Measurements (All)[2]	Median RPD
Arsenic	102	192	22%	527	718	18%
Iron	190	192	3.3%	717	718	1.6%
Manganese	186	192	10%	713	718	7.6%
Molybdenum	58	192	19%	333	718	21%
Lead	189	192	11%	713	718	11%
Thorium	175	192	16%	702	718	14%
Uranium	172	192	15%	684	718	11%
Vanadium	189	192	10%	714	718	9.4%
Zinc	184	192	9.0%	713	718	8.2%

Notes:

Field replicates involved seven in situ XRF measurements at a minimum of one per day per instrument; the instrument was not lifted off the ground between measurements.

1 If any of the seven data points contained a “<LOD” measurement value, it was not included in this column.

2 Includes all field replicate measurement data pairs that were collected during the field investigation for this particular XRF instrument.

LOD Limit of detection
RPD Relative percent difference
RSD Relative standard deviation
XRF X-ray fluorescence

2.0 QUALITY CONTROL CHARTS

2.1 NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST) QUALITY CONTROL CHARTS

2.1.1 Arsenic

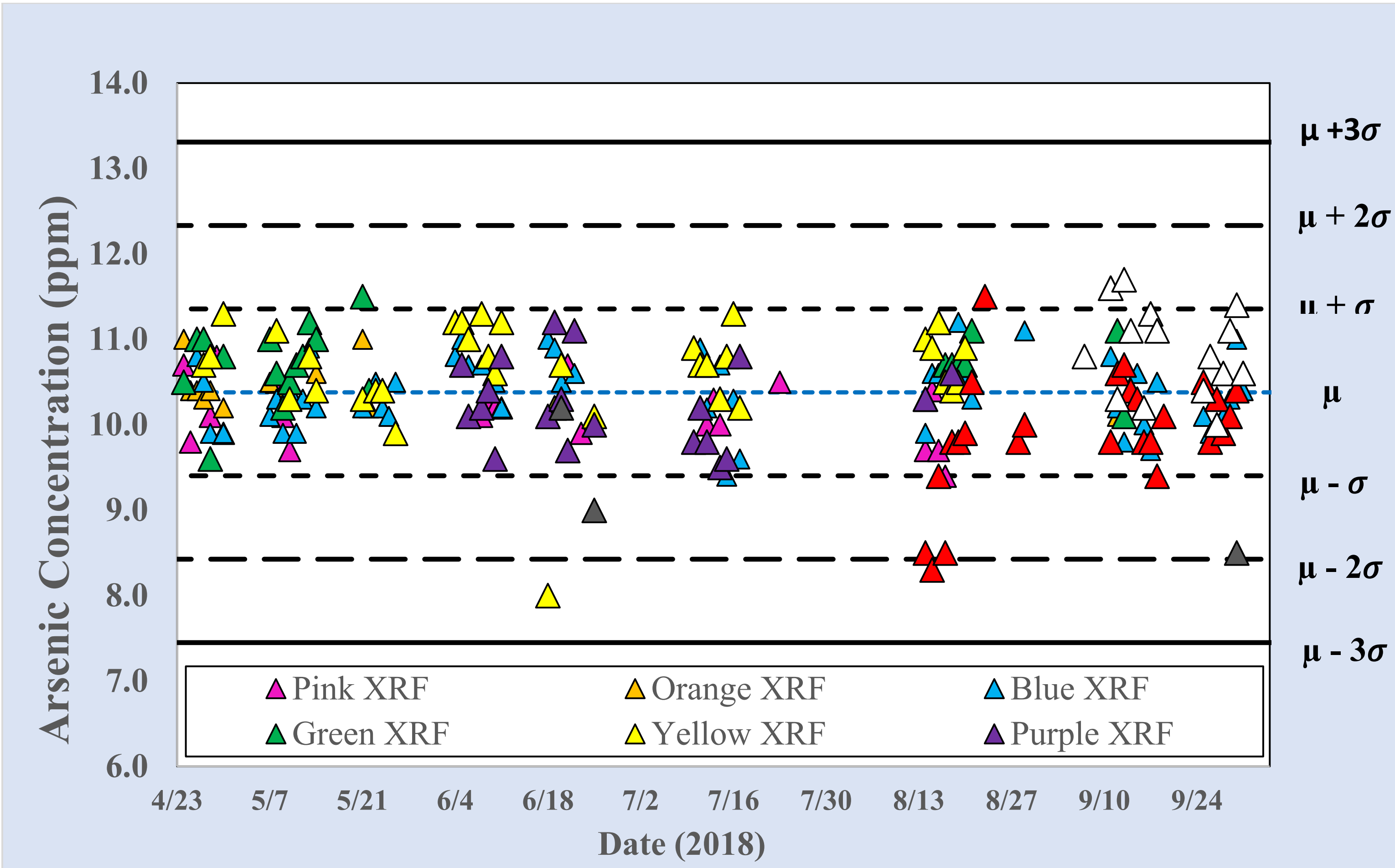


Figure B1-1. Arsenic NIST Quality Control Chart

2.1.2 Thorium

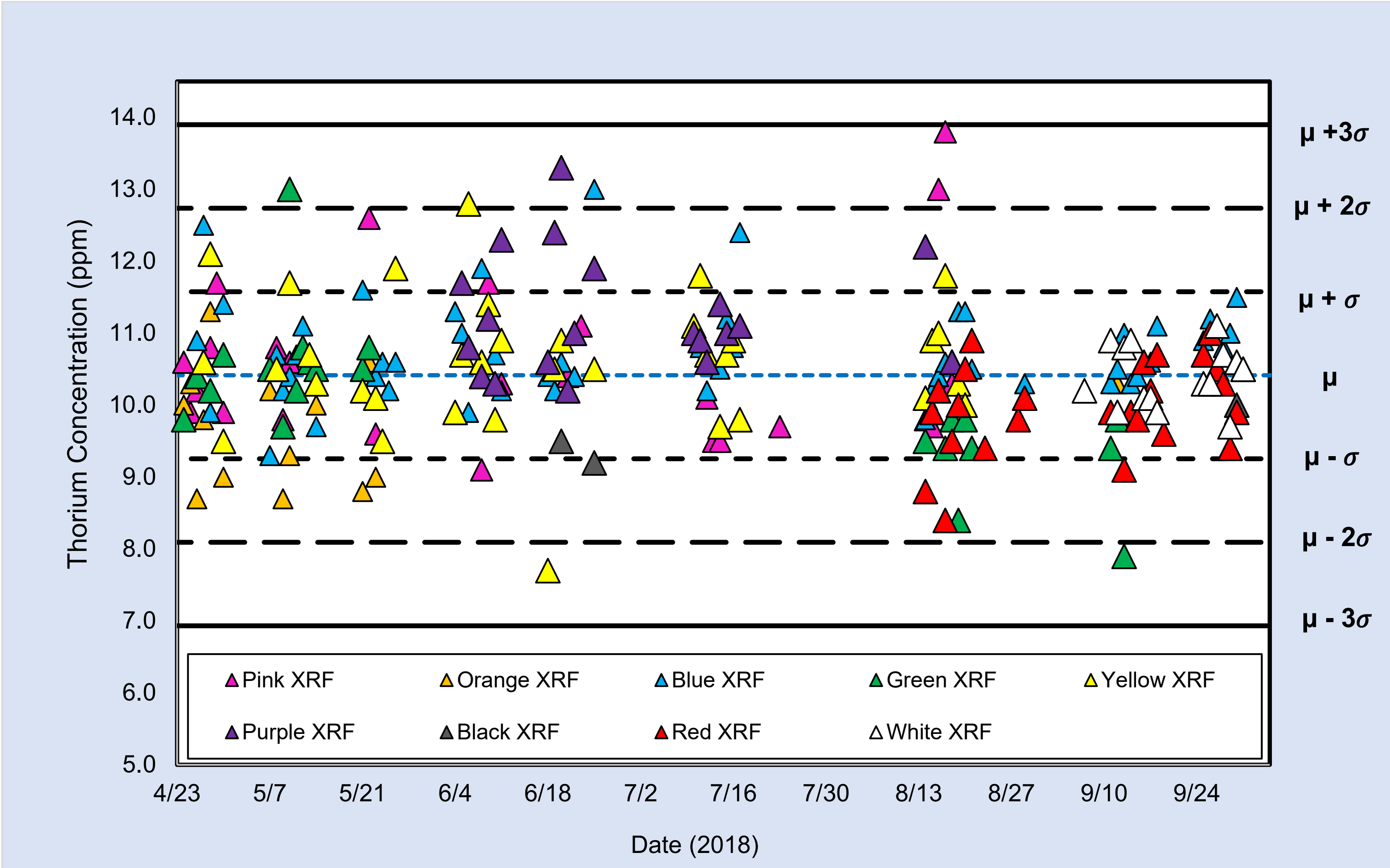


Figure B1-2. Thorium NIST Quality Control Chart

2.2 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) QUALITY CONTROL CHARTS

2.2.1 Arsenic

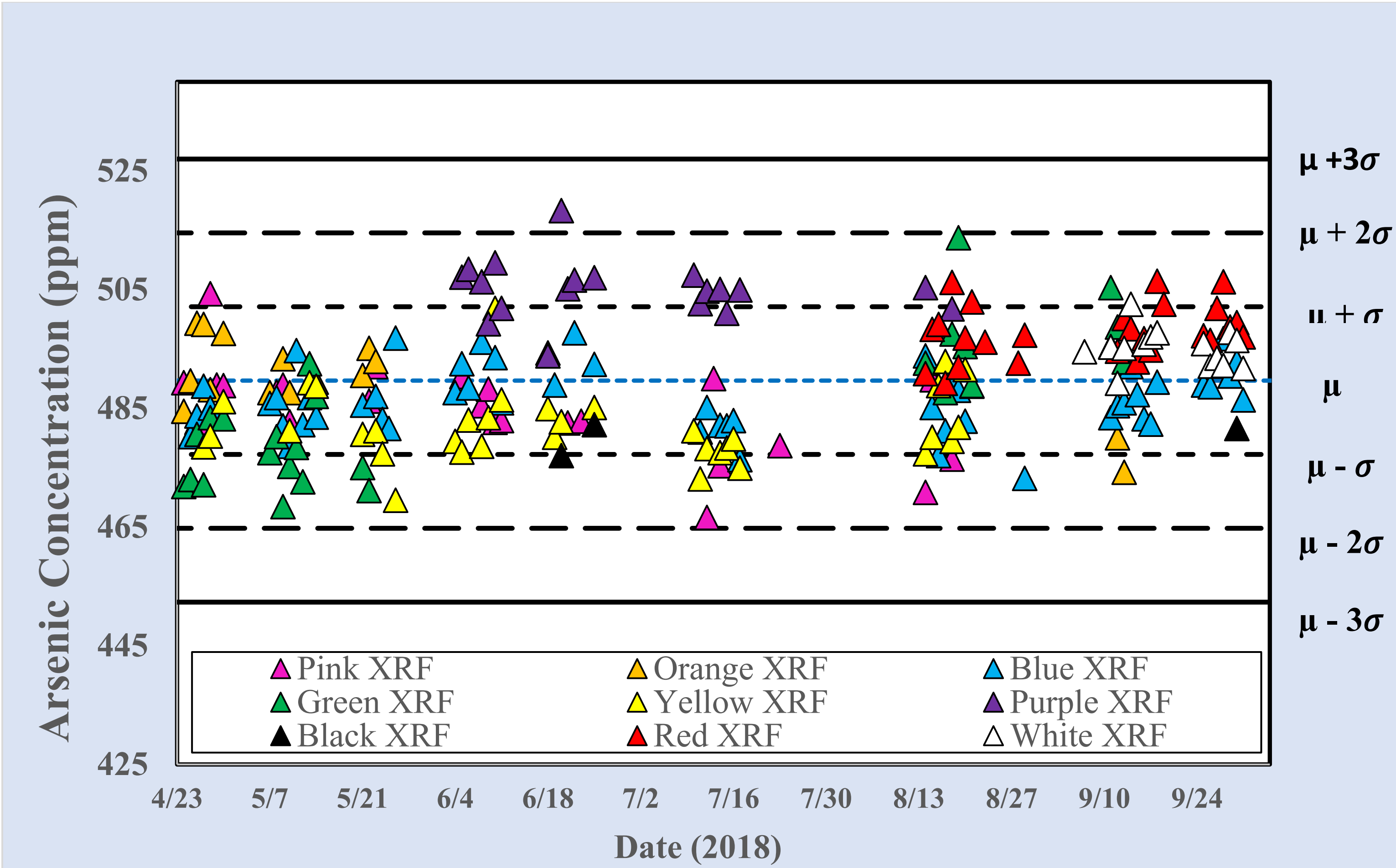


Figure B1-3. Arsenic RCRA Quality Control Chart

2.2.2 Lead

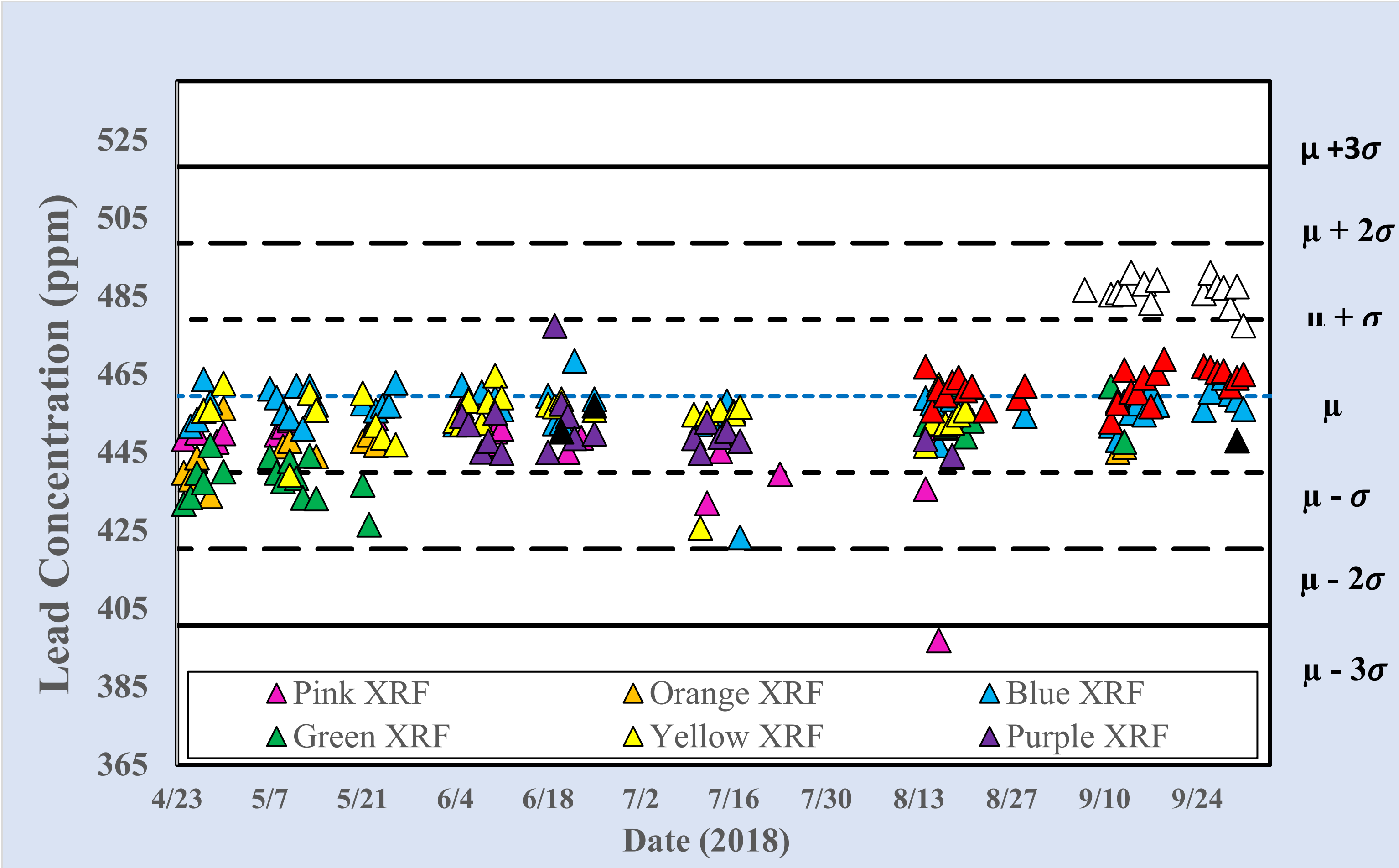


Figure B1-4. Lead RCRA Quality Control Chart

2.3 NATURAL URANIUM (UNAT) QUALITY CONTROL CHARTS

2.3.1 Arsenic

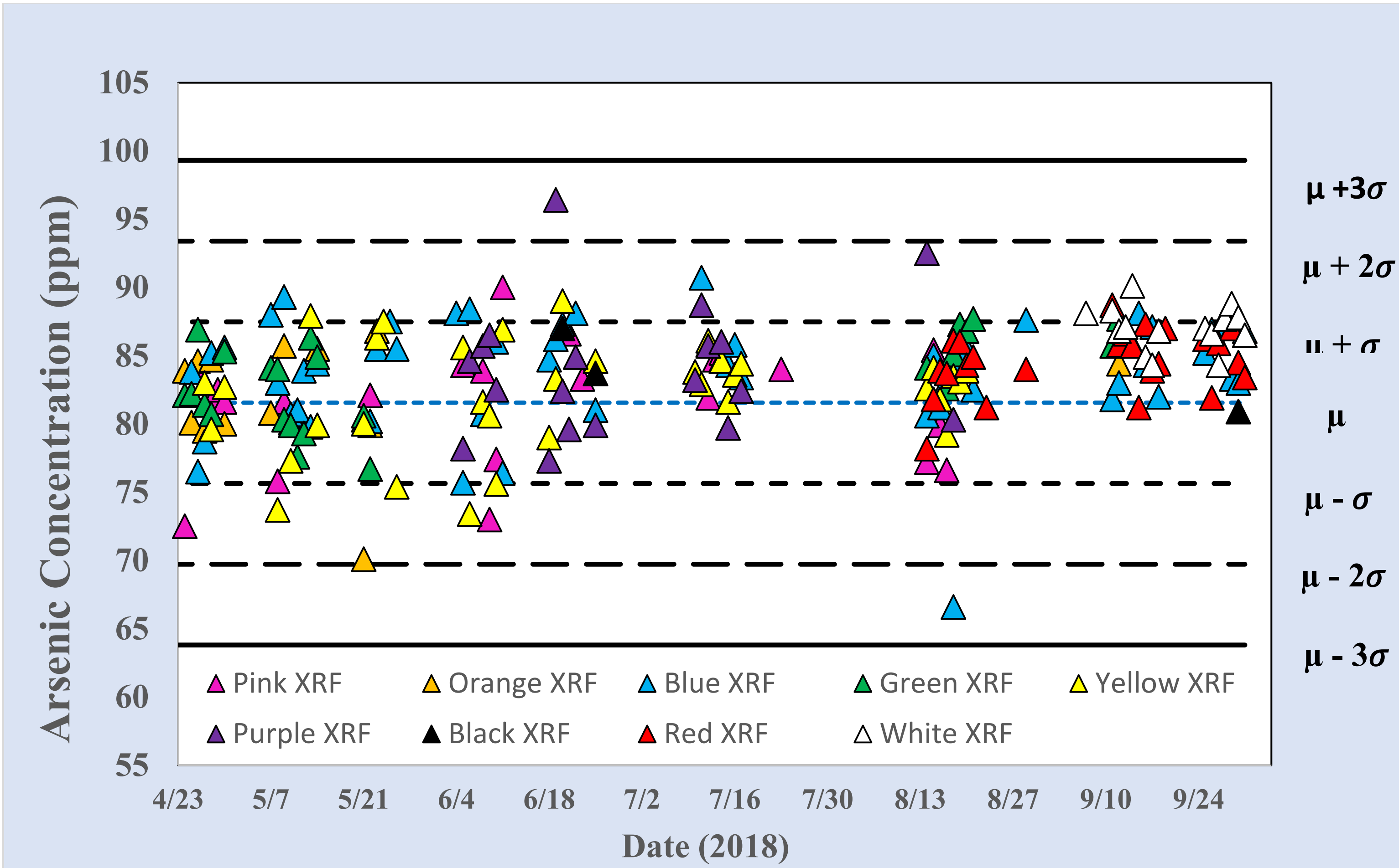


Figure B1-5. Arsenic UNAT Quality Control Chart

2.3.2 Lead

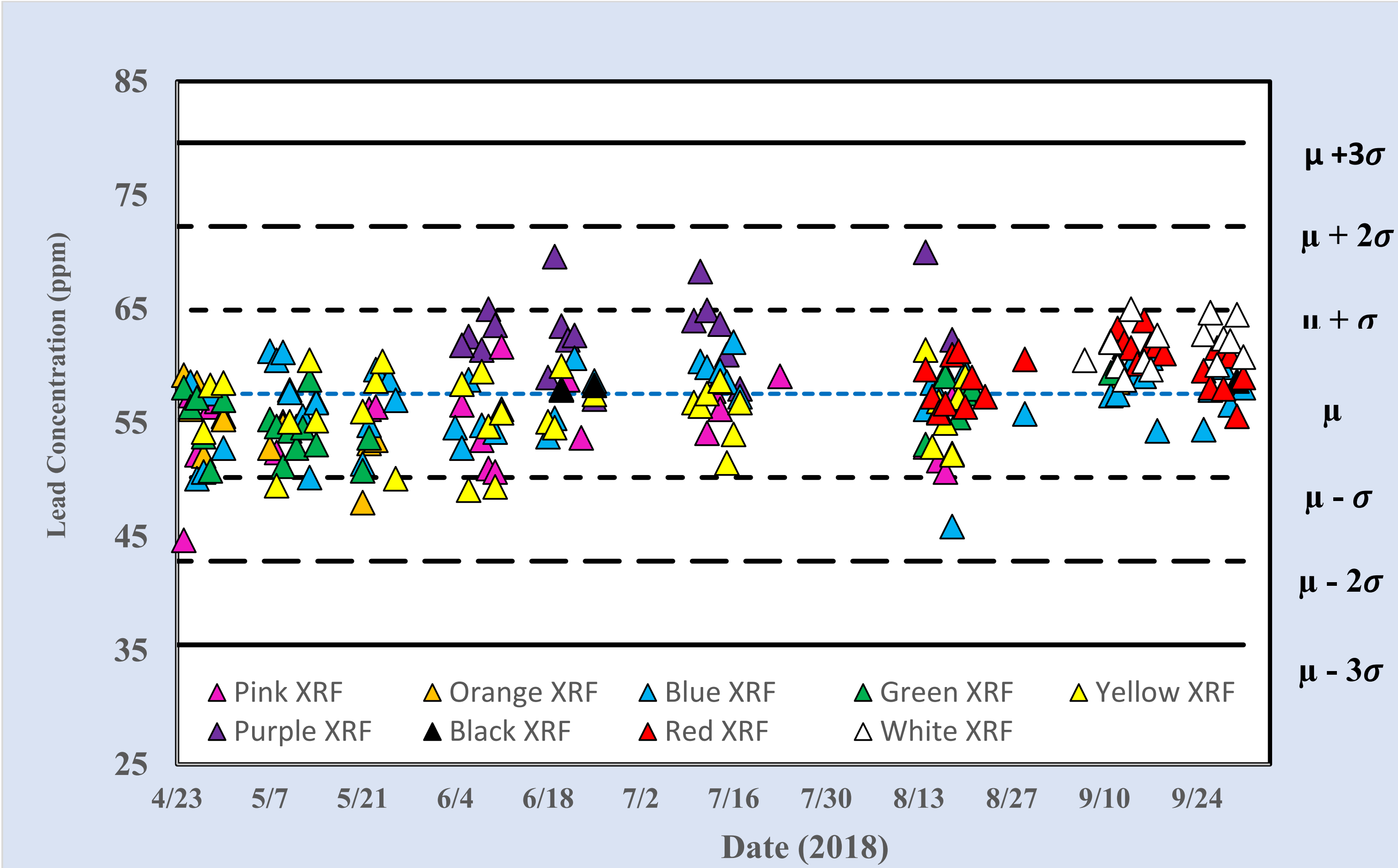


Figure B1-6. Lead UNAT Quality Control Chart

2.3.3 Uranium

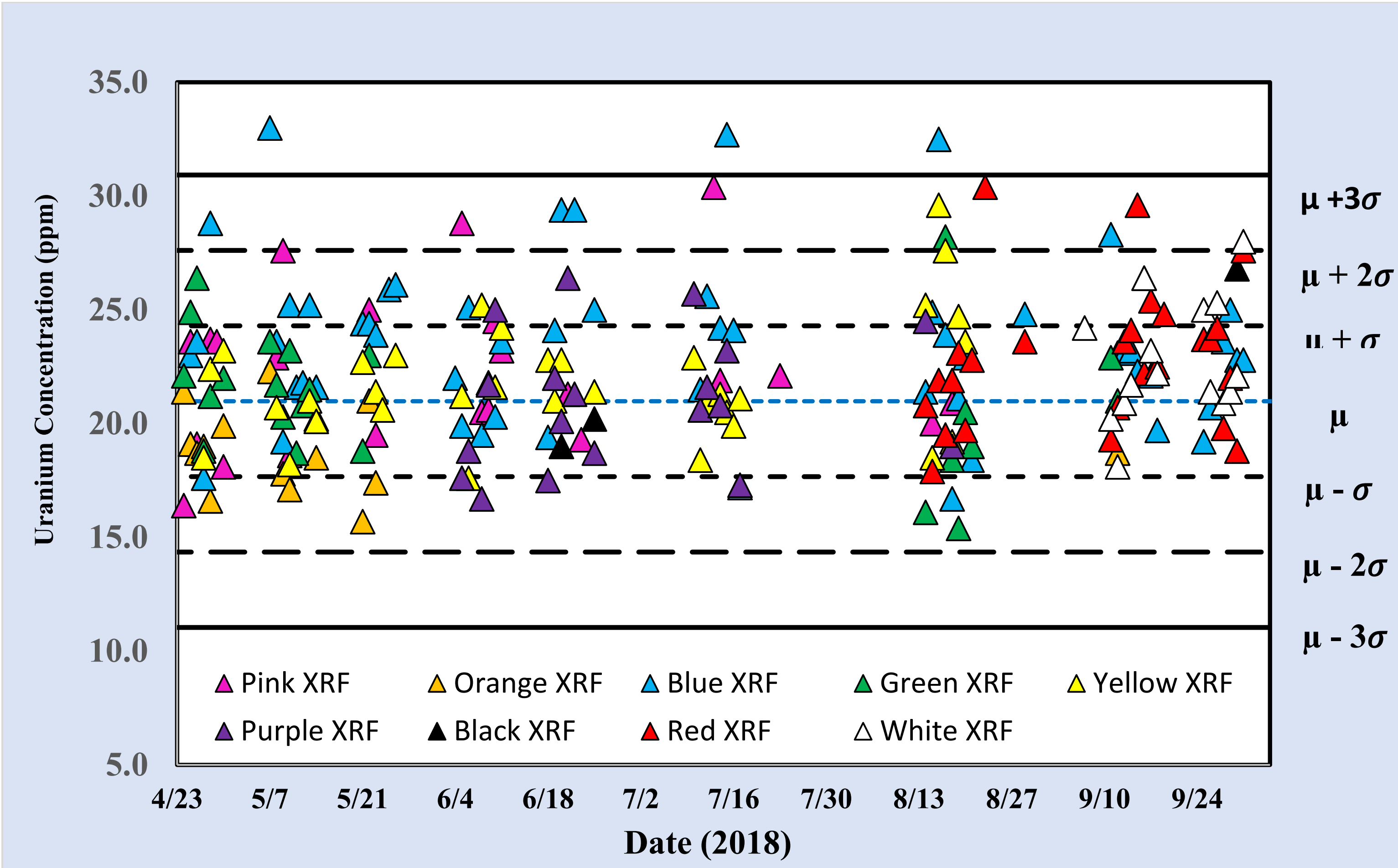


Figure B1-7. Uranium UNAT Quality Control Chart

ATTACHMENT B2

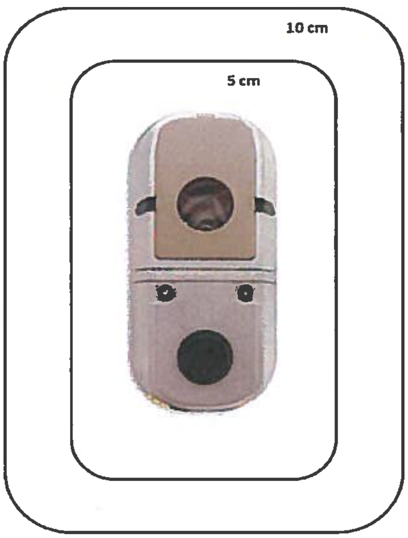
XRF ANALYZER CALIBRATION DOCUMENTATION

ThermoFisher SCIENTIFIC

The world leader in serving science

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model:	XL5 580-09131		RadEye
Instrument S/N:	X500939	Detector Model:	B20-ER
		Detector S/N:	0216
		Calibration Date:	March 31, 2017



Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
603	253

• All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Steve DeSimone

Survey Date: August 28, 2017

Thermo Scientific
Portable Analytical Instruments

2 Radcliff Road, Tewksbury
Massachussetts 01876 USA

+1 978-670-7460
+1 978-670-7430 fax

www.thermoscientific.com/pai
800-875-1578 (toll free)

ThermoFisher SCIENTIFIC

The world leader in serving science

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model:	XL5 580-09131
Instrument S/N:	X500870

	RadEye
Detector Model:	B20-ER
Detector S/N:	0216
Calibration Date:	March 31, 2017

Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
733	154

• All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Steve DeSimone

Survey Date: January 8, 2018

Thermo Scientific
Portable Analytical Instruments

2 Radcliff Road, Tewksbury
Massachussetts 01876 USA

+1 978-670-7460
+1 978-670-7430 fax

www.thermoscientific.com/pai
800-875-1578 (toll free)

ThermoFisher SCIENTIFIC

The world leader in serving science

Save Cert Back Clear For

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model: XL5
Instrument S/N: 500870

Detector Model: RadEye
Detector S/N: 0216
Calibration Date: 4/24/2018

Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
824	371

• All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Perry Pulicari

Survey 6/25/2018

Thermo Scientific Portable Analytical Instruments
2 Radcliff Road Tewksbury MA 01876 USA

+1 978-670-7460
+1 978-670-7430 fax

800-875-1578 (toll free)
www.thermoscientific.com/pai

ThermoFisher SCIENTIFIC

Certificate of Calibration

XL5Soil QC 8mm Certificate
Document: 140-00296
Revision: E
Date: 15 November 2017

Serial Number: X500870 Model: Niton XL5 Software: 5372 Date of Q.C.: Mon Jul 9, 2018 - 10:24
Resolution: 155.913 142.246 Escale: 7.4697 7.47835 Inspector: VK

180 second analysis time, 60 seconds per filter, all 3 filters switched on, all results in ppm

SiO2 blank 180-615

Elem	Certified	Low	High	Measured	2-sigma		
Ba	0	0	20	0.0	9.2	OK	<LOD
Cs	0	0	20	0.0	6.9	OK	<LOD
Te	0	0	20	0.0	4.2	OK	<LOD
Sb	0	0	20	0.0	2.2	OK	<LOD
Sn	0	0	20	0.0	2.1	OK	<LOD
Cd	0	0	20	0.0	1.1	OK	<LOD
Pd	0	0	20	0.0	1.0	OK	<LOD
Ag	0	0	20	0.0	0.7	OK	<LOD
Mo	0	0	10	0.0	0.5	OK	<LOD
Th	0	0	10	0.0	0.6	OK	<LOD
Zr	0	0	10	0.0	0.4	OK	<LOD
Sr	0	0	10	0.0	0.2	OK	<LOD
U	0	0	10	0.0	1.0	OK	<LOD
Rb	0	0	10	0.0	0.3	OK	<LOD
As	0	0	10	0.0	0.4	OK	<LOD
Se	0	0	10	0.0	0.2	OK	<LOD
Au	0	0	10	0.0	1.4	OK	<LOD
Hg	0	0	30	0.0	1.8	OK	<LOD
Pb	0	0	10	0.0	0.5	OK	<LOD
W	0	0	10	0.0	3.3	OK	<LOD
Zn	0	0	10	0.0	0.7	OK	<LOD
Cu	0	0	10	0.0	1.7	OK	<LOD
Ni	0	0	20	0.0	3.2	OK	<LOD
Co	0	0	20	0.0	3.1	OK	<LOD
Fe	0	0	20	0.0	6.2	OK	<LOD
Mn	0	0	20	0.0	8.1	OK	<LOD
Cr	0	0	20	0.0	1.7	OK	<LOD
V	0	0	20	0.0	1.5	OK	<LOD
Ti	0	0	20	0.0	3.5	OK	<LOD
Sc	0	0	20	0.0	1.9	OK	<LOD
Ca	0	0	100	0.0	4.5	OK	<LOD
K	0	0	50	0.0	16.0	OK	<LOD
S	0	0	60	39.6	21.3	OK	

NIST 2710 180-427

Elem	Certified	Low	High	Measured	2-sigma		
Ba	707	530.3	883.8	831.4	24.3	OK	
Cs	107	96.3	117.7	107.0	17.8	OK	
Te				0.0	8.8		
Sb	38.4	19.2	57.6	30.3	5.5	OK	
Sn				18.6	4.7		
Cd	21.8	15.26	28.34	18.4	2.8	OK	
Pd				0.0	1.4		
Ag	35.3	28.24	42.36	35.5	2.2	OK	
Mo	19	13.3	24.7	20.1	1.4	OK	
Th	13			21.7	7.6		
Zr				156.4	3.1		
Sr	330	247.5	412.5	387.5	2.9	OK	
U	25			41.2	5.0		
Rb	120	78	162	144.1	3.1	OK	
As	626			835.1	17.6		
Se				3.8	1.3		
Au	0.6			0.0	9.2		<LOD
Hg	32.6	26.08	39.12	33.1	10.9	OK	
Pb	5532	4425.6	6638.4	6144.2	22.8	OK	
W	93			266.5	28.6		
Zn	6952	5561.6	8342.4	7080.9	22.3	OK	
Cu	2950	2655	3245	2957.7	26.1	OK	
Ni	14.3			58.3	9.8		
Co	10			0.0	41.0		<LOD
Fe	33800	25350	42250	40974.3	140.8	OK	
Mn	10100	8080	12120	10214.0	93.0	OK	
Cr	39			59.0	7.1		
V	76.6	57.45	95.75	93.7	11.3	OK	
Ti	2830	2264	3396	3338.7	37.2	OK	
Sc	8.7			71.6	34.8		
Ca	12500	10000	15000	14041.8	157.9	OK	
K	21100	16880	25320	24902.6	257.0	OK	
S	2400			5226.6	202.3		

NIST 2711a 180-688

Elem	Certified	Low	High	Measured	2-sigma		
Ba	730	547.5	912.5	671.9	15.9	OK	
Cs				43.6	11.7		
Te				0.0	5.8		
Sb	23.8			12.9	3.6		
Sn				12.8	3.1		
Cd	54.1	45.99	62.22	46.9	2.1	OK	
Pd				0.0	1.0		<LOD
Ag	6			0.0	1.2		<LOD
Mo				0.0	0.9		<LOD
Th	15	7.5	11.25	13.5	2.8		
Zr				321.2	2.6		
Sr	242	193.6	290.4	228.8	1.6	OK	
U	3			6.0	2.4		
Rb	120			115.7	1.9		
As	107	85.6	128.4	118.6	6.1	OK	
Se	2			2.5	0.5		
Au				0.0	3.6		<LOD
Hg	7.42			7.3	3.2		
Pb	1400	1120	1680	1341.2	8.2	OK	
W				0.0	0.0		
Zn	414	331.2	496.8	356.8	4.0	OK	
Cu	140	110.6	169.4	110.9	4.7	OK	
Ni	21.7			30.4	6.4		
Co	9.9			31.1	25.8		<LOD
Fe	28200	25380	31020	27351.8	92.9	OK	
Mn	675	337.5	1012.5	524.5	21.1	OK	
Cr	52.3	26.15	78.45	71.7	4.3	OK	
V	80.47	64.376	96.564	80.3	7.2	OK	
Ti	3170	2853	3487	3092.9	23.8	OK	
Sc	8.5			0.0	43.7		<LOD
Ca	24200	20570	27830	25772.5	138.2	OK	
K	25300	22770	27830	24587.4	176.1	OK	
S				1376.6	87.8		

NIST 2709 180-425

Elem	Certified	Low	High	Measured	2-sigma		
Ba	968	658.24	1277.76	689.2	16.6	OK	
Cs	5.3			20.3	12.0		
Te				0.0	6.1		
Sb	7.9			0.0	4.4		<LOD
Sn				0.0	4.3		<LOD
Cd	0.38			0.0	1.7		<LOD
Pd				0.0	1.0		<LOD
Ag	0.41			0.0	1.1		<LOD
Mo	2			0.0	0.8		<LOD
Th	11			9.8	1.3		
Zr	160	128	192	144.5	2.0	OK	
Sr	231	196.35	265.65	210.4	1.7	OK	
U	3			6.8	2.4		
Rb	96	76.8	115.2	83.1	1.7	OK	
As	17.7	12.39	23.01	17.7	1.2	OK	
Se	1.57			1.3	0.4		
Au	0.3			0.0	2.2		<LOD
Hg	1.4			2.6	3.2		<LOD
Pb	18.9	14.18	23.63	15.4	1.4	OK	
W	2			0.0	6.3		<LOD
Zn	106	74.2	137.8	86.2	2.3	OK	
Cu	34.6	20.76	48.44	21.5	3.4	OK	
Ni	88	61.6	114.4	88.0	8.2		
Co	13.4			60.8	30.2		
Fe	35000	31500	38500	32242.0	106.7	OK	
Mn	538	376.6	699.4	410.9	21.2	OK	
Cr	130	91	169	113.9	5.4	OK	
V	112	84	140	98.3	8.7	OK	
Ti	3420	2804.4	4035.6	3162.3	28.4	OK	
Sc	12			36.4	31.4		<LOD
Ca	18900	17010	20790	19447.0	140.8	OK	
K	20300	18270	22330	16717.6	173.9		
S	890	801	979	878.9	89.5		

DL-1a 180-612

Elem	Certified	Low	High	Measured	2-sigma		
Ba				324.1	14.0		
Cs				39.6	10.6		
Te				0.0	5.4		<LOD
Sb				0.0	3.2		<LOD
Sn				4.2	2.8		
Cd				0.0	1.5		<LOD
Pd				0.0	0.9		<LOD
Ag				0.0	1.0		<LOD
Mo				2.6	0.8		
Th	76	64.6	87.4	72.7	2.1	OK	
Zr				76.9	1.4		
Sr				15.6	0.5		
U	116	104.4	127.6	115.4	4.2	OK	
Rb				97.1	2.0		
As				0.0	1.5		<LOD
Se				1.9	0.4		
Au				0.0	0.0		
Hg				0.0	3.9		<LOD
Pb				64.7	2.1		
W				0.0	5.4		<LOD
Zn				59.8	1.9		
Cu				11.8	2.8		
Ni				8.4	5.2		
Co				17.2	14.6		<LOD
Fe	*9300*			7016.4	54.3		
Mn				30.1	12.9		
Cr				57.3	3.4		
V				28.9	4.1		
Ti				807.1	13.9		
Sc				0.0	11.5		<LOD
Ca				2917.8	55.8		
K				22153.4	150.9		
S	*4100*			1295.1	62.0		

TILL 4 180-646

Elem	Certified	Low	High	Measured	2-sigma		
Ba	395	237	553	433.7	17.2	OK	
Cs	12			55.5	13.0		
Te				0.0	6.5		
Sb	1			0.0	3.8		<LOD
Sn				16.7	3.5		
Cd				0.0	1.8		<LOD
Pd				0.0	1.1		<LOD
Ag				0.0	1.2		<LOD
Mo	16	8	24	15.5	1.1	OK	
Th	17.4	8.7	26.1	20.9	2.4	OK	
Zr	385	346.5	423.5	371.4	3.0	OK	
Sr	109	98.1	119.9	114.1	1.3	OK	
U	5			6.0	2.6		
Rb	161	144.9	177.1	155.8	2.4	OK	
As	111	83.25	138.75	108.6	2.3	OK	
Se				4.6	0.5		
Au				4.8	3.2		
Hg				3.8	5.0		
Pb	50	42.5	57.5	43.3	2.0	OK	
W	204	183.6	224.4	198.5	10.9	OK	
Zn	70	52.5	87.5	56.9	2.3	OK	
Cu	237.0	189.6	284.4	200.2	6.6	OK	
Ni	17			25.1	7.7		
Co	8			34.3	34.0		<LOD
Fe	39378	35440.2	43315.8	39407.3	118.1	OK	
Mn	490	343	637	390.1	21.5	OK	
Cr	53			70.9	5.4		
V	67	46.9	87.1	86.2	9.8	OK	
Ti	4840	3872	5324	4573.3	31.8	OK	
Sc	10			0.0	24.6		<LOD
Ca	8934	7147.2	10720.8	8436.1	111.5	OK	
K	26980	22933	31027	24387.5	219.5	OK	
S	800	600	1000	902.5	98.4		

NIST 2780 180-601

Elem	Certified	Low	High	Measured	2-sigma		
Ba	993	695.1	1290.9	1070.7	22.2	OK	
Cs	*13*			60.7	15.8		
Te	*5*			0.0	7.8		<LOD
Sb	*160*	144	176	161.5	5.5	OK	
Sn				18.6	4.2		
Cd	12.1			5.0	2.3		
Pd				0.0	1.8		<LOD
Ag	27	18.9	35.1	24.2	1.8	OK	
Mo	*11*	7.7	14.3	10.2	1.1	OK	
Th	12			26.8	6.3		
Zr	*176*	132	220	197.1	2.8	OK	
Sr	217	173.6	260.4	244.4	2.1	OK	
U	*4*	3.2	4.8	10.5	3.5		
Rb	*175*	140	210	187.0	3.0	OK	
As	48.8			29.8	14.0		
Se	*5*			4.2	1.0		
Au	0.18			0.0	10.7		<LOD
Hg	0.71			0.0	6.3		<LOD
Pb	5770	4904.5	6635.5	5069.2	19.0	OK	
W				63.0	15.5		
Zn	2570	1799	3341	2171.1	11.7	OK	
Cu	215.5	150.85	280.15	152.4	6.6	OK	
Ni	*12*			10.4	7.8		<LOD
Co	*2.2*			32.7	32.4		<LOD
Fe	27840	25056	30624	28864.2	116.2	OK	
Mn	462	369.6	554.4	477.6	25.3	OK	
Cr	*44*			61.7	5.8		
V	268	241.2	294.8	256.7	12.9	OK	
Ti	6990	6291	7689	7343.9	39.8	OK	
Sc	*23*			0.0	18.7		<LOD
Ca	1950			2831.5	86.6		
K	33800	30420	37180	35292.4	248.3	OK	
S	12630	11367	13893	12623.5	217.1	OK	

JSAC 403 180-726

Elem	Certified	Low	High	Measured	2-sigma		
Ba				374.4	16.4		
Cs				35.2	12.4		
Te				0.0	6.2		<LOD
Sb				0.0	3.9		<LOD
Sn				4.7	3.3		<LOD
Cd	183	164.7	201.3	185.0	3.2	OK	
Pd				0.0	1.0		<LOD
Ag				0.0	1.2		<LOD
Mo				0.0	0.9		<LOD
Th				11.5	1.8		
Zr				294.7	2.6		
Sr				53.8	0.9		
U				2.5	2.1		<LOD
Rb				81.1	1.7		
As	199	159.2	238.8	204.8	3.6	OK	
Se	169	152.1	185.9	169.0	1.4	OK	
Au				6.9	5.6		<LOD
Hg	11.1	3.33	19.98	9.4	3.8	OK	
Pb	224	179.2	268.8	190.3	3.9	OK	
W				0.0	6.3		<LOD
Zn	91.8	68.85	114.75	80.3	2.3	OK	
Cu	26	13.1	39.3	19.5	3.4	OK	
Ni	26.2			33.0	7.6		
Co				44.4	32.7		<LOD
Fe				37450.1	114.1		
Mn	252	189	315	215.1	18.7	OK	
Cr	257	205.6	308.4	254.2	6.4	OK	
V	101	75.75	126.25	114.0	9.8	OK	
Ti				4670.4	31.2		
Sc				0.0	17.1		<LOD
Ca				4106.3	78.1		
K				14184.8	168.6		
S				621.4	91.1		

AGV-2 180-678

Elem	Certified	Low	High	Measured	2-sigma		
Ba	1140	912	1368	1108.5	17.8	OK	
Cs				52.3	12.5		
Te				0.0	6.2		<LOD
Sb	*0.6*			0.0	3.7		<LOD
Sn	2.3			9.3	3.3		
Cd				0.0	1.7		<LOD
Pd				0.0	1.0		<LOD
Ag				0.0	1.1		<LOD
Mo				0.0	0.9		<LOD
Th	6.1	4.27	7.93	6.6	1.2		
Zr	230	207	253	249.2	2.6		
Sr	658	592.2	723.8	639.4	2.8		
U	1.88			8.7	2.8		
Rb	68.6	61.74	75.46	61.5	1.5		
As				2.0	0.9		
Se				0.0	0.5		<LOD
Au				0.0	2.4		<LOD
Hg				0.0	2.9		<LOD
Pb	**13**	**7.8**	**18.2**	10.3	1.2	OK	
W				0.0	5.8		<LOD
Zn	**86**	**68.8**	**103.2**	71.1	2.1		
Cu	**53**	**37.1**	**68.9**	42.1	3.6	OK	
Ni	19			23.3	7.2		
Co	16			82.4	33.2		
Fe	**46800**	**42120**	**51480**	45605.9	113.4	OK	
Mn	**770**	**577.5**	**962.5**	652.3	23.0	OK	
Cr	17			52.2	5.3		
V	**120**	**102**	**138**	128.9	11.1	OK	
Ti	**6300**	**5670**	**6930**	6229.0	36.8	OK	
Sc	13	11.7	14.3	110.7	43.6		
Ca	**37200**	**33480**	**40920**	37862.8	185.8	OK	
K	**23900**	**21510**	**26290**	24422.0	201.8	OK	
S				0.0	109.4		<LOD

NCS DC 73309 180-727

Elem	Certified	Low	High	Measured	2-sigma		
Ba	260			277.8	18.0		
Cs				27.3	13.9		
Te				0.0	6.8		<LOD
Sb	14.9			0.0	4.5		<LOD
Sn	**370**	**333**	**407**	370.0	5.6	OK	
Cd	2.3			0.0	2.0		<LOD
Pd				0.0	1.1		<LOD
Ag	3.2			1.2	1.2		<LOD
Mo	**5.9**	**4.13**	**7.67**	4.4	0.9	OK	
Th	**23.3**	**11.65**	**34.95**	29.0	3.2	OK	
Zr	**153**	**137.7**	**168.3**	146.5	2.0	OK	
Sr	**29**	**23.2**	**34.8**	29.9	0.8	OK	
U	9.1			13.5	3.2		
Rb	**408**	**367.2**	**448.8**	399.4	3.7	OK	
As	**188**	**141**	**235**	192.6	5.1	OK	
Se	0.2			2.3	0.5		
Au				0.0	0.0		
Hg	0.072			4.2	4.8		
Pb	**636**	**572.4**	**699.6**	606.7	6.3	OK	
W	**126**	**100.8**	**151.2**	134.1	10.5	OK	
Zn	**373**	**298.4**	**447.6**	332.1	4.4	OK	
Cu	**79**	**59.25**	**98.75**	68.5	4.5	OK	
Ni	14.3			12.8	7.1		
Co	8.5			35.9	30.5		<LOD
Fe	**30705**	**27634.5**	**33775.5**	30157.2	108.2	OK	
Mn	**2490**	**1867.5**	**3112.5**	2054.8	40.3	OK	
Cr	40	36	44	70.6	4.9		
V	**47**	**42.3**	**51.7**	52.8	7.0		
Ti	**2100**	**1890**	**2310**	2141.7	22.6	OK	
Sc	**7.4**	**6.66**	**8.14**	0.0	16.3		<LOD
Ca	**2723**	**2042.25**	**3403.75**	2841.6	76.5	OK	
K	**27229**	**24506.1**	**29951.9**	27502.4	215.9	OK	
S	170			463.1	83.4		

NCS DC 93007 180-707

Elem	Certified	Low	High	Measured	2-sigma		
Ba				669.5	38.3		
Cs				107.0	28.7		
Te				33.8	14.4		
Sb				0.0	8.4		<LOD
Sn				40.6	7.8		
Cd				0.0	3.9		<LOD
Pd				0.0	3.3		<LOD
Ag	**26.2**	**19.65**	**32.75**	28.3	3.4	OK	
Mo				62.6	2.2		
Th				0.0	5.1		<LOD
Zr				37.3	2.6		
Sr				109.5	2.4		
U				12.8	5.1		
Rb				102.2	3.6		
As				28.9	6.0		
Se				8.4	1.1		
Au	37.3			19.0	7.5		
Hg				49.0	11.4		
Pb				288.0	8.5		
W				0.0	36.5		<LOD
Zn				658.7	12.3		
Cu				8517.6	65.3		
Ni				467.9	38.5		
Co				303.7	116.0		
Fe				299000.1	358.6		
Mn				323.2	33.8		
Cr				34.6	15.5		
V				66.2	19.5		
Ti				2373.5	63.4		
Sc				0.0	64.4		<LOD
Ca				11358.0	247.2		
K				23412.4	423.2		
S				207430.0	1228.8		

G310-10 180-728

Elem	Certified	Low	High	Measured	2-sigma		
Ba				573.4	18.6		
Cs				0.0	4.1		<LOD
Te				0.0	6.9		<LOD
Sb				0.0	4.1		<LOD
Sn				13.3	3.7		
Cd				0.0	1.9		<LOD
Pd				0.0	1.1		<LOD
Ag	*10.5*			10.3	1.5		
Mo				0.0	0.9		<LOD
Th				14.9	1.5		
Zr				134.3	2.1		
Sr				172.7	1.7		
U				9.7	2.7		
Rb				101.1	2.0		
As				1.9	1.1		
Se				0.0	0.5		<LOD
Au	**48**	**36**	**60**	48.0	4.2	OK	
Hg				0.0	5.2		<LOD
Pb				18.8	1.6		
W				0.0	0.0		
Zn				61.2	2.2		
Cu				24.9	3.7		
Ni				39.1	8.3		
Co				0.0	62.3		<LOD
Fe				45790.6	128.4		
Mn				588.9	25.2		
Cr				90.5	6.1		
V				135.0	11.9		
Ti				5994.0	37.9		
Sc				105.4	48.9		
Ca				37700.1	208.2		
K				19072.4	205.5		
S				384.9	99.6		

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Standards used for factory calibrations are either certified reference standards (CRM) or reference samples (RM).
Certificates of Analysis (CoA) are available on request, if available.
Values in italics are informational only (i.e. not certified)

Signed:

Lee A. Graham
Director of Quality, FSI

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy Light 8mm QC Sheet
Document: 140-00195
Revision: G
Release Date:10 June 2016

Serial Number: X500870 Model: Niton XL5- Software: 5372 Date of Q.C.: 5-Jul-18
Resolution: 170.341 156.71 Escale: 7.453 7.478 Spot Size: 8mm Inspector: VK

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0005	<LOD
Pb			0.001	0.0014	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0026	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0006	<LOD
Sb			0.000	0.0012	<LOD
Sn			0.000	0.0011	<LOD
Cd			0.000	0.0010	<LOD
Ag			0.000	0.0011	<LOD
Pd			0.000	0.0012	<LOD
Ru			0.000	0.0002	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0003	<LOD
Zn			0.004	0.0008	
Cu			0.000	0.0013	<LOD
Ni			0.000	0.0084	<LOD
Co			0.000	0.0111	<LOD
Fe	0	0.02	0.000	0.0188	OK
Mn			0.000	0.0058	<LOD
Cr			0.000	0.0068	<LOD
V			0.000	0.0164	<LOD
Ti			0.000	0.0322	<LOD
S			0.000	0.0005	<LOD
P			0.000	0.0019	<LOD
Si			0.000	0.0083	<LOD
Al			0.053	0.0317	
Mg	99.85	100	99.97	0.0394	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0016	<LOD
Pb			0.007	0.0045	
Au			0.000	0.0000	<LOD
Re			0.000	0.0011	<LOD
W			0.000	0.0049	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0000	<LOD
Sb			0.000	0.0031	<LOD
Sn			0.000	0.0027	<LOD
Cd			0.000	0.0026	<LOD
Ag			0.000	0.0028	<LOD
Pd			0.000	0.0032	<LOD
Ru			0.000	0.0005	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0008	<LOD
Zn			0.000	0.0021	<LOD
Cu			0.000	0.0035	<LOD
Ni			0.036	0.0259	<LOD
Co			0.000	0.0406	<LOD
Fe	99.85	100	99.97	0.0656	OK
Mn			0.000	0.0113	<LOD
Cr			0.006	0.0045	<LOD
V			0.000	0.0182	<LOD
Ti			0.000	0.0282	<LOD
S			0.000	0.0022	<LOD
P			0.000	0.0062	<LOD
Si			0.000	0.0050	<LOD
Al			0.000	0.0226	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.001	0.0005	
Pb			0.001	0.0006	
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.003	0.0029	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0020	<LOD
Sb			0.000	0.0014	<LOD
Sn			0.000	0.0015	<LOD
Cd			0.000	0.0012	<LOD
Ag			0.000	0.0014	<LOD
Pd			0.000	0.0017	<LOD
Ru			0.000	0.0003	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0001	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0003	<LOD
Zn			0.000	0.0013	<LOD
Cu			0.000	0.0014	<LOD
Ni			0.000	0.0020	<LOD
Co			0.000	0.0030	<LOD
Fe			0.000	0.0068	<LOD
Mn			0.000	0.0104	<LOD
Cr			0.000	0.0320	<LOD
V			0.059	0.0614	<LOD
Ti	99.8	100	99.95	0.0894	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0113	<LOD
Al			0.079	0.0522	
Mg			0.000	0.0000	<LOD

Certificate of Calibration

Ti 6-6-2 — IARM 178B — 195-095

	Certified	Low	High	Measured	Err	
Bi				0.001	0.0006	
Pb				0.000	0.0006	<LOD
Au				0.000	0.0005	<LOD
Re				0.000		OK
W				0.006	0.0027	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0035	<LOD
Sb				0.000	0.0019	<LOD
Sn	1.99	1.750	2.229	1.969	0.01	OK
Cd				0.002	0.0017	<LOD
Ag				0.010	0.0015	
Pd				0.002	0.0016	<LOD
Ru				0.000	0.0004	<LOD
Mo	0.008	0.002	0.014	0.007	0.0003	OK
Nb				0.001	0.0005	<LOD
Zr	0.004	0.001	0.010	0.004	0.0003	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn				0.002	0.0021	<LOD
Cu	0.51	0.420	0.600	0.506	0.0082	OK
Ni	0.017	0.007	0.027	0.012	0.0031	OK
Co				0.000	0.0060	<LOD
Fe	0.56	0.420	0.640	0.556	0.0169	OK
Mn	0.003			0.015	0.0140	<LOD
Cr	0.015			0.000	0.0312	<LOD
V	5.51	5.210	5.810	5.470	0.0661	OK
Ti	85.5	83.790	87.210	85.922	0.1244	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.000	0.050	0.019	0.0136	OK
Al	5.57	5.124	6.016	5.512	0.1147	OK
Mg				0.000	0.0000	<LOD

AA 4032 — ALCOA SS-4032D — 195-093

	Certified	Low	High	Measured	Err	
Bi	0.0000			0.001	0.0004	<LOD
Pb	0.0006			0.001	0.0004	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.008	0.0062	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0009	<LOD
Sb	0.000			0.000	0.0008	<LOD
Sn	0.0003			0.001	0.0007	<LOD
Cd	0.000			0.000	0.0008	<LOD
Ag	0.0001			0.002	0.0006	
Pd				0.000	0.0008	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	
Nb				0.000	0.0001	<LOD
Zr	0.0018			0.004	0.0001	
Y				0.000	0.0000	
Se				0.000	0.0002	<LOD
Zn	0.102	0.082	0.122	0.105	0.0019	OK
Cu	0.895	0.850	0.940	0.900	0.0065	OK
Ni	0.90	0.810	0.990	0.902	0.0074	OK
Co	0.0003			0.000	0.0028	<LOD
Fe	0.232	0.186	0.278	0.268	0.0064	OK
Mn	0.0307	0.015	0.043	0.033	0.0052	OK
Cr	0.0499	0.030	0.065	0.056	0.0088	OK
V	0.0099			0.022	0.0209	<LOD
Ti	0.012			0.060	0.0340	
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	12.20	11.712	12.688	12.23	0.0695	OK
Al	84.4	82.732	86.108	84.34	0.0853	OK
Mg	1.10	0.420	1.780	1.059	0.0993	OK

AA5083 — ALCAN 5083AF — 195-091

	Certified	Low	High	Measured	Err	
Bi	0.008			0.007	0.0004	
Pb	0.0077			0.007	0.0004	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.002	0.0015	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0009	<LOD
Sb	0.0012			0.001	0.0008	<LOD
Sn	0.020	0.010	0.030	0.019	0.0006	OK
Cd	0.0012			0.001	0.0007	<LOD
Ag				0.000	0.0008	<LOD
Pd				0.000	0.0007	<LOD
Ru				0.000	0.0001	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0035	0.002	0.005	0.003	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0001	<LOD
Zn	0.050	0.040	0.060	0.052	0.001	OK
Cu	0.078	0.062	0.094	0.079	0.002	OK
Ni	0.03	0.010	0.050	0.030	0.0016	OK
Co				0.000	0.0030	<LOD
Fe	0.34	0.272	0.408	0.322	0.0080	OK
Mn	0.740	0.666	0.814	0.742	0.0134	OK
Cr	0.15	0.11	0.20	0.140	0.0106	OK
V	0.02			0.000	0.0205	<LOD
Ti	0.027			0.000	0.0457	<LOD
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	0.17	0.102	0.240	0.174	0.0127	OK
Al	93.4	91.532	95.268	93.302	0.1430	OK
Mg	4.85	4.365	5.335	5.120	0.1398	OK

CDA 642 — IARM 81B — 195-097

	Certified	Low	High	Measured	Err	
Bi				0.005	0.0021	
Pb	0.006			0.010	0.0029	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0301	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.007	0.0063	<LOD
Sb	0.003			0.005	0.0051	<LOD
Sn	0.008			0.012	0.0044	
Cd				0.000	0.0056	<LOD
Ag	0.004			0.019	0.0046	
Pd				0.005	0.0061	<LOD
Ru				0.001	0.0012	<LOD
Mo				0.001	0.0007	<LOD
Nb				0.001	0.0009	<LOD
Zr				0.002	0.0014	<LOD
Y				0.001	0.0005	<LOD
Se				0.000	0.0040	<LOD
Zn	0.176	0.141	0.211	0.189	0.0181	OK
Cu	91.2	89.376	93.024	91.121	0.1203	OK
Ni	0.003			0.007	0.0086	<LOD
Co				0.000	0.0122	<LOD
Fe	0.047	0.027	0.067	0.048	0.0052	OK
Mn	0.012			0.013	0.0051	
Cr				0.011	0.0137	<LOD
V				0.000	0.0363	<LOD
Ti				0.021	0.0541	<LOD
S				0.055	0.0065	
P	0.004			0.034	0.0089	
Si	1.84	1.440	2.240	1.821	0.0231	OK
Al	6.70	6.030	7.370	6.632	0.1032	OK
Mg				0.000	0.0000	<LOD

CDA 922 — 32X PB11 F — 195-100

	Certified	Low	High	Measured	Err	
Bi	0.033			0.045	0.0061	

Nitronic 60 — IARM 18C — 195-089

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0003	<LOD

Pb	1.038	0.934	1.142	0.996	0.02	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.056	0.0298	
Ta				0.000		OK
Hf				0.000		OK
Te				0.010	0.0092	<LOD
Sb	0.478	0.430	0.526	0.479	0.01	OK
Sn	3.40	3.060	3.740	3.379	0.02	OK
Cd				0.000	0.0047	<LOD
Ag				0.019	0.0049	
Pd				0.000	0.0068	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.000	0.0007	<LOD
Zr				0.002	0.0013	<LOD
Y				0.003	0.0028	<LOD
Se				0.000	0.0023	<LOD
Zn	1.50	1.350	1.650	1.501	0.02	OK
Cu	90.54	88.729	92.351	90.473	0.08	OK
Ni	0.904	0.723	1.085	0.906	0.02	OK
Co	0.097	0.078	0.116	0.097	0.01	OK
Fe	0.566	0.453	0.679	0.567	0.01	OK
Mn	0.201	0.161	0.241	0.201	0.01	OK
Cr				0.000	0.0252	<LOD
V				0.000	0.0346	<LOD
Ti				0.055	0.0255	
S	0.0227			0.142	0.0119	
P	0.885	0.664	1.106	1.002	0.03	
Si	0.099			0.067	0.01	
Al				0.000	0.0359	<LOD
Mg	0.004			0.000	0.0000	<LOD

Pb				0.000	0.0011	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.089	0.0362	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.004	0.0029	<LOD
Sn	0.004			0.012	0.0022	
Cd				0.000	0.0027	<LOD
Ag				0.026	0.0023	
Pd				0.000	0.0026	<LOD
Ru				0.000	0.0008	<LOD
Mo	0.354	0.283	0.425	0.350	0.0024	OK
Nb	0.090	0.072	0.108	0.089	0.0012	
Zr				0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0040	<LOD
Cu	0.285	0.228	0.342	0.280	0.0128	OK
Ni	8.05	7.648	8.453	7.991	0.0490	OK
Co	0.060	0.000	0.150	0.000	0.0407	OK
Fe	63.0	61.760	64.280	62.981	0.0820	OK
Mn	7.69	7.306	8.075	7.637	0.0457	OK
Cr	16.19	15.785	16.595	16.155	0.0409	OK
V	0.099			0.139	0.0101	
Ti	0.013			0.032	0.0125	
S	0.0010			0.179	0.0041	
P	0.027			0.059	0.0094	
Si	3.80	3.420	4.180	3.959	0.0281	OK
Al	0.014			0.000	0.0282	<LOD
Mg				0.000	0.0000	<LOD

		RIFM T2/2		195-101		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0017	<LOD
Pb				0.007	0.0042	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0081	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.003	0.0035	<LOD
Sn				0.008	0.0027	
Cd				0.000	0.0036	<LOD
Ag				0.009	0.0028	
Pd				0.000	0.0039	<LOD
Ru				0.000	0.0007	<LOD
Mo				0.013	0.0006	
Nb				0.001	0.0004	
Zr				0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0006	<LOD
Zn				0.000	0.0025	<LOD
Cu	0.075			0.068	0.0062	
Ni	0.74			0.066	0.0196	
Co				0.000	0.0449	<LOD
Fe	95.5	94.259	96.742	95.694	0.0653	OK
Mn	0.28	0.238	0.322	0.266	0.0119	OK
Cr	0.065	0.035	0.095	0.061	0.0055	OK
V				0.000	0.0198	<LOD
Ti	0.037			0.036	0.0128	
S	0.02			0.026	0.0022	
P	0.012			0.012	0.0071	
Si	3.84	3.648	4.032	3.733	0.0261	OK
Al				0.000	0.0247	<LOD
Mg				0.000	0.0000	<LOD

	Ti6-2-4-2	IARM 177C		180-503		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.000	0.0013	<LOD
Au				0.000	0.0026	<LOD
Re				0.000		OK
W				0.000	0.0000	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0039	<LOD
Sb				0.000	0.0030	<LOD
Sn	2.02	1.919	2.121	2.005	0.0122	OK
Cd				0.000	0.0025	<LOD
Ag				0.007	0.0025	
Pd				0.000	0.0029	<LOD
Ru				0.000	0.0012	<LOD
Mo	1.96	1.764	2.352	1.939	0.0091	OK
Nb				0.001	0.0008	<LOD
Zr	3.99	3.751	4.229	3.948	0.0164	OK
Y				0.000	0.0006	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0020	<LOD
Cu				0.000	0.0032	<LOD
Ni				0.005	0.0056	<LOD
Co				0.000	0.0066	<LOD
Fe				0.018	0.0120	<LOD
Mn				0.000	0.0203	<LOD
Cr				0.000	0.0527	<LOD
V				0.000	0.1224	<LOD
Ti	85.72	84.006	87.434	86.050	0.1619	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.000	0.160	0.054	0.0160	OK
Al	6.02	5.520	6.520	5.973	0.1211	OK
Mg				0.000	0.0000	<LOD

	SS416	IARM 10c		195-151		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0007	<LOD
Pb				0.000	0.0014	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.016	0.0091	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.006	0.0040	
Sn	0.009			0.014	0.0024	
Cd				0.000	0.0028	<LOD

	Iron	BAS SCRM 660/09			195-166	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.007	0.0042	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0080	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0033	<LOD
Sn				0.000	0.0039	<LOD
Cd				0.000	0.0026	<LOD

Ag				0.025	0.0024					0.004	0.0037	<LOD
Pd				0.000	0.0026	<LOD				0.000	0.0039	<LOD
Ru				0.001	0.0006					0.000	0.0006	<LOD
Mo	0.08	0.040	0.120	0.088	0.0013	OK				0.001	0.0006	<LOD
Nb	0.003			0.001	0.0004					0.003	0.0004	
Zr				0.000	0.0004	<LOD				0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Se				0.000	0.0007	<LOD				0.000	0.0007	<LOD
Zn				0.005	0.0023					0.000	0.0023	<LOD
Cu	0.155	0.110	0.200	0.160	0.0073	OK				0.000	0.0039	<LOD
Ni	0.24	0.160	0.310	0.242	0.0115	OK				0.026	0.0260	<LOD
Co	0.022			0.058	0.0410					0.000	0.0407	<LOD
Fe	86.0	81.700	90.300	85.976	0.0683	OK	94.18	91.355	97.005	94.330	0.0636	OK
Mn	0.35	0.250	0.460	0.416	0.0269	OK	0.406	0.365	0.447	0.388	0.0134	OK
Cr	12.25	11.638	12.863	12.138	0.0356	OK				0.011	0.0047	
V	0.024			0.057	0.0083					0.009	0.0145	<LOD
Ti	0.002			0.030	0.0120					0.020	0.0127	
S	0.29	0.220	0.360	0.355	0.0050	OK	0.105	0.079	0.131	0.101	0.0031	OK
P	0.026			0.034	0.0077		0.153	0.122	0.184	0.153	0.0115	OK
Si	0.37	0.310	0.430	0.375	0.0101	OK	1.70	1.274	2.124	1.468	0.0177	OK
Al	0.003			0.000	0.0252	<LOD				0.000	0.0261	<LOD
Mg				0.000	0.0000	<LOD				0.000	0.0000	<LOD

	LAS	BS15a		195-167			Mar-M 247	IARM 333a		195-173		
	Certified	Low	High	Measured	Err		Provisional	Low	High	Measured	Err	
Bi				0.000	0.0018	<LOD				0.000	0.0011	<LOD
Pb				0.005	0.0044	<LOD				0.000		OK
Au				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Re				0.000		OK	*0.01*			0.000	0.0295	
W				0.000	0.0081	<LOD	*9.7*	8.730	10.670	9.962	0.2262	OK
Ta				0.000		OK	*3.15*	2.835	3.465	3.090	0.0968	OK
Hf				0.000		OK	*1.4*	1.260	1.540	1.448	0.0428	OK
Te				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Sb				0.000	0.0029	<LOD				0.007	0.0048	<LOD
Sn				0.000	0.0031	<LOD				0.011	0.0045	
Cd				0.000	0.0024	<LOD				0.006	0.0039	
Ag				0.000	0.0028	<LOD				0.000	0.0048	<LOD
Pd				0.000	0.0029	<LOD				0.000	0.0052	<LOD
Ru				0.000	0.0006	<LOD				0.000	0.0013	<LOD
Mo				0.008	0.0006		*0.49*	0.466	0.515	0.492	0.0055	OK
Nb				0.043	0.0011		*0.005*			0.004	0.0007	
Zr				0.018	0.0008		*0.009*			0.003	0.0009	
Y				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Se				0.000	0.0007	<LOD				0.000	0.0130	<LOD
Zn				0.004	0.0031	<LOD				0.000		OK
Cu				0.034	0.0052		*0.01*			0.000		OK
Ni				0.081	0.0195		*61.1*	58.045	64.155	60.511	0.2097	OK
Co				0.000	0.0406	<LOD	*9.4*	8.930	9.870	9.466	0.0638	OK
Fe	*98.4*	95.448	100.000	97.751	0.0662	OK	*0.036*	0.016	0.056	0.033	0.0085	OK
Mn	1.12	1.008	1.232	1.088	0.0190	OK	*0.005*			0.027	0.0234	<LOD
Cr				0.047	0.0052		*8.32*	7.904	8.736	8.415	0.0604	OK
V				0.012	0.0074					0.031	0.0193	
Ti				0.000	0.0335	<LOD	*0.73*	0.621	0.840	0.725	0.0423	OK
S				0.008	0.0022					0.026	0.0054	
P				0.035	0.0072		*0.004*			0.097	0.0066	
Si	0.058	0.030	0.100	0.061	0.0062	OK	*0.08*			0.000	0.0487	
Al				0.046	0.0253		*5.53*	5.254	5.807	5.618	0.0950	OK
Mg				0.000	0.0000	<LOD				0.000	0.0000	<LOD

Certificate of Calibration

	CMSX-4	IARM 332a		195-174		
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	2.9	2.610	3.190	2.940	0.0610	OK
W	6.5	5.850	7.150	6.590	0.2423	OK
Ta	6.51	5.859	7.161	6.947	0.1060	OK
Hf	0.098			0.089	0.0344	
Te				0.000	0.0000	<LOD
Sb				0.007	0.0049	
Sn				0.011	0.0046	
Cd				0.010	0.0039	
Ag				0.000	0.0048	<LOD
Pd				0.000	0.0051	<LOD
Ru				0.002	0.0014	<LOD
Mo	0.61	0.549	0.671	0.586	0.0062	
Nb				0.004	0.0008	
Zr				0.001	0.0006	
Y				0.000	0.0000	<LOD
Se				0.000	0.0131	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	61	59.780	62.220	60.002	0.2072	OK
Co	9.4	8.930	9.588	9.480	0.0629	OK
Fe	0.023	0.003	0.043	0.025	0.0081	OK
Mn				0.021	0.0210	<LOD
Cr	6.31	5.679	6.941	6.285	0.0557	OK
V				0.028	0.0444	<LOD
Ti	0.99	0.891	1.089	1.022	0.0488	OK
S				0.027	0.0058	
P				0.104	0.0081	
Si				0.000	0.0492	
Al	5.8	5.220	6.380	5.861	0.0953	OK
Mg				0.000	0.0000	<LOD

	Cu-Cd	MBH 36X CCD2		195-156		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0020	<LOD
Pb				0.006	0.0030	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.042	0.0297	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.012	0.0085	<LOD
Sb				0.023	0.0089	
Sn	0.2	0.180	0.220	0.199	0.0070	OK
Cd	1.18	1.062	1.298	1.179	0.0123	OK
Ag	0.0012			0.008	0.0051	<LOD
Pd				0.000	0.0078	<LOD
Ru				0.000	0.0013	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.001	0.0009	<LOD
Zr				0.005	0.0016	
Y				0.000	0.0005	<LOD
Se				0.000	0.0026	<LOD
Zn	0.0019			0.000	0.0239	<LOD
Cu	98.6	98.000	99.200	98.466	0.0855	
Ni				0.000	0.0081	<LOD
Co				0.000	0.0115	<LOD
Fe				0.000	0.0174	<LOD
Mn				0.008	0.0054	<LOD
Cr				0.016	0.0114	<LOD
V				0.000	0.0385	<LOD
Ti				0.021	0.0475	<LOD
S				0.054	0.0064	
P				0.024	0.0083	
Si				0.000	0.0074	<LOD
Al				0.000	0.0331	<LOD
Mg				0.000	0.0000	<LOD

	AA7075		ALC 7075 AF		180-505	
	Cert	Low	High	Measured	Err	
Bi	0.007			0.007	0.0005	
Pb	0.0073			0.007	0.0005	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.093	0.0667	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.001	0.0015	<LOD
Sb				0.003	0.0022	<LOD
Sn	0.014	0.004	0.024	0.016	0.0009	OK
Cd				0.001	0.0009	<LOD
Ag				0.006	0.0008	
Pd				0.001	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	
Zr	0.0024	0.001	0.003	0.003	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	5.75	5.578	5.923	5.772	0.0267	OK
Cu	1.750	1.663	1.838	1.755	0.0108	OK
Ni	0.027	0.007	0.047	0.027	0.0016	OK
Co				0.000	0.0023	<LOD
Fe	0.17	0.136	0.204	0.161	0.0053	OK
Mn	0.031	0.016	0.046	0.035	0.0053	OK
Cr	0.22	0.187	0.253	0.219	0.0104	OK
V	0.020			0.048	0.0150	
Ti	0.092	0.012	0.172	0.164	0.0297	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.114	0.266	0.186	0.0122	OK
Al	89	87.220	90.780	89.137	0.1144	OK
Mg	2.66	2.261	3.059	2.354	0.1366	OK

	CDA510	IARM 77B		195-177		
	Certified	Low	High	Measured	Err	
Bi				0.005	0.0014	
Pb	0.016	0.008	0.024	0.021	0.0020	
Au				0.000	0.0000	<LOD
Re				0.000		<LOD
W				0.052	0.0153	
Ta				0.000		<LOD
Hf				0.000		<LOD
Te				0.009	0.0017	
Sb				0.000	0.0055	<LOD
Sn	4.66	4.520	4.800	4.680	0.0076	OK
Cd				0.000	0.0041	<LOD
Ag				0.007	0.0038	
Pd				0.000	0.0053	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0043	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.000	0.0070	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0010	<LOD
Zn				0.059	0.0035	
Cu	95.2	94.248	96.152	94.898	0.0075	
Ni				0.000	0.0195	<LOD
Co				0.000	0.0452	<LOD
Fe				0.000	0.0713	<LOD
Mn				0.007	0.0172	<LOD
Cr				0.000	0.0260	<LOD
V				0.000	0.0662	<LOD
Ti				0.059	0.0743	<LOD
S				0.068	0.0028	
P	0.148	0.118	0.178	0.154	0.0086	OK
Si				0.000	0.0376	<LOD
Al				0.000	0.0761	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 8mm QC Sheet
Document:140-00195
Revision: G
Release Date: 10 June 2016

Serial Number: X500870 | Model: Niton XL5- | Software: 5372 | Date of Q.C.: 5-Jul-18
Resolution: 157.655 141.526 | Escale: 7.470 7.478 | Spot Size: 8mm | Inspector: VK

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0016	<LOD
Pb			0.007	0.0045	
Au			0.000	0.0011	<LOD
Re			0.000		OK
W			0.000	0.0049	<LOD
Ta			0.000	0.0577	OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0031	<LOD
Sn			0.000	0.0027	<LOD
Cd			0.000	0.0026	<LOD
Ag			0.000	0.0028	<LOD
Pd			0.000	0.0032	<LOD
Ru			0.000	0.0005	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0008	<LOD
Zn			0.000	0.0021	<LOD
Cu			0.000	0.0036	<LOD
Ni			0.036	0.0259	<LOD
Co			0.000	0.0406	<LOD
Fe	99.85	100.000	99.974	0.0610	OK
Mn			0.000	0.0113	<LOD
Cr			0.006	0.0045	<LOD
V			0.000	0.0181	<LOD
Ti			0.000	0.0282	<LOD
Al (Bal)			0.000	0.0000	OK
LEC			0.000		

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.000	0.0039	<LOD
Pb			0.000	0.0000	<LOD
Au			0.000	0.0000	<LOD
Re			0.024	0.0040	
W			0.098	0.1039	<LOD
Ta	99.5	100	99.957	0.1207	OK
Hf			0.000	0.0591	<LOD
Te			0.000	0.0090	<LOD
Sb			0.000	0.0062	<LOD
Sn			0.000	0.0065	<LOD
Cd			0.000	0.0048	<LOD
Ag			0.000	0.0073	<LOD
Pd			0.000	0.0055	<LOD
Ru			0.000	0.0015	<LOD
Mo			0.001	0.0009	<LOD
Nb			0.001	0.0009	<LOD
Zr			0.001	0.0010	<LOD
Y			0.000	0.0008	<LOD
Se			0.000	0.0227	<LOD
Zn			0.000	0.0000	OK
Cu			0.000	0.0000	OK
Ni			0.000	0.0127	<LOD
Co			0.000	0.0278	<LOD
Fe			0.000	0.0171	<LOD
Mn			0.000	0.0257	<LOD
Cr			0.000	0.0327	<LOD
V			0.000	0.0489	<LOD
Ti			0.000	0.0830	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.006	0.0049	<LOD
Pb			0.007	0.0046	<LOD
Au			0.000	0.0072	<LOD
Re			0.000		OK
W			0.000	0.0085	<LOD
Ta			0.000	0.0000	OK
Hf			0.000		OK
Te			0.025	0.0232	<LOD
Sb			0.028	0.0239	<LOD
Sn	99	100.000	99.838	0.4157	OK
Cd			0.022	0.0103	
Ag			0.000	0.0097	<LOD
Pd			0.000	0.0084	<LOD
Ru			0.000	0.0016	<LOD
Mo			0.000	0.0013	<LOD
Nb			0.000	0.0010	<LOD
Zr			0.000	0.0016	<LOD
Y			0.000	0.0010	<LOD
Se			0.000	0.0026	<LOD
Zn			0.000	0.0089	<LOD
Cu			0.000	0.0115	<LOD
Ni			0.000	0.0188	<LOD
Co			0.000	0.0252	<LOD
Fe			0.000	0.0398	<LOD
Mn			0.000	0.0633	<LOD
Cr			0.000	0.0964	<LOD
V			0.000	0.1779	<LOD
Ti			0.347	0.3489	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC			0.000		

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.002	<LOD
Pb			0.003	0.003	<LOD
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.000	0.027	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.007	0.008	<LOD
Sb			0.000	0.005	<LOD
Sn			0.000	0.005	<LOD
Cd			0.000	0.006	<LOD
Ag			0.000	0.005	<LOD
Pd			0.000	0.005	<LOD
Ru			0.000	0.001	<LOD
Mo			0.000	0.001	<LOD
Nb			0.000	0.001	<LOD
Zr			0.003	0.002	
Y			0.001	0.001	<LOD
Se			0.000	0.005	<LOD
Zn			0.000	0.024	<LOD
Cu	99.85	100	99.992	0.080	OK
Ni			0.000	0.009	<LOD
Co			0.004	0.008	<LOD
Fe			0.000	0.013	<LOD
Mn			0.000	0.020	<LOD
Cr			0.000	0.021	<LOD
V			0.000	0.029	<LOD
Ti			0.000	0.052	<LOD
Al (Bal)			0.000	0.000	<LOD
LEC			0.000		

Certificate of Calibration

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.003	0.0020	
Pb			0.000	0.0032	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.7171	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.005	0.0054	<LOD
Sn			0.000	0.0044	<LOD
Cd			0.000	0.0042	<LOD
Ag			0.000	0.0047	<LOD
Pd			0.000	0.0056	<LOD
Ru			0.000	0.0009	<LOD
Mo			0.000	0.0006	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.000	0.0005	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0157	<LOD
Zn			0.051	0.0480	<LOD
Cu			0.000	0.0280	<LOD
Ni	99.85	100.000	99.979	0.7220	OK
Co			0.000	0.0101	<LOD
Fe			0.005	0.0087	<LOD
Mn			0.000	0.0133	<LOD
Cr			0.000	0.0171	<LOD
V			0.000	0.0316	<LOD
Ti			0.000	0.0443	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC			0.000		

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.001	0.001	
Pb			0.001	0.001	
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.003	0.003	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.002	<LOD
Sb			0.000	0.001	<LOD
Sn			0.000	0.001	<LOD
Cd			0.000	0.001	<LOD
Ag			0.000	0.001	<LOD
Pd			0.000	0.002	<LOD
Ru			0.000	0.000	<LOD
Mo			0.000	0.000	<LOD
Nb			0.000	0.000	<LOD
Zr			0.000	0.000	<LOD
Y			0.000	0.000	<LOD
Se			0.000	0.000	<LOD
Zn			0.000	0.001	<LOD
Cu			0.000	0.001	<LOD
Ni			0.000	0.002	<LOD
Co			0.000	0.003	<LOD
Fe			0.000	0.007	<LOD
Mn			0.000	0.010	<LOD
Cr			0.000	0.032	<LOD
V			0.060	0.061	<LOD
Ti	99.85	100	99.975	0.071	OK
Al (Bal)			0.000	0.000	<LOD
LEC			0.000		

20Cb3 — IARM 25C — 180-509

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0008	<LOD
Pb				0.000	0.0014	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.080			0.134	0.1115	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0039	<LOD
Sn	0.01	0.002	0.020	0.011	0.0029	OK
Cd				0.000	0.0026	<LOD
Ag				0.032	0.0029	
Pd				0.000	0.0031	<LOD
Ru				0.000	0.0013	<LOD
Mo	2.26	2.030	2.480	2.207	0.0091	OK
Nb	0.58	0.480	0.680	0.571	0.0040	OK
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0031	<LOD
Zn				0.000	0.0108	<LOD
Cu	3.51	3.260	3.760	3.523	0.0345	OK
Ni	33.30	31.640	35.640	33.070	0.1269	OK
Co	0.091	0.020	0.200	0.178	0.0365	OK
Fe	38.80	36.800	40.800	38.651	0.0723	OK
Mn	0.90	0.400	1.400	0.930	0.0318	OK
Cr	19.97	19.570	20.570	20.048	0.0534	OK
V	0.095	0.035	0.155	0.138	0.0129	OK
Ti	0.003			0.042	0.0159	
Al (Bal)	0.019			0.000	0.00	<LOD
LEC				0.500		

Stellite 6B — IARM 95B — 180-502

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0008	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0140	
W	3.42	3.120	3.720	3.432	0.0499	OK
Ta				0.000	0.0229	<LOD
Hf				0.047	0.0361	<LOD
Te				0.000	0.0000	<LOD
Sb				0.001	0.0038	<LOD
Sn				0.009	0.0026	
Cd				0.000	0.0024	<LOD
Ag				0.033	0.0027	
Pd				0.000	0.0028	<LOD
Ru				0.000	0.0009	<LOD
Mo	0.83	0.700	0.960	0.833	0.0043	OK
Nb	0.002			0.002	0.0005	
Zr	0.002			0.001	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0036	<LOD
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	2.25	1.913	2.588	2.258	0.0364	OK
Co	60.90	59.682	61.814	59.936	0.1004	OK
Fe	1.10	0.990	1.210	1.104	0.0236	OK
Mn	0.99	0.891	1.089	0.994	0.0291	OK
Cr	28.90	28.467	29.334	29.005	0.0591	OK
V	0.002			0.041	0.0111	
Ti	0.004			0.040	0.0143	
Al (Bal)	0.07			0.000	0.00	<LOD
LEC		2.250	2.250	2.250		

ThermoFisher SCIENTIFIC

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	0.01			0.047	0.0098	
Pb	5.03	4.680	5.440	4.768	0.0404	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.039	0.0283	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.011	0.0089	<LOD
Sb	0.143	0.122	0.164	0.136	0.0071	OK
Sn	4.37	3.460	5.380	4.389	0.0237	OK
Cd				0.000	0.0049	<LOD
Ag	0.02			0.040	0.0053	
Pd				0.000	0.0063	<LOD
Ru				0.000	0.0013	<LOD
Mo				0.000	0.0007	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.002	0.0014	
Y				0.020	0.0134	<LOD
Se				0.000	0.0034	<LOD
Zn	5.38	4.790	6.080	5.039	0.0340	OK
Cu	84.6	82.600	86.600	84.907	0.0712	OK
Ni	0.27	0.100	0.400	0.270	0.0104	OK
Co				0.000	0.0152	<LOD
Fe	0.24	0.210	0.270	0.250	0.0100	OK
Mn	0.002			0.012	0.0159	<LOD
Cr				0.015	0.0212	<LOD
V				0.025	0.0290	<LOD
Ti				0.062	0.0291	
Al (Bal)	0.002			0.000	0.00	<LOD
LEC						

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0014	<LOD
Pb	0.0009			0.014	0.0084	
Au				0.000	0.0016	
Re				0.000		OK
W	0.004			0.000	0.0060	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0032	<LOD
Sn	0.002			0.003	0.0035	<LOD
Cd				0.000	0.0025	<LOD
Ag				0.007	0.0029	
Pd				0.000	0.0031	<LOD
Ru				0.000	0.0008	<LOD
Mo	0.47	0.430	0.530	0.480	0.0036	OK
Nb	0.002			0.000	0.0004	<LOD
Zr	0.001			0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0033	<LOD
Cu	0.033	0.018	0.048	0.028	0.0052	OK
Ni	0.071			0.081	0.0201	
Co	0.004			0.000	0.0419	<LOD
Fe	96.96	95.900	98.000	96.975	0.0635	OK
Mn	0.56	0.350	0.750	0.562	0.0175	OK
Cr	1.11	0.999	1.221	1.073	0.0138	OK
V	0.004			0.014	0.0089	
Ti	0.0016			0.018	0.0310	<LOD
Al (Bal)	0.028			0.000	0.00	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.000	0.0024	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.62	0.320	0.920	0.413	0.1578	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0050	<LOD
Sn	0.002			0.000	0.0043	<LOD
Cd				0.000	0.0041	<LOD
Ag				0.019	0.0044	
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0029	<LOD
Mo	8.30	7.720	8.890	8.300	0.0314	OK
Nb	0.09	0.030	0.150	0.076	0.0021	OK
Zr	0.004			0.002	0.0009	
Y				0.000	0.0000	<LOD
Se				0.000	0.0057	<LOD
Zn				0.033	0.0236	<LOD
Cu				0.131	0.0262	
Ni	48.80	46.800	50.760	48.482	0.1837	OK
Co	1.11	0.930	1.350	1.194	0.0391	OK
Fe	18.30	17.390	19.220	18.296	0.0675	OK
Mn	0.47	0.200	0.900	0.470	0.0361	OK
Cr	21.60	20.740	22.470	22.019	0.0703	OK
V	0.03			0.070	0.0163	
Ti	0.02			0.041	0.0376	<LOD
Al (Bal)	0.12			0.00	0.00	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0007	<LOD
Pb				0.000	0.0026	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	6.30	5.800	6.870	6.653	0.0704	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0041	<LOD
Sn	0.01			0.005	0.0037	<LOD
Cd				0.000	0.0033	<LOD
Ag				0.020	0.0037	
Pd				0.000	0.0039	<LOD
Ru				0.000	0.0020	<LOD
Mo	4.85	4.610	5.150	4.843	0.0161	OK
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0056	<LOD
Zn				0.000	0.0173	<LOD
Cu	0.13	0.104	0.156	0.123	0.0106	OK
Ni	0.35	0.280	0.420	0.305	0.0175	OK
Co	0.31	0.217	0.403	0.303	0.0455	OK
Fe	80.59	78.590	82.590	80.190	0.0963	OK
Mn	0.29	0.240	0.340	0.294	0.0234	OK
Cr	3.98	3.590	4.420	4.011	0.0319	OK
V	2.03	1.570	2.460	2.010	0.0322	OK
Ti				0.022	0.0405	<LOD
Al (Bal)	0.02			0.00	0.00	<LOD
LEC				1.24		

ThermoFisher SCIENTIFIC

Niton XL5 Alloy 8mm QC Sheet
Document:140-00195
Revision: G
Release Date: 10 June 2016

Certificate of Calibration

	SS321		IARM 6D		180-512	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0003	<LOD
Pb				0.000	0.0012	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09			0.181	0.0405	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.007	0.0038	
Sn	0.013	0.003	0.023	0.020	0.0024	OK
Cd				0.000	0.0024	<LOD
Ag				0.030	0.0024	
Pd				0.000	0.0028	<LOD
Ru				0.000	0.0008	<LOD
Mo	**0.358**	**0.290**	**0.440**	0.364	0.0025	OK
Nb	**0.039**	**0.010**	**0.060**	0.040	0.0009	OK
Zr	***0.002***			0.001	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0053	<LOD
Cu	**0.302**	**0.150**	**0.500**	0.319	0.0139	OK
Ni	**9.42**	**9.000**	**9.800**	9.332	0.0534	OK
Co	**0.182**	**0.109**	**0.255**	0.210	0.0403	OK
Fe	**69.40**	**68.400**	**70.400**	69.083	0.0828	OK
Mn	**1.52**	**1.250**	**1.850**	1.612	0.0333	OK
Cr	**17.45**	**17.100**	**18.000**	17.523	0.0433	OK
V	**0.128**	**0.077**	**0.179**	0.171	0.0118	OK
Ti	**0.63**	**0.378**	**0.882**	0.637	0.0207	OK
Al (Bal)	0.11			0.00	0.00	<LOD
LEC				0.50		OK

	Ti 6-2-4-2		IARM 177C		180-503	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0014	<LOD
Pb				0.000	0.0015	<LOD
Au				0.000	0.0029	<LOD
Re				0.000		OK
W				0.000	0.0000	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0045	<LOD
Sb				0.000	0.0034	<LOD
Sn	**2.02**	**1.919**	**2.121**	2.023	0.0123	OK
Cd				0.000	0.0028	<LOD
Ag				0.007	0.0029	
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0013	<LOD
Mo	**1.96**	**1.764**	**2.156**	1.959	0.0090	OK
Nb				0.001	0.0009	<LOD
Zr	**3.99**	**3.751**	**4.229**	3.989	0.0155	OK
Y				0.000	0.0007	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0022	<LOD
Cu	0.003			0.000	0.0036	<LOD
Ni	0.011			0.006	0.0062	<LOD
Co				0.000	0.0073	<LOD
Fe	0.033	0.023	0.053	0.018	0.0132	<LOD
Mn	0.0015			0.000	0.0225	<LOD
Cr				0.000	0.0584	<LOD
V	0.02			0.000	0.1299	<LOD
Ti	**85.72**	**84.006**	**87.434**	85.997	0.1376	OK
Al (Bal)	6.02			0.00	0.00	<LOD
LEC				6.0		OK

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.007	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.093	0.0668	
Ta				0.000		OK
Hf				0.000		OK
Te				0.001	0.0015	<LOD
Sb				0.003	0.0023	<LOD
Sn	0.014	0.007	0.021	0.015	0.0009	OK
Cd				0.001	0.0009	<LOD
Ag				0.006	0.0008	
Pd				0.001	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	
Zr	0.0024	0.001	0.003	0.0025	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	**5.75**	**5.578**	**5.923**	5.766	0.0112	OK
Cu	**1.750**	**1.663**	**1.838**	1.756	0.0081	OK
Ni	0.027	0.007	0.047	0.027	0.0016	OK
Co				0.000	0.0023	<LOD
Fe	**0.17**	**0.136**	**0.204**	0.168	0.0053	OK
Mn	0.031	0.016	0.046	0.036	0.0053	OK
Cr	**0.22**	**0.187**	**0.253**	0.220	0.0104	OK
V	0.020			0.048	0.0150	
Ti	**0.092**	**0.012**	**0.172**	0.145	0.0298	OK
Al (Bal)	***91.7***	**89.827**	**93.493**	91.69	0.08	OK
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

1.25Cr 0.5Mo — **IARM35H** — 195-019

	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0014	<LOD
Pb	*0.001*			0.014	0.0084	
Au				0.000	0.0016	<LOD
Re				0.000		OK
W	*0.004*			0.000	0.0060	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	*0.002*			0.000	0.0032	<LOD
Sn	*0.002*			0.003	0.0036	<LOD
Cd				0.000	0.0025	<LOD
Ag				0.007	0.0029	
Pd				0.000	0.0031	<LOD
Ru				0.000	0.0008	<LOD
Mo	***0.47***	**0.432**	**0.508**	0.482	0.0035	OK
Nb	*0.002*			0.000	0.0004	<LOD
Zr	*0.001*			0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0033	<LOD
Cu	*0.032*	0.012	0.052	0.028	0.0052	OK
Ni	*0.071*			0.081	0.0202	
Co	*0.004*			0.000	0.0419	<LOD
Fe	***96.96***	**95.990**	**97.930**	96.955	0.0509	OK
Mn	***0.56***	**0.476**	**0.644**	0.564	0.0176	OK
Cr	***1.11***	**0.999**	**1.221**	1.109	0.0052	OK
V	*0.004*			0.000	0.0014	<LOD
Ti	*0.002*			0.002	0.0012	
Al (Bal)	*0.028*			0.00	0.00	<LOD
LEC	**0.75**			0.750		OK

Tool steel T-1 — **IARM 48C** — 195-152

	Certified	Low	High	Measured	Err	
Bi				0.002	0.0004	
Pb				0.000	0.0029	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**17.50**	**16.625**	**18.375**	17.269	0.0769	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.009	0.0031	
Sn	0.012			0.025	0.0030	
Cd				0.003	0.0032	<LOD
Ag				0.055	0.0031	
Pd				0.000	0.0030	<LOD
Ru				0.002	0.0013	<LOD
Mo	0.17	0.150	0.190	0.160	0.0019	OK
Nb	0.005	0.001	0.010	0.003	0.0005	OK
Zr				0.001	0.0004	
Y				0.000	0.0000	<LOD
Se				0.000	0.0077	<LOD
Zn				0.024	0.0197	<LOD
Cu	0.13	0.090	0.170	0.118	0.0112	OK
Ni	0.204	0.143	0.265	0.164	0.0165	OK
Co	0.22	0.120	0.320	0.192	0.0389	OK
Fe	***74.5***	**73.383**	**75.618**	74.945	0.0912	OK
Mn	**0.39**	**0.304**	**0.476**	0.420	0.0217	OK
Cr	**4.24**	**3.901**	**4.579**	4.329	0.0297	OK
V	**1.27**	**1.143**	**1.397**	1.255	0.0074	OK
Ti	0.006			0.002	0.0018	<LOD
Al (Bal)	0.017			0.00	0.00	<LOD
LEC	**1.025**			1.025		OK

Custom 455 — **IARM16B** — 195-142

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0007	<LOD
Pb				0.003	0.0015	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.098	0.0391	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.004	0.0034	<LOD
Sn	0.004			0.007	0.0024	
Cd				0.002	0.0023	<LOD
Ag				0.028	0.0025	
Pd				0.000	0.0028	<LOD
Ru				0.001	0.0009	<LOD
Mo	0.016	0.010	0.022	0.015	0.0006	OK
Nb	**0.25**	**0.225**	**0.275**	0.256	0.0022	OK
Zr				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0053	<LOD
Cu	**2.23**	**2.119**	**2.342**	2.203	0.0255	OK
Ni	**8.28**	**7.866**	**8.694**	8.241	0.0518	OK
Co	0.027			0.057	0.0391	<LOD
Fe	***76.4***	**72.580**	**80.220**	76.498	0.0353	OK
Mn	0.026			0.091	0.0245	
Cr	**11.44**	**10.868**	**12.012**	11.335	0.0353	OK
V	0.067			0.061	0.0038	
Ti	**1.11**	**1.055**	**1.166**	1.106	0.0080	OK
Al (Bal)	0.062			0.000	0.00	<LOD

AA7075 — **ALC 7075 AF** — 180-505

	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.007	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.093	0.0667	
Ta				0.000		OK
Hf				0.000		OK
Te				0.001	0.0015	<LOD
Sb				0.003	0.0023	<LOD
Sn	0.014	0.007	0.021	0.015	0.0009	OK
Cd				0.001	0.0009	<LOD
Ag				0.006	0.0008	
Pd				0.001	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	
Zr	0.0024	0.000	0.004	0.003	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	**5.75**	**5.578**	**5.923**	5.764	0.0111	OK
Cu	**1.750**	**1.663**	**1.838**	1.756	0.0080	OK
Ni	0.027	0.007	0.047	0.027	0.0016	OK
Co				0.000	0.0261	<LOD
Fe	**0.17**	**0.136**	**0.204**	0.168	0.0053	OK
Mn	0.031	0.016	0.046	0.036	0.0052	OK
Cr	**0.22**	**0.198**	**0.242**	0.221	0.0026	OK
V	0.020			0.026	0.0013	
Ti	**0.092**	**0.072**	**0.112**	0.092	0.0020	OK
Al (Bal)	***91.7***	**89.827**	**93.493**	91.769	0.01	OK

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Serial Number: X500870 Model: Niton XL5- ________ Software: 5372 Date of Q.C.: 5-Jul-18
Resolution: 157.6548 141.5258 Escale: 7.470 7.478 Spot Size: 3mm Inspector: VK

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0002	<LOD
Pb			0.001	0.0005	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0021	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0013	<LOD
Sb			0.000	0.0010	<LOD
Sn			0.000	0.0008	<LOD
Cd			0.000	0.0009	<LOD
Ag			0.000	0.0008	<LOD
Pd			0.000	0.0011	<LOD
Ru			0.000	0.0002	<LOD
Mo			0.000	0.0001	<LOD
Nb			0.000	0.0001	<LOD
Zr			0.000	0.0001	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0001	<LOD
Zn			0.004	0.0007	
Cu			0.000	0.0009	<LOD
Ni			0.000	0.0012	<LOD
Co			0.000	0.0018	<LOD
Fe	0	0.02	0.000	0.0032	<LOD
Mn			0.000	0.0060	<LOD
Cr			0.000	0.0107	<LOD
V			0.000	0.0226	<LOD
Ti			0.000	0.0463	<LOD
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0129	<LOD
Al			0.000	0.0665	<LOD
Mg	99.85	100	100.00	0.0865	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0014	<LOD
Pb			0.007	0.0045	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.016	0.0149	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0039	<LOD
Sn			0.000	0.0037	<LOD
Cd			0.000	0.0035	<LOD
Ag			0.000	0.0045	<LOD
Pd			0.000	0.0043	<LOD
Ru			0.000	0.0009	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.001	0.0004	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0012	<LOD
Zn			0.000	0.0033	<LOD
Cu			0.000	0.0070	<LOD
Ni			0.000	0.0200	<LOD
Co			0.063	0.0631	<LOD
Fe	99.75	100	99.96	0.1003	OK
Mn			0.000	0.0136	<LOD
Cr			0.000	0.0138	<LOD
V			0.000	0.0273	<LOD
Ti			0.000	0.0429	<LOD
S			0.000	0.0037	<LOD
P			0.000	0.0091	<LOD
Si			0.015	0.0104	<LOD
Al			0.000	0.0436	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.002	0.0011	
Pb			0.001	0.0009	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0084	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0040	<LOD
Sb			0.000	0.0027	<LOD
Sn			0.000	0.0027	<LOD
Cd			0.000	0.0031	<LOD
Ag			0.000	0.0027	<LOD
Pd			0.000	0.0035	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0003	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0002	<LOD
Se			0.000	0.0006	<LOD
Zn			0.000	0.0027	<LOD
Cu			0.000	0.0035	<LOD
Ni			0.000	0.0041	<LOD
Co			0.000	0.0051	<LOD
Fe			0.000	0.0092	<LOD
Mn			0.000	0.0188	<LOD
Cr			0.000	0.0743	<LOD
V			0.000	0.1085	<LOD
Ti	99.7	100	99.99	0.1474	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.013	0.0127	<LOD
Al			0.000	0.0573	<LOD
Mg			0.000	0.0000	<LOD

Certificate of Calibration

Ti 6-6-2 — IARM 178B — 195-095

	Certified	Low	High	Measured	Err	
Bi				0.002	0.0013	
Pb				0.000	0.0015	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0148	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0061	<LOD
Sb				0.000	0.0042	<LOD
Sn	1.99	1.70	2.30	1.946	0.0160	OK
Cd				0.000	0.0041	<LOD
Ag				0.012	0.0036	
Pd				0.004	0.0047	<LOD
Ru				0.000	0.0010	<LOD
Mo	0.008	0.002	0.014	0.007	0.0007	OK
Nb				0.001	0.0007	<LOD
Zr	0.004	0.001	0.01	0.004	0.0006	OK
Y				0.000	0.0003	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0042	OK
Cu	0.51	0.40	0.60	0.586	0.0200	OK
Ni	0.017	0.005	0.030	0.017	0.0075	OK
Co				0.000	0.0157	<LOD
Fe	0.56	0.42	0.64	0.561	0.0392	OK
Mn	0.003			0.045	0.0241	
Cr	0.015			0.000	0.0670	<LOD
V	5.51	5.21	5.81	5.599	0.1427	OK
Ti	85.5	83.79	87.21	85.642	0.1994	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.00	0.05	0.020	0.0149	<LOD
Al	5.57	5.15	6.09	5.560	0.1367	OK
Mg				0.000	0.0000	<LOD

AA 4032 — ALCOA SS-4032D — 195-093

	Certified	Low	High	Measured	Err	
Bi	0.0000			0.001	0.0004	
Pb	0.0006			0.001	0.0007	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.010	0.0111	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0017	<LOD
Sb	0.000			0.000	0.0013	<LOD
Sn	0.0003			0.000	0.0013	<LOD
Cd	0.000			0.000	0.0012	<LOD
Ag	0.0001			0.001	0.0011	<LOD
Pd				0.000	0.0015	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0018			0.005	0.0002	
Y				0.000	0.0001	
Se				0.000	0.0003	<LOD
Zn	0.102	0.051	0.153	0.100	0.0032	OK
Cu	0.895	0.81	0.98	0.898	0.0111	OK
Ni	0.90	0.77	1.04	0.902	0.0129	OK
Co	0.0003			0.000	0.0044	<LOD
Fe	0.232	0.162	0.302	0.268	0.0105	OK
Mn	0.0307	0.015	0.043	0.034	0.0083	
Cr	0.0499	0.030	0.065	0.055	0.0136	
V	0.0099			0.029	0.0330	<LOD
Ti	0.012			0.081	0.0581	<LOD
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	12.20	11.47	12.93	12.23	0.1155	OK
Al	84.4	81.04	87.80	84.40	0.1431	OK
Mg	1.10	0.350	1.850	1.045	0.1663	OK

AA5083 — ALCAN 5083AF — 195-091

	Certified	Low	High	Measured	Err	
Bi	0.008			0.009	0.0006	
Pb	0.0077			0.011	0.0007	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0038	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0016	<LOD
Sb	0.0012			0.000	0.0014	<LOD
Sn	0.020			0.018	0.0012	
Cd	0.0012			0.001	0.0013	<LOD
Ag				0.000	0.0011	<LOD
Pd				0.000	0.0014	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0035			0.004	0.0021	
Y				0.000	0.0001	
Se				0.000	0.0002	<LOD
Zn	0.050	0.04	0.06	0.050	0.0021	OK
Cu	0.078	0.06	0.09	0.080	0.0031	OK
Ni	0.03			0.030	0.0027	
Co				0.000	0.0044	<LOD
Fe	0.34	0.27	0.41	0.321	0.0129	OK
Mn	0.740	0.67	0.81	0.741	0.0222	OK
Cr	0.15	0.08	0.21	0.140	0.0164	OK
V	0.02			0.045	0.0298	
Ti	0.027			0.000	0.0603	<LOD
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	0.17	0.09	0.26	0.17	0.0216	OK
Al	93.4	88.73	98.07	93.27	0.2357	OK
Mg	4.85	4.12	5.58	5.14	0.2370	OK

CDA 642 — IARM 81B — 195-097

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0024	<LOD
Pb	0.006			0.011	0.0030	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0266	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.007	0.0094	<LOD
Sb	0.003			0.000	0.0079	<LOD
Sn	0.008			0.010	0.0050	
Cd				0.000	0.0053	<LOD
Ag	0.004			0.022	0.0053	
Pd				0.008	0.0063	<LOD
Ru				0.001	0.0013	<LOD
Mo				0.001	0.0008	<LOD
Nb				0.001	0.0011	<LOD
Zr				0.003	0.0016	
Y				0.000	0.0004	<LOD
Se				0.000	0.0043	<LOD
Zn	0.176	0.132	0.220	0.182	0.0186	OK
Cu	91.2	89.38	93.02	91.169	0.1983	OK
Ni	0.003			0.000	0.0101	
Co				0.000	0.0092	<LOD
Fe	0.047	0.022	0.072	0.052	0.0051	
Mn	0.012			0.011	0.0051	
Cr				0.000	0.0164	<LOD
V				0.000	0.0313	<LOD
Ti				0.000	0.0675	
S				0.061	0.0130	
P	0.004			0.036	0.0143	
Si	1.84	1.44	2.24	1.820	0.0413	OK
Al	6.70	5.36	8.04	6.622	0.1860	OK
Mg				0.000	0.0000	<LOD

Certificate of Calibration

	CDA 922	32X PB11 F		195-100		
	Certified	Low	High	Measured	Err	
Bi	0.033			0.043	0.0062	
Pb	1.038	0.88	1.19	1.04	0.0207	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.042	0.0313	
Ta				0.000		OK
Hf				0.000		OK
Te				0.010	0.0084	
Sb	0.478	0.41	0.55	0.477	0.0103	OK
Sn	3.40	2.89	3.91	3.399	0.0224	OK
Cd				0.000	0.0061	
Ag				0.025	0.0055	
Pd				0.000	0.0079	<LOD
Ru				0.000	0.0014	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.000	0.0014	<LOD
Y				0.004	0.0026	<LOD
Se				0.000	0.0025	<LOD
Zn	1.50	1.28	1.73	1.50	0.0248	OK
Cu	90.54	87.82	93.26	90.39	0.1047	OK
Ni	0.904	0.68	1.13	0.90	0.0170	OK
Co	0.097	0.073	0.121	0.097	0.0063	
Fe	0.566	0.42	0.71	0.57	0.0129	OK
Mn	0.201	0.15	0.25	0.20	0.0106	OK
Cr				0.010	0.0203	<LOD
V				0.000	0.0312	<LOD
Ti				0.058	0.0249	
S	0.0227			0.165	0.0240	
P	0.885	0.62	1.15	1.01	0.0566	OK
Si	0.099			0.09	0.0187	
Al				0.000	0.0643	<LOD
Mg	0.004			0.000	0.0000	<LOD

	Nitronic 60	IARM 18C		195-089		
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0008	
Pb				0.000	0.0015	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.124	0.0556	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.004	0.0039	<LOD
Sn	0.004			0.010	0.0035	
Cd				0.000	0.0040	<LOD
Ag				0.029	0.0037	
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0011	
Mo	0.354	0.27	0.44	0.351	0.0036	OK
Nb	0.090	0.068	0.113	0.090	0.0019	
Zr				0.001	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0020	<LOD
Zn				0.000	0.0062	<LOD
Cu	0.285	0.21	0.36	0.279	0.0189	OK
Ni	8.05	7.25	8.86	8.023	0.0726	OK
Co	0.060	0.00	0.15	0.045	0.0664	OK
Fe	63.0	61.13	64.91	62.868	0.1239	OK
Mn	7.69	6.92	8.46	7.664	0.0665	OK
Cr	16.19	15.70	16.68	16.191	0.0593	OK
V	0.099			0.137	0.0142	
Ti	0.013			0.049	0.0175	
S	0.0010			0.185	0.0075	
P	0.027			0.035	0.0132	
Si	3.80	3.04	4.56	3.913	0.0486	OK
Al	0.014			0.000	0.0498	<LOD
Mg				0.000	0.0000	<LOD

		RIFM T2/2		195-101		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb				0.003	0.0022	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0180	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0055	<LOD
Sn				0.005	0.0062	<LOD
Cd				0.000	0.0045	<LOD
Ag				0.015	0.0039	
Pd				0.000	0.0058	<LOD
Ru				0.000	0.0010	<LOD
Mo				0.012	0.0008	
Nb				0.001	0.0006	<LOD
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0037	<LOD
Cu	0.075			0.082	0.0089	
Ni	0.74			0.050	0.0251	
Co				0.000	0.0649	<LOD
Fe	95.5	93.59	97.41	95.646	0.1014	OK
Mn	0.28	0.22	0.34	0.268	0.0151	OK
Cr	0.065			0.057	0.0069	
V				0.016	0.0205	
Ti	0.037			0.030	0.0234	
S	0.02			0.032	0.0041	
P	0.012			0.015	0.0134	
Si	3.84	3.57	4.11	3.785	0.0475	OK
Al				0.000	0.0448	<LOD
Mg				0.000	0.0000	<LOD

	Ti6-2-4-2	IARM 177C		180-503		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0111	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0051	<LOD
Sb				0.000	0.0038	<LOD
Sn	2.02	1.82	2.22	2.004	0.0152	OK
Cd				0.000	0.0033	<LOD
Ag				0.005	0.0035	<LOD
Pd				0.000	0.0040	<LOD
Ru				0.000	0.0015	<LOD
Mo	1.96	1.67	2.25	1.933	0.0112	OK
Nb				0.000	0.0011	
Zr	3.99	3.59	4.39	3.935	0.0199	OK
Y				0.000	0.0008	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0028	<LOD
Cu				0.000	0.0051	<LOD
Ni				0.006	0.0078	<LOD
Co				0.000	0.0097	<LOD
Fe				0.022	0.0137	
Mn				0.000	0.0247	<LOD
Cr				0.000	0.0636	<LOD
V				0.000	0.1501	<LOD
Ti	85.72	83.15	88.29	85.897	0.1926	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.00	0.16	0.058	0.0179	OK
Al	6.02	5.52	6.52	6.149	0.1371	OK
Mg				0.000	0.0000	<LOD

ThermoFisher SCIENTIFIC

Certificate of Calibration

	SS416 Certified	IARM 10c Low	High	195-151 Measured	Err	
Bi				0.002	0.0008	
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.022	0.0221	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.008	0.0042	
Sn	0.009			0.014	0.0036	
Cd				0.004	0.0035	<LOD
Ag				0.030	0.0037	
Pd				0.000	0.0047	<LOD
Ru				0.001	0.0009	<LOD
Mo	0.08	0.04	0.14	0.089	0.0018	OK
Nb	0.003			0.001	0.0006	
Zr				0.001	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0010	<LOD
Zn				0.004	0.0035	<LOD
Cu	0.155	0.11	0.20	0.165	0.0109	OK
Ni	0.24	0.16	0.31	0.243	0.0164	OK
Co	0.022			0.070	0.0577	
Fe	86.0	81.70	90.30	85.890	0.1033	OK
Mn	0.35	0.25	0.46	0.426	0.0374	OK
Cr	12.25	11.64	12.86	12.183	0.0495	OK
V	0.024			0.050	0.0111	
Ti	0.002			0.043	0.0164	
S	0.29	0.20	0.38	0.372	0.0093	OK
P	0.026			0.028	0.0113	
Si	0.37	0.31	0.43	0.370	0.0181	OK
Al	0.003			0.000	0.0458	<LOD
Mg				0.000	0.0000	<LOD

	Iron Certified	BAS SCRM 660/09 Low	High	Measured	195-166 Err	
Bi				0.002	0.0009	
Pb				0.013	0.0074	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0176	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0042	<LOD
Sn				0.000	0.0039	<LOD
Cd				0.000	0.0038	<LOD
Ag				0.004	0.0048	<LOD
Pd				0.000	0.0046	<LOD
Ru				0.000	0.0009	<LOD
Mo				0.001	0.0007	<LOD
Nb				0.003	0.0006	
Zr				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0037	<LOD
Cu				0.000	0.0082	<LOD
Ni				0.029	0.0302	<LOD
Co				0.000	0.0518	<LOD
Fe	94.18	90.41	97.95	94.294	0.0945	OK
Mn	0.406	0.37	0.45	0.380	0.0165	OK
Cr				0.009	0.0110	<LOD
V				0.014	0.0170	<LOD
Ti				0.021	0.0256	<LOD
S	0.105	0.053	0.158	0.107	0.0060	OK
P	0.153	0.077	0.230	0.173	0.0194	OK
Si	1.70	1.19	2.21	1.488	0.0323	OK
Al				0.000	0.0463	<LOD
Mg				0.000	0.0000	<LOD

	LAS Certified	BS15a Low	High	195-167 Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.008	0.0068	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0157	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0044	<LOD
Sn				0.000	0.0039	<LOD
Cd				0.000	0.0033	<LOD
Ag				0.000	0.0045	<LOD
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0009	<LOD
Mo				0.007	0.0008	
Nb				0.044	0.0014	
Zr				0.018	0.0011	
Y				0.000	0.0000	<LOD
Se				0.000	0.0010	<LOD
Zn				0.005	0.0042	<LOD
Cu				0.046	0.0077	
Ni				0.064	0.0247	
Co				0.000	0.0514	<LOD
Fe	98.4	95.45	100.0	97.736	0.0909	OK
Mn	1.12	1.01	1.23	1.109	0.0238	OK
Cr				0.042	0.0064	
V				0.016	0.0102	
Ti				0.000	0.0333	<LOD
S				0.000	0.0046	<LOD
P				0.046	0.0107	
Si	0.058	0.03	0.1	0.072	0.0116	OK
Al				0.049	0.0519	<LOD
Mg				0.000	0.0000	<LOD

	Mar-M 247 Provisional	IARM 333a Low	High	195-173 Measured		
Bi				0.000	0.0024	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	0.01			0.000	0.0368	
W	9.7	8.73	10.67	9.678	0.2857	OK
Ta	3.15	2.84	3.47	3.092	0.1184	OK
Hf	1.4	1.260	1.540	1.484	0.0520	OK
Te				0.000	0.0000	<LOD
Sb				0.013	0.0077	
Sn				0.017	0.0062	
Cd				0.005	0.0065	<LOD
Ag				0.000	0.0066	<LOD
Pd				0.000	0.0076	<LOD
Ru				0.002	0.0020	<LOD
Mo	0.49	0.44	0.54	0.494	0.0071	OK
Nb	0.005			0.004	0.0010	
Zr	0.009			0.004	0.0011	
Y				0.000	0.0000	<LOD
Se				0.000	0.0166	<LOD
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	61.1	54.99	67.21	60.877	0.2757	OK
Co	9.4	8.46	10.34	9.585	0.0804	OK
Fe	0.036	0.016	0.056	0.038	0.0104	OK
Mn	0.005			0.026	0.0417	<LOD
Cr	8.32	7.49	9.15	8.459	0.0750	OK
V				0.040	0.0282	<LOD
Ti	0.73	0.621	0.840	0.717	0.0507	OK
S				0.040	0.0095	
P	0.004			0.091	0.0100	
Si	0.08			0.000	0.0824	
Al	5.53	4.98	6.08	5.373	0.1557	OK
Mg				0.000	0.0000	<LOD

Certificate of Calibration

	CMSX-4	IARM 332a		195-174		
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0020	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	*2.9*	*2.465*	*3.335*	2.936	0.0770	OK
W	*6.5*	*5.525*	*7.475*	6.584	0.3046	OK
Ta	*6.51*	*5.534*	*7.487*	7.335	0.1297	OK
Hf	*0.098*			0.068	0.0409	
Te				0.000	0.0000	<LOD
Sb				0.007	0.0065	<LOD
Sn				0.011	0.0063	
Cd				0.007	0.0063	<LOD
Ag				0.000	0.0068	<LOD
Pd				0.000	0.0076	<LOD
Ru				0.000	0.0023	<LOD
Mo	*0.61*	0.488	0.732	0.596	0.0011	OK
Nb				0.005	0.0011	
Zr				0.002	0.0008	
Y				0.000	0.0000	<LOD
Se				0.000	0.0165	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	*61*	*59.17*	*62.83*	59.650	0.2716	OK
Co	*9.4*	*8.46*	*10.34*	9.523	0.0792	OK
Fe	*0.023*			0.018	0.0098	
Mn				0.049	0.0585	<LOD
Cr	*6.31*	5.36	7.26	6.246	0.0692	OK
V				0.031	0.0462	<LOD
Ti	*0.99*	0.84	1.14	0.986	0.0583	OK
S				0.048	0.0105	
P				0.082	0.0127	
Si				0.000	0.0858	
Al	*5.8*	4.93	6.67	5.873	0.1631	OK
Mg				0.000	0.0000	<LOD

	Cu-Cd	MBH 36X CCD2		195-156		
	Certified	Low	High	Measured	Err	
Bi				0.004	0.0026	
Pb				0.000	0.0029	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0321	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0102	<LOD
Sb				0.018	0.0089	
Sn	0.2	0.16	0.24	0.196	0.0076	OK
Cd	1.18	1.003	1.357	1.179	0.0131	OK
Ag	*0.0012*			0.013	0.0058	
Pd				0.006	0.0076	<LOD
Ru				0.000	0.0018	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.001	0.0011	<LOD
Zr				0.002	0.0016	<LOD
Y				0.000	0.0007	<LOD
Se				0.000	0.0047	<LOD
Zn	*0.0019*			0.021	0.0245	<LOD
Cu	*98.6*	98	99.2	98.494	0.1090	OK
Ni				0.000	0.0092	<LOD
Co				0.000	0.0100	<LOD
Fe				0.008	0.0155	<LOD
Mn				0.012	0.0052	
Cr				0.011	0.0145	<LOD
V				0.000	0.0311	<LOD
Ti				0.000	0.0661	<LOD
S				0.067	0.0125	
P				0.019	0.0188	<LOD
Si				0.000	0.0137	<LOD
Al				0.000	0.0606	<LOD
Mg				0.000	0.0000	<LOD

	AA7075		ALC 7075 AF		180-505	
	Cert	Low	High	Measured	Err	
Bi	0.007			0.009	0.0010	
Pb	0.0073			0.009	0.0011	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0118	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0033	<LOD
Sb				0.002	0.0027	<LOD
Sn	0.014	0.004	0.024	0.014	0.0020	
Cd				0.000	0.0025	<LOD
Ag				0.008	0.0018	
Pd				0.003	0.0030	<LOD
Ru				0.000	0.0006	<LOD
Mo				0.000	0.0004	<LOD
Nb				0.000	0.0002	
Zr	0.0024			0.003	0.0003	
Y				0.000	0.0002	<LOD
Se				0.000	0.0006	<LOD
Zn	5.75	5.463	6.038	5.699	0.0484	OK
Cu	1.750	1.575	1.925	1.710	0.0207	OK
Ni	0.027			0.027	0.0033	
Co				0.000	0.0054	OK
Fe	0.17	0.1275	0.2125	0.160	0.0106	OK
Mn	0.031			0.036	0.0105	
Cr	0.22	0.187	0.253	0.220	0.0206	OK
V	0.020			0.063	0.0278	
Ti	0.092	0.012	0.172	0.139	0.0549	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.095	0.285	0.192	0.0206	OK
Al	89	86.33	91.67	89.471	0.1975	OK
Mg	2.66	2.128	3.192	2.255	0.2323	OK

	CDA510	IARM 77b		195-177		
	Certified	Low	High	Measured	Err	
Bi				0.006	0.0026	
Pb	0.016	0.008	0.024	0.022	0.0040	OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0000	<LOD
W				0.044	0.0277	
Ta				0.000	0.0886	<LOD
Hf				0.000	0.0084	<LOD
Te				0.008	0.0076	<LOD
Sb				0.000	0.0059	<LOD
Sn	4.66	4.520	4.800	4.654	0.0261	OK
Cd				0.000	0.0058	<LOD
Ag				0.000	0.0062	<LOD
Pd				0.000	0.0068	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.001	0.0009	<LOD
Zr				0.000	0.0013	<LOD
Y				0.000	0.0006	<LOD
Se				0.000	0.0019	<LOD
Zn				0.058	0.0194	
Cu	95.2	94.248	96.152	94.941	0.0886	OK
Ni				0.000	0.0084	<LOD
Co				0.000	0.0101	<LOD
Fe				0.006	0.0127	<LOD
Mn				0.007	0.0143	<LOD
Cr				0.000	0.0211	<LOD
V				0.000	0.0314	<LOD
Ti				0.048	0.0247	
S				0.069	0.0026	
P	0.148	0.118	0.178	0.142	0.0236	OK
Si				0.000	0.0137	<LOD
Al				0.000	0.0623	<LOD
Mg				0.000	0.0000	<LOD

Thermo Scientific
Portable Analytical Instruments
2 Radcliff Road
Tewksbury, MA 01876
USA
+1 978 670-7460 ph
+1 978 670-7430 fax
www.thermoscientific.com/pai

Thermo Fisher SCIENTIFIC

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

ThermoFisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

Serial Number: X500870 | Model: Niton XL5 | Software: 5372 | Date of Q.C.: 5-Jul-18
Resolution: 157.6548 141.5258 | Escale: 7.470 7.478 | Spot Size: 3mm | Inspector: VK

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0014	<LOD
Pb			0.007	0.0045	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.017	0.0149	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0039	<LOD
Sn			0.000	0.0037	<LOD
Cd			0.000	0.0035	<LOD
Ag			0.000	0.0045	<LOD
Pd			0.000	0.0043	<LOD
Ru			0.000	0.0009	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.001	0.0004	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0012	<LOD
Zn			0.000	0.0033	<LOD
Cu			0.000	0.0070	<LOD
Ni			0.000	0.0200	<LOD
Co			0.053	0.0631	<LOD
Fe	99.75	100	99.967	0.0891	OK
Mn			0.000	0.0136	<LOD
Cr			0.008	0.0138	<LOD
V			0.000	0.0273	<LOD
Ti			0.000	0.0429	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.002	0.0048	<LOD
Pb			0.000		OK
Au			0.000	0.0000	<LOD
Re			0.000	0.0288	<LOD
W			0.000	0.1566	<LOD
Ta	99.4	100	99.999	0.2341	OK
Hf			0.000	0.1056	<LOD
Te			0.000	0.0108	<LOD
Sb			0.000	0.0107	<LOD
Sn			0.000	0.0117	<LOD
Cd			0.000	0.0064	<LOD
Ag			0.000	0.0099	<LOD
Pd			0.000	0.0076	<LOD
Ru			0.000	0.0020	<LOD
Mo			0.000	0.0013	<LOD
Nb			0.002	0.0012	<LOD
Zr			0.000	0.0015	<LOD
Y			0.000	0.0014	<LOD
Se			0.000	0.0289	<LOD
Zn			0.000		OK
Cu			0.000		OK
Ni			0.000	0.0156	<LOD
Co			0.000	0.0338	<LOD
Fe			0.000	0.0241	<LOD
Mn			0.000	0.0289	<LOD
Cr			0.000	0.0362	<LOD
V			0.000	0.0626	<LOD
Ti			0.000	0.0919	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.007	0.0038	
Pb			0.008	0.0051	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0257	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0227	<LOD
Sb			0.000	0.0269	<LOD
Sn	99	100	99.934	0.4213	OK
Cd			0.000	0.0147	<LOD
Ag			0.000	0.0091	<LOD
Pd			0.000	0.0086	<LOD
Ru			0.000	0.0016	<LOD
Mo			0.000	0.0014	<LOD
Nb			0.001	0.0010	<LOD
Zr			0.000	0.0012	<LOD
Y			0.000	0.0009	<LOD
Se			0.000	0.0026	<LOD
Zn			0.000	0.0077	<LOD
Cu			0.000	0.0113	<LOD
Ni			0.000	0.0222	<LOD
Co			0.000	0.0218	<LOD
Fe			0.000	0.0368	<LOD
Mn			0.000	0.0512	<LOD
Cr			0.000	0.0767	<LOD
V			0.160	0.1387	<LOD
Ti			0.000	0.3804	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.003	0.0024	<LOD
Pb			0.000	0.0022	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0290	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0078	<LOD
Sb			0.000	0.0054	<LOD
Sn			0.000	0.0051	<LOD
Cd			0.000	0.0051	<LOD
Ag			0.000	0.0065	<LOD
Pd			0.000	0.0069	<LOD
Ru			0.000	0.0015	<LOD
Mo			0.000	0.0007	<LOD
Nb			0.002	0.0011	<LOD
Zr			0.002	0.0017	<LOD
Y			0.000	0.0005	<LOD
Se			0.000	0.0048	<LOD
Zn			0.022	0.0244	<LOD
Cu	99.8	100	99.984	0.0811	OK
Ni			0.000	0.0085	<LOD
Co			0.000	0.0102	<LOD
Fe			0.010	0.0105	<LOD
Mn			0.007	0.0163	<LOD
Cr			0.000	0.0177	<LOD
V			0.000	0.0281	<LOD
Ti			0.000	0.0554	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.003	0.0022	<LOD
Pb			0.000		<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.6407	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0053	<LOD
Sn			0.000	0.0057	<LOD
Cd			0.000	0.0054	<LOD
Ag			0.000	0.0074	<LOD
Pd			0.000	0.0073	<LOD
Ru			0.002	0.0011	<LOD
Mo			0.000	0.0009	<LOD
Nb			0.000	0.0006	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0179	<LOD
Zn			0.000	0.0700	<LOD
Cu			0.000	0.0314	<LOD
Ni	99.7	100	99.992	0.6497	OK
Co			0.000	0.0137	<LOD
Fe			0.000	0.0123	<LOD
Mn			0.000	0.0162	<LOD
Cr			0.012	0.0153	<LOD
V			0.000	0.0281	<LOD
Ti			0.000	0.0544	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.002	0.0011	
Pb			0.001		
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0084	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0040	<LOD
Sb			0.000	0.0027	<LOD
Sn			0.000	0.0027	<LOD
Cd			0.000	0.0031	<LOD
Ag			0.000	0.0027	<LOD
Pd			0.000	0.0035	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0003	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0002	<LOD
Se			0.000	0.0006	<LOD
Zn			0.000	0.0027	<LOD
Cu			0.000	0.0035	<LOD
Ni			0.000	0.0041	<LOD
Co			0.000	0.0051	<LOD
Fe			0.000	0.0092	<LOD
Mn			0.000	0.0188	<LOD
Cr			0.000	0.0743	<LOD
V			0.000	0.1085	<LOD
Ti	99.75	100	99.998	0.1351	OK
Al (Bal)			0.000	0.0000	<LOD
LEC					

20Cb3 IARM 25C 180-509

	Certified	Low	High	Measured	Err	
Bi				0.002	0.0016	<LOD
Pb				0.000	0.0019	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.08			0.346	0.1316	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.000	0.0044	
Sn	0.01	0.002	0.020	0.007	0.0041	
Cd				0.000	0.0037	
Ag				0.032	0.0043	
Pd				0.000	0.0046	<LOD
Ru				0.000	0.0018	<LOD
Mo	2.26	2.03	2.48	2.193	0.0117	OK
Nb	0.58	0.48	0.68	0.572	0.0053	OK
Zr				0.000	0.0007	
Y				0.000	0.0000	
Se				0.000	0.0044	
Zn				0.000	0.0142	
Cu	3.51	3.26	3.76	3.499	0.0457	OK
Ni	33.30	31.64	35.64	33.280	0.1578	OK
Co	0.091			0.204	0.0498	
Fe	38.80	36.8	40.8	38.185	0.0955	OK
Mn	0.90	0.40	1.40	0.944	0.0428	OK
Cr	19.97	19.57	20.57	20.175	0.0700	OK
V	0.095	0.035	0.155	0.128	0.0169	
Ti	0.003			0.042	0.0202	
Al (Bal)	0.019			0.000		<LOD
LEC				0.500		

Stellite 6B IARM 95B 180-502

	Certified	Low	High	Measured	Err	
Bi				0.002	0.0013	
Pb				0.000		OK
Au				0.000	0.0000	
Re				0.000	0.0167	
W	3.42	3.12	3.72	3.420	0.0713	OK
Ta				0.000	0.0321	<LOD
Hf				0.018	0.0541	<LOD
Te				0.000	0.0000	
Sb				0.004	0.0047	
Sn				0.006	0.0039	
Cd				0.000	0.0034	
Ag				0.034	0.0042	
Pd				0.000	0.0043	<LOD
Ru				0.000	0.0012	<LOD
Mo	0.83	0.70	0.96	0.830	0.0062	OK
Nb	0.002			0.001	0.0007	
Zr	0.002			0.000	0.0007	
Y				0.000	0.0000	
Se				0.000	0.0059	
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	2.25	1.80	2.70	2.250	0.0509	OK
Co	60.90	59.68	62.12	60.113	0.1419	
Fe	1.10	0.94	1.27	1.100	0.0319	OK
Mn	0.99	0.84	1.14	0.990	0.0403	OK
Cr	28.90	28.32	29.48	28.900	0.0819	OK
V	0.002			0.048	0.0149	
Ti	0.004			0.036	0.0192	
Al (Bal)	0.07			0.000		<LOD
LEC				2.250		

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	0.01			0.050	0.0104	
Pb	5.03	4.68	5.44	5.025	0.0417	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.055	0.0358	
Ta				0.000		OK
Hf				0.000		OK
Te				0.009	0.0091	
Sb	0.143	0.114	0.172	0.135	0.0077	OK
Sn	4.37	3.46	5.38	4.355	0.0256	OK
Cd				0.000	0.0061	<LOD
Ag	0.02			0.038	0.0060	
Pd				0.000	0.0082	<LOD
Ru				0.000	0.0014	<LOD
Mo				0.001	0.0008	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.002	0.0015	<LOD
Y				0.019	0.0127	
Se				0.000	0.0047	<LOD
Zn	5.38	4.79	6.08	5.276	0.0352	OK
Cu	84.6	82.60	86.60	84.498	0.0759	OK
Ni	0.27	0.10	0.40	0.267	0.0108	OK
Co				0.008	0.0133	<LOD
Fe	0.24	0.21	0.27	0.242	0.0098	OK
Mn	0.002			0.008	0.0066	<LOD
Cr				0.000	0.0268	<LOD
V				0.000	0.0339	<LOD
Ti				0.038	0.0275	<LOD
Al (Bal)	0.002			0.000	0.0000	<LOD
LEC				#DIV/0!		

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb	0.0009			0.003	0.0029	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0168	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0046	<LOD
Sn	0.002			0.000	0.0040	<LOD
Cd				0.000	0.0034	<LOD
Ag				0.006	0.0041	<LOD
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.47	0.43	0.53	0.485	0.0046	OK
Nb	0.002			0.000	0.0006	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.004	0.0041	<LOD
Cu	0.033	0.013	0.053	0.033	0.0076	OK
Ni	0.071			0.057	0.0254	
Co	0.004			0.000	0.0639	<LOD
Fe	96.96	95.9	98	97.006	0.0931	OK
Mn	0.56	0.35	0.75	0.560	0.0218	OK
Cr	1.11	0.89	1.33	1.087	0.0173	OK
V	0.004			0.000	0.0261	<LOD
Ti	0.0016			0.033	0.0419	<LOD
Al (Bal)	0.028			0.000	0.0000	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0019	<LOD
Pb				0.000	0.0027	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.62	0.32	0.92	0.578	0.1915	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0061	<LOD
Sn	0.002			0.000	0.0054	<LOD
Cd				0.000	0.0052	<LOD
Ag				0.020	0.0057	
Pd				0.000	0.0062	<LOD
Ru				0.000	0.0034	<LOD
Mo	8.30	7.72	8.89	8.244	0.0406	OK
Nb	0.09	0.03	0.15	0.075	0.0025	OK
Zr	0.004			0.002	0.0013	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0069	<LOD
Zn				0.023	0.0242	<LOD
Cu				0.035	0.0382	<LOD
Ni	48.80	46.80	50.76	48.720	0.2279	OK
Co	1.11	0.93	1.35	1.193	0.0462	OK
Fe	18.30	17.39	19.22	18.170	0.0783	OK
Mn	0.47	0.20	0.90	0.467	0.0423	OK
Cr	21.60	20.74	22.47	21.944	0.0833	OK
V	0.03			0.057	0.0181	
Ti	0.02			0.000	0.0688	<LOD
Al (Bal)	0.12			0.00	0.0000	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0017	<LOD
Pb				0.000	0.0029	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	6.30	5.8	6.87	6.654	0.0882	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0053	<LOD
Sn	0.01			0.000	0.0053	<LOD
Cd				0.000	0.0044	<LOD
Ag				0.026	0.0051	
Pd				0.000	0.0054	<LOD
Ru				0.000	0.0026	<LOD
Mo	4.85	4.61	5.15	4.884	0.0196	OK
Nb				0.000	0.0012	<LOD
Zr				0.000	0.0008	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0070	<LOD
Zn				0.000	0.0249	<LOD
Cu	0.13	0.091	0.169	0.128	0.0134	OK
Ni	0.35	0.245	0.455	0.316	0.0222	OK
Co	0.31	0.217	0.403	0.301	0.0569	OK
Fe	80.59	78.59	82.59	80.275	0.1186	OK
Mn	0.29	0.23	0.35	0.282	0.0288	OK
Cr	3.98	3.59	4.42	4.082	0.0392	OK
V	2.03	1.57	2.46	1.809	0.0392	OK
Ti				0.022	0.0400	<LOD
Al (Bal)	0.02			0.00	0.0000	<LOD
LEC				1.24		

Certificate of Calibration

SS321 — IARM 6D — 180-512

	Certified	Low	High	Measured	Err	
Bi				0.003	0.0012	
Pb				0.000	0.0015	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09	0.030	0.190	0.192	0.0620	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0042	<LOD
Sn	0.013			0.017	0.0037	
Cd				0.000	0.0036	<LOD
Ag				0.033	0.0038	
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0011	<LOD
Mo	**0.358**	**0.29**	**0.44**	0.363	0.0038	OK
Nb	**0.039**	**0.01**	**0.06**	0.041	0.0013	OK
Zr	***0.002***			0.000	0.0007	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0023	<LOD
Zn				0.000	0.0078	<LOD
Cu	**0.302**	**0.15**	**0.5**	0.302	0.0206	OK
Ni	**9.42**	**9**	**9.8**	9.528	0.0794	OK
Co	**0.182**	**0.091**	**0.273**	0.198	0.0592	
Fe	**69.40**	**68.4**	**70.4**	68.802	0.1211	OK
Mn	**1.52**	**1.25**	**1.85**	1.620	0.0469	OK
Cr	**17.45**	**17.1**	**18**	17.603	0.0627	OK
V	**0.128**	**0.0768**	**0.1792**	0.152	0.0167	
Ti	**0.63**	**0.43**	**0.83**	0.654	0.0294	OK
Al (Bal)	**0.11**			0.00	0.0000	<LOD
LEC				0.50		**OK**

Ti 6-2-4-2 — IARM 177C — 180-503

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0016	<LOD
Pb				0.000	0.0018	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0122	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0058	<LOD
Sb				0.000	0.0043	<LOD
Sn	**2.02**	**1.818**	**2.222**	2.029	0.0156	OK
Cd				0.000	0.0037	<LOD
Ag				0.005	0.0039	<LOD
Pd				0.000	0.0045	<LOD
Ru				0.000	0.0017	<LOD
Mo	**1.96**	**1.725**	**2.195**	1.960	0.0113	OK
Nb				0.000	0.0012	<LOD
Zr	**3.99**	**3.59**	**4.39**	3.990	0.0192	OK
Y				0.000	0.0009	<LOD
Se				0.000	0.0011	<LOD
Zn				0.000	0.0031	<LOD
Cu	0.003			0.000	0.0057	<LOD
Ni	0.011			0.008	0.0086	<LOD
Co				0.000	0.0107	<LOD
Fe	0.033			0.026	0.0151	
Mn	0.0015			0.000	0.0273	<LOD
Cr				0.000	0.0703	<LOD
V	0.02			0.000	0.1590	<LOD
Ti	**85.72**	**83.15**	**88.29**	85.993	0.1684	OK
Al (Bal)	6.02			0.00		<LOD
LEC				6.0		**OK**

AA7075 — ALC 7075 AF — 180-505

	Certified	Low	High	Measured	Err	
Bi	0.007			0.009	0.0008	
Pb	0.0073			0.010	0.0008	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0087	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0023	<LOD
Sb				0.003	0.0023	<LOD
Sn	0.014	0.004	0.024	0.014	0.0015	**OK**
Cd				0.000	0.0019	<LOD
Ag				0.007	0.0014	
Pd				0.000	0.0024	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024			0.0024	0.0002	
Y				0.000	0.0001	
Se				0.000	0.0004	<LOD
Zn	**5.75**	**5.463**	**6.038**	5.779	0.0177	**OK**
Cu	**1.750**	**1.575**	**1.925**	1.760	0.0126	OK
Ni	0.027			0.026	0.0025	
Co				0.000	0.0041	<LOD
Fe	**0.17**	**0.1445**	**0.1955**	0.164	0.0079	OK
Mn	0.031			0.039	0.0078	
Cr	**0.22**	**0.187**	**0.253**	0.220	0.0154	OK
V	0.020			0.043	0.0209	
Ti	**0.092**	**0.012**	**0.172**	0.120	0.0414	OK
Al (Bal)	***91.7***	**88.9102**	**94.4098**	91.81	0.1253	**OK**
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

	1.25Cr 0.5Mo		IARM35H		195-019	
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb	0.001			0.003	0.0030	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0169	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb	0.002			0.000	0.0046	<LOD
Sn	0.002			0.000	0.0040	<LOD
Cd				0.000	0.0034	<LOD
Ag				0.006	0.0041	<LOD
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.47	0.423	0.517	0.486	0.0045	OK
Nb	0.002			0.000	0.0006	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.004	0.0041	<LOD
Cu	0.032	0.017	0.077	0.033	0.0077	OK
Ni	0.071			0.057	0.0255	
Co	0.004			0.000	0.0639	<LOD
Fe	96.96	95.021	98.899	96.981	0.0748	OK
Mn	0.56	0.45	0.67	0.561	0.0219	OK
Cr	1.11	0.89	1.33	1.109	0.0076	OK
V	0.004			0.000	0.0020	<LOD
Ti	0.002			0.003	0.0021	
Al (Bal)	0.028			0.00	0.0000	<LOD
LEC	0.75			0.750		OK

	Tool steel T-1		IARM 48C		195-152	
	Certified	Low	High	Measured	Err	
Bi				0.006	0.0013	
Pb				0.000	0.0036	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	17.50	16.63	18.38	17.364	0.1092	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.006	0.0046	<LOD
Sn	0.012			0.021	0.0046	
Cd				0.004	0.0044	<LOD
Ag				0.060	0.0048	
Pd				0.000	0.0052	<LOD
Ru				0.002	0.0011	<LOD
Mo	0.17	0.150	0.190	0.164	0.0028	OK
Nb	0.005	0.001	0.010	0.004	0.0007	OK
Zr				0.001	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0109	<LOD
Zn				0.000	0.0410	<LOD
Cu	0.13			0.117	0.0155	
Ni	0.204			0.160	0.0220	
Co	0.22			0.190	0.0550	
Fe	74.5	73.3825	75.618	74.717	0.1303	OK
Mn	0.39	0.27	0.51	0.424	0.0306	OK
Cr	4.24	3.90	4.58	4.454	0.0417	OK
V	1.27	1.08	1.46	1.262	0.0115	OK
Ti	0.006			0.005	0.0035	<LOD
Al (Bal)	0.017			0.00	0.0000	<LOD
LEC	1.025			1.025		OK

	Custom 455		IARM16B		195-142	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.120	0.0578	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0061	<LOD
Sn	0.004			0.005	0.0036	<LOD
Cd				0.000	0.0046	<LOD
Ag				0.030	0.0039	
Pd				0.000	0.0047	<LOD
Ru				0.002	0.0012	
Mo	0.016	0.010	0.022	0.001	0.0009	<LOD
Nb	0.25	0.20	0.30	0.262	0.0033	OK
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0020	<LOD
Zn				0.000	0.0074	<LOD
Cu	2.23	1.90	2.56	2.258	0.0364	OK
Ni	8.28	7.45	9.11	8.347	0.0740	OK
Co	0.027			0.078	0.0555	<LOD
Fe	76.4	72.58	80.22	76.210	0.1096	OK
Mn	0.026			0.061	0.0341	
Cr	11.44	10.52	12.36	11.419	0.0494	OK
V	0.067			0.067	0.0049	
Ti	1.11	0.999	1.221	1.109	0.0106	OK
Al (Bal)	0.062			0.000	0.0000	<LOD
LEC						

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007			0.009	0.0008	
Pb	0.0073			0.010	0.0008	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0087	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0023	<LOD
Sb				0.003	0.0023	<LOD
Sn	0.014	0.007	0.021	0.014	0.0015	OK
Cd				0.000	0.0019	<LOD
Ag				0.007	0.0013	
Pd				0.000	0.0024	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024	0.0004	0.0044	0.002	0.0002	OK
Y				0.000	0.0001	
Se				0.000	0.0004	<LOD
Zn	5.75	5.463	6.038	5.771	0.0174	OK
Cu	1.750	1.575	1.925	1.757	0.0125	OK
Ni	0.027			0.026	0.0025	
Co				0.000	0.0178	<LOD
Fe	0.17	0.1445	0.1955	0.164	0.0079	OK
Mn	0.031			0.039	0.0078	
Cr	0.22	0.187	0.253	0.221	0.0042	OK
V	0.020			0.017	0.0022	
Ti	0.092	0.062	0.122	0.092	0.0035	OK
Al (Bal)	91.7	88.9102	94.4098	91.867	0.1135	OK

Certificate of Calibration

Small Spot Locator Sample (30s main filter only)

	Low	High	Measured	Err	
Cu	93	100	98.833	0.0638	OK
Ti			0.966	0.0428	
Al			0.000	0.0000	

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Gmail by Google

Darby Soza <dsoza@mferentals.com>

SE-1805235599 for X500870 - XL5

1 message

James Collins <james.collins@thermofisher.com> Tue, May 29, 2018 at 5:14 AM
To: "dsoza@mferentals.com" <dsoza@mferentals.com>

ThermoFisher SCIENTIFIC

5/29/2018

MFE Enterprises Incorporated

Darby Soza

2330 E. Artesia Blvd
Long Beach, California 90805
United States

dsoza@mferentals.com

Subject: SE-1805235599 for Thermo Scientific X500870 - XL5

Dear Darby Soza

No XL5 models available for loaners at this time.

SE-1805235599 has been assigned as the reference number for your service case - please ensure that all subsequent paperwork and inquiries reference this number.

When returning your Thermo Scientific X500870 - XL5 and associated equipment, please make sure that the equipment is in its original packaging and note the following:

- **Return shipment**
  - DO NOT SHIP US MAIL! IT IS ILLEGAL TO SHIP ANY XRF DEVICE THIS METHOD.
  - Identify the Service Event Number (SE-1805235599) on the outside of the box.

- Instrument MUST be returned in its original hard-shell case and packed into a larger cardboard box
- Please **DO NOT** ship any batteries with your analyzer unless specifically instructed by the customer support representative.
- DO NOT return any accessory or check sample(s) unless specifically requested by the technical support representative. Please contact your TSR with any questions.

- **License Requirement**
  - If you are returning an isotope based analyzer (models XLp, XLi, or XL3p), please be sure to include a copy of either your radioactive materials license (issued by State) or a signed general license acknowledgement.
  - If you are returning an x-ray tube based analyzer (models XL3t, XL2, XLt, DXL, or FXL), please be sure to include a copy of your tube registration. (A tube registration is state specific and does not apply to all states)

- **Leak test**
  - When returning an isotope-based instrument, regulations require that you provide a copy of a valid leak test with the shipment. (Does NOT apply to x-ray tube based analyzers).
  - By returning your equipment, you acknowledge the leak test requirement as well as the consequences of returning that equipment without a valid leak test.

Full shipment requirements for your Thermo Scientific Niton analyzer can be found on Portables.com. You will need to login to access the shipment instructions.

- **Saving of data/readings (including custom libraries, data fields, signatures etc)**
  - Safekeeping of your data is our top priority. Due to procedures that may be necessary during the course of servicing your analyzer, however, it is not possible for us to guarantee that we will be able to download and save the data (including custom libraries, data fields, signatures, etc) stored in your analyzer when it arrives.
  - For this reason, ***please be sure that you have downloaded all readings, custom libraries, data fields, signatures, etc, that you wish to retain from your analyzer prior to sending it in for service.***
  - If you have questions or need assistance with the above, please don't hesitate to contact us.

Return address for your Niton Analyzer is:

Thermo Fisher Scientific PAI

C/O Depot Repair

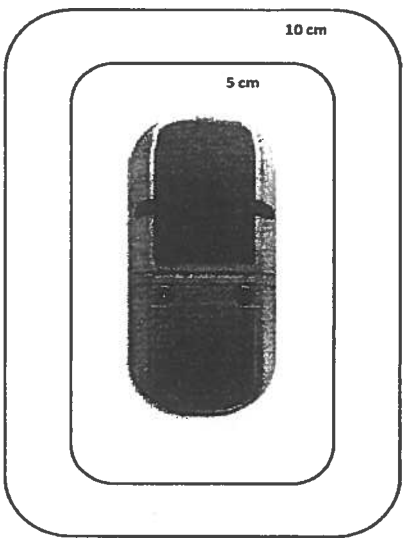
2 Radcliff Road

Tewksbury, MA 01876

ThermoFisher SCIENTIFIC The world leader in serving science

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model:	XL5 580-09131	Detector Model:	RadEye B20-ER
Instrument S/N:	X500872	Detector S/N:	0216
		Calibration Date:	March 31, 2017



Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
575	397

- All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Steve DeSimone

Survey Date: January 8, 2018

Thermo Scientific
Portable Analytical Instruments

2 Radcliff Road, Tewksbury
Massachussetts 01876 USA

+1 978-670-7460
+1 978-670-7430 fax

www.thermoscientific.com/pai
800-875-1578 (toll free)

ThermoFisher SCIENTIFIC

The world leader in serving science

Save Cert | Back | Clear Form

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model:	XL5
Instrument S/N:	500872

Detector Model:	RadEye
Detector S/N:	0216
Calibration Date:	4/24/2018

Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
932	165

- All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Perry Pulicari

Survey 6/22/2018

Certificate of Calibration

Serial Number: X500872 Model: Niton XL5 Software: 5372 Date of Q.C.: Sat Jul 21, 2018 - 13:26
Resolution: 159.806 148.86 Escale: 7.38518 7.37654 Inspector: VK

180 second analysis time, 60 seconds per filter, all 3 filters switched on, all results in ppm

SiO2 blank 180-615

Elem	Certified	Low	High	Measured	2-sigma		
Ba	0	0	20	0.0	12.2	OK	<LOD
Cs	0	0	20	0.0	8.0	OK	<LOD
Te	0	0	20	0.0	4.4	OK	<LOD
Sb	0	0	20	0.0	2.8	OK	<LOD
Sn	0	0	20	0.0	2.9	OK	<LOD
Cd	0	0	20	0.0	1.9	OK	<LOD
Pd	0	0	20	0.0	1.0	OK	<LOD
Ag	0	0	20	4.6	1.0	OK	
Mo	0	0	10	0.0	0.8	OK	<LOD
Th	0	0	10	0.0	0.7	OK	<LOD
Zr	0	0	10	0.0	0.6	OK	<LOD
Sr	0	0	10	0.0	0.3	OK	<LOD
U	0	0	10	0.0	1.3	OK	<LOD
Rb	0	0	10	0.0	0.5	OK	<LOD
As	0	0	10	0.0	1.0	OK	<LOD
Se	0	0	10	0.0	0.3	OK	<LOD
Au	0	0	10	0.0	2.1	OK	<LOD
Hg	0	0	30	0.0	1.8	OK	<LOD
Pb	0	0	10	0.0	0.6	OK	<LOD
W	0	0	10	0.0	3.2	OK	<LOD
Zn	0	0	10	0.0	1.2	OK	<LOD
Cu	0	0	10	0.0	1.6	OK	<LOD
Ni	0	0	20	0.0	2.1	OK	<LOD
Co	0	0	20	0.0	3.3	OK	<LOD
Fe	0	0	20	0.0	6.0	OK	<LOD
Mn	0	0	20	0.0	8.3	OK	<LOD
Cr	0	0	20	0.0	1.9	OK	<LOD
V	0	0	20	0.0	1.4	OK	<LOD
Ti	0	0	20	0.0	3.3	OK	<LOD
Sc	0	0	20	0.0	5.0	OK	<LOD
Ca	0	0	100	0.0	5.2	OK	<LOD
K	0	0	50	0.0	12.2	OK	<LOD
S	0	0	60	0.0	22.5	OK	<LOD

NIST 2710 180-427

Elem	Certified	Low	High	Measured	2-sigma		
Ba	707	530.3	883.8	862.9	28.8	OK	
Cs	107	96.3	117.7	108.2	17.5	OK	
Te				0.0	9.0		
Sb	38.4	19.2	57.6	21.6	6.0	OK	
Sn				25.0	5.8		
Cd	21.8	15.26	28.34	17.9	3.0	OK	
Pd				0.0	1.6		
Ag	35.3	28.24	42.36	33.7	2.5	OK	
Mo	19	13.3	24.7	21.2	1.8	OK	
Th	13			22.3	8.4		
Zr				159.2	3.0		
Sr	330	247.5	412.5	391.3	3.1	OK	
U	25			55.8	5.1		
Rb	120	78	162	145.4	3.3	OK	
As	626			893.3	35.7		
Se				0.0	1.4		<LOD
Au	0.6			0.0	11.9		<LOD
Hg	32.6	26.08	39.12	32.6	10.5	OK	
Pb	5532	4425.6	6638.4	6190.3	19.7	OK	
W	93			350.0	29.8		
Zn	6952	5561.6	8342.4	7483.8	30.5	OK	
Cu	2950	2655	3245	3155.9	21.1	OK	
Ni	14.3			25.2	5.1		
Co	10			0.0	38.1		<LOD
Fe	33800	25350	42250	39928.0	116.3	OK	
Mn	10100	8080	12120	10179.2	83.0	OK	
Cr	39			55.2	6.2		
V	76.6	57.45	95.75	92.1	10.5	OK	
Ti	2830	2264	3396	3284.9	31.1	OK	
Sc	8.7			130.7	92.8		<LOD
Ca	12500	10000	15000	13686.7	138.9	OK	
K	21100	16880	25320	23151.2	215.4	OK	
S	2400			2486.3	174.4		

NIST 2711a 180-688

Elem	Certified	Low	High	Measured	2-sigma		
Ba	730	547.5	912.5	687.2	20.6	OK	
Cs				41.3	12.5		
Te				0.0	6.5		
Sb	23.8			6.7	4.4		
Sn				12.2	4.2		
Cd	54.1	45.99	62.22	49.5	2.5	OK	
Pd				0.0	1.2		<LOD
Ag	6			3.2	1.4		
Mo				0.0	1.2		<LOD
Th	15	7.5	11.25	15.4	3.2		
Zr				312.8	2.5		
Sr	242	193.6	290.4	219.1	1.8	OK	
U	3			16.6	2.7		
Rb	120			109.7	2.1		
As	107	85.6	128.4	118.6	12.9	OK	
Se	2			0.0	0.8		<LOD
Au				0.0	4.7		<LOD
Hg	7.42			15.9	2.9		
Pb	1400	1120	1680	1275.7	7.3	OK	
W				0.0	0.0		
Zn	414	331.2	496.8	375.8	5.9	OK	
Cu	140	110.6	169.4	115.5	4.0	OK	
Ni	21.7			17.7	3.6		
Co	9.9			0.0	39.4		<LOD
Fe	28200	25380	31020	26092.1	81.1	OK	
Mn	675	337.5	1012.5	593.7	21.1	OK	
Cr	52.3	26.15	78.45	64.4	4.2	OK	
V	80.47	64.376	96.564	78.4	7.5	OK	
Ti	3170	2853	3487	2878.5	22.2	OK	
Sc	8.5			0.0	113.7		<LOD
Ca	24200	20570	27830	25013.5	137.4	OK	
K	25300	22770	27830	23407.4	168.5	OK	
S				594.1	85.2		

NIST 2709 180-425

Elem	Certified	Low	High	Measured	2-sigma		
Ba	968	658.24	1277.76	744.9	21.2	OK	
Cs	5.3			27.2	12.7		
Te				0.0	6.6		
Sb	7.9			0.0	4.4		<LOD
Sn				5.8	4.2		<LOD
Cd	0.38			0.0	2.0		<LOD
Pd				0.0	1.2		<LOD
Ag	0.41			0.0	1.3		<LOD
Mo	2			0.0	1.9		<LOD
Th	11			10.0	1.6		
Zr	160	128	192	136.6	2.0	OK	
Sr	231	196.35	265.65	204.3	1.9	OK	
U	3			13.3	2.8		
Rb	96	76.8	115.2	84.0	2.0	OK	
As	17.7	12.39	23.01	20.3	2.7	OK	
Se	1.57			0.8	0.4		
Au	0.3			0.0	3.1		<LOD
Hg	1.4			5.5	2.9		
Pb	18.9	14.18	23.63	15.7	1.3	OK	
W	2			0.0	5.9		<LOD
Zn	106	74.2	137.8	85.5	3.5	OK	
Cu	34.6	20.76	48.44	24.4	3.0	OK	
Ni	88	61.6	114.4	84.2	5.1		
Co	13.4			0.0	33.5		<LOD
Fe	35000	31500	38500	32539.4	98.0	OK	
Mn	538	376.6	699.4	565.8	23.2	OK	
Cr	130	91	169	138.4	5.7	OK	
V	112	84	140	111.8	9.5	OK	
Ti	3420	2804.4	4035.6	3122.9	27.5	OK	
Sc	12			0.0	122.1		<LOD
Ca	18900	17010	20790	18397.1	140.9	OK	
K	20300	18270	22330	16039.9	169.4		
S	890	801	979	696.7	88.6		

DL-1a 180-612

Elem	Certified	Low	High	Measured	2-sigma		
Ba				327.9	17.9		
Cs				32.7	11.3		
Te				0.0	5.9		<LOD
Sb				0.0	3.9		<LOD
Sn				5.6	3.8		<LOD
Cd				0.0	1.8		<LOD
Pd				0.0	1.1		<LOD
Ag				0.0	1.2		<LOD
Mo				5.1	1.2		
Th	76	64.6	87.4	70.1	2.4	OK	
Zr				73.1	1.5		
Sr				15.4	0.6		
U	116	104.4	127.6	111.4	4.1	OK	
Rb				96.1	2.3		
As				0.0	3.3		<LOD
Se				0.0	0.6		<LOD
Au				0.0	0.0		
Hg				0.0	2.9		<LOD
Pb				59.4	2.0		
W				0.0	7.3		<LOD
Zn				55.0	2.8		
Cu				10.4	2.5		
Ni				4.4	3.1		<LOD
Co				21.3	14.8		<LOD
Fe	*9300*			6640.3	48.8		
Mn				63.9	13.3		
Cr				59.6	3.4		
V				24.4	4.3		
Ti				800.5	12.9		
Sc				0.0	35.4		<LOD
Ca				2736.0	56.5		
K				20648.2	147.2		
S	*4100*			1204.4	63.3		

TILL 4 180-646

Elem	Certified	Low	High	Measured	2-sigma		
Ba	395	237	553	424.7	22.0	OK	
Cs	12			33.4	13.8		
Te				0.0	7.1		
Sb	1			0.0	4.6		<LOD
Sn				16.8	4.6		
Cd				0.0	2.2		<LOD
Pd				0.0	1.3		<LOD
Ag				0.0	1.4		<LOD
Mo	16	8	24	17.3	1.5	OK	
Th	17.4	8.7	26.1	18.6	2.7	OK	
Zr	385	346.5	423.5	359.7	3.0	OK	
Sr	109	98.1	119.9	112.6	1.5	OK	
U	5			10.2	3.0		
Rb	161	144.9	177.1	154.2	2.7	OK	
As	111	83.25	138.75	122.3	5.3	OK	
Se				3.0	0.6		
Au				4.5	4.6		<LOD
Hg				16.3	4.7		
Pb	50	42.5	57.5	45.3	2.0	OK	
W	204	183.6	224.4	187.8	9.6	OK	
Zn	70	52.5	87.5	56.0	3.5	OK	
Cu	237.0	189.6	284.4	218.1	5.9	OK	
Ni	17			20.1	4.5		
Co	8			0.0	34.7		<LOD
Fe	39378	35440.2	43315.8	38571.4	107.8	OK	
Mn	490	343	637	470.3	22.5	OK	
Cr	53			65.3	5.4		
V	67	46.9	87.1	83.7	10.3	OK	
Ti	4840	3872	5324	4427.8	30.7	OK	
Sc	10			0.0	120.9		<LOD
Ca	8934	7147.2	10720.8	8001.0	110.8	OK	
K	26980	22933	31027	23010.8	210.6	OK	
S	800	600	1000	661.4	95.4		

NIST 2780 180-601

Elem	Certified	Low	High	Measured	2-sigma		
Ba	993	695.1	1290.9	1058.5	25.1	OK	
Cs	*13*			54.7	14.8		
Te	*5*			0.0	7.6		<LOD
Sb	*160*	144	176	162.3	5.9	OK	
Sn				22.5	4.9		
Cd	12.1			5.8	2.4		
Pd				0.0	1.3		<LOD
Ag	27	18.9	35.1	20.4	1.9	OK	
Mo	*11*	7.7	14.3	8.2	1.4	OK	
Th	12			23.0	6.8		
Zr	*176*	132	220	208.5	2.7	OK	
Sr	217	173.6	260.4	248.0	2.2	OK	
U	*4*	3.2	4.8	22.4	3.7		
Rb	*175*	140	210	187.4	3.1	OK	
As	48.8			56.8	28.0		
Se	*5*			0.0	1.8		<LOD
Au	0.18			0.0	9.6		<LOD
Hg	0.71			0.0	6.0		<LOD
Pb	5770	4904.5	6635.5	5060.7	16.0	OK	
W				136.7	16.0		
Zn	2570	1799	3341	2281.6	15.8	OK	
Cu	215.5	150.85	280.15	184.8	5.5	OK	
Ni	*12*			8.2	4.1		
Co	*2.2*			0.0	30.0		<LOD
Fe	27840	25056	30624	28542.3	94.7	OK	
Mn	462	369.6	554.4	469.7	22.1	OK	
Cr	*44*			61.6	5.3		
V	268	241.2	294.8	263.3	12.5	OK	
Ti	6990	6291	7689	7212.2	35.3	OK	
Sc	*23*			0.0	48.4		<LOD
Ca	1950			1659.7	75.5		
K	33800	30420	37180	37100.0	228.6	OK	
S	12630	11367	13893	13030.0	216.8	OK	

JSAC 403 180-726

Elem	Certified	Low	High	Measured	2-sigma		
Ba				342.1	20.5		
Cs				23.8	12.9		
Te				0.0	6.7		<LOD
Sb				0.0	4.6		<LOD
Sn				0.0	5.2		<LOD
Cd	183	164.7	201.3	183.1	3.7	OK	
Pd				0.0	1.5		<LOD
Ag				0.0	1.4		<LOD
Mo				0.0	1.3		<LOD
Th				12.1	2.3		
Zr				270.2	2.7		
Sr				52.0	1.1		
U				6.7	2.5		
Rb				82.7	2.0		
As	199	159.2	238.8	233.1	8.4	OK	
Se	169	152.1	185.9	166.4	1.7	OK	
Au				6.5	8.4		<LOD
Hg	11.1	3.33	19.98	14.7	3.5	OK	
Pb	224	179.2	268.8	199.8	3.8	OK	
W				0.0	5.9		<LOD
Zn	91.8	68.85	114.75	72.0	3.5	OK	
Cu	26	13.1	39.3	18.8	3.0	OK	
Ni	26.2			23.9	4.6		
Co				0.0	34.6		<LOD
Fe				37749.8	107.4		
Mn	252	189	315	278.0	20.0	OK	
Cr	257	205.6	308.4	237.2	6.5	OK	
V	101	75.75	126.25	104.8	10.4	OK	
Ti				4641.5	30.6		
Sc				62.7	52.4		<LOD
Ca				4006.0	80.2		
K				13757.0	165.6		
S				350.8	90.5		

AGV-2 180-678

Elem	Certified	Low	High	Measured	2-sigma		
Ba	1140	912	1368	1111.5	25.3	OK	
Cs				51.6	14.6		
Te				0.0	7.6		<LOD
Sb	*0.6*			0.0	4.9		<LOD
Sn	2.3			15.2	4.8		
Cd				0.0	2.3		<LOD
Pd				0.0	1.4		<LOD
Ag				0.0	1.5		<LOD
Mo				0.0	1.4		<LOD
Th	6.1	4.27	7.93	6.8	1.5		
Zr	230	207	253	246.3	3.0		
Sr	658	592.2	723.8	615.3	3.6		
U	1.88			27.8	3.9		
Rb	68.6	61.74	75.46	58.3	2.0		
As				2.3	2.2		<LOD
Se				0.0	0.4		<LOD
Au				0.0	3.3		<LOD
Hg				0.0	4.9		<LOD
Pb	**13**	**7.8**	**18.2**	9.3	1.3	OK	
W				0.0	6.1		<LOD
Zn	**86**	**68.8**	**103.2**	71.9	3.6		
Cu	**53**	**37.1**	**68.9**	41.4	3.6	OK	
Ni	19			21.6	4.8		
Co	16			0.0	38.2		<LOD
Fe	**46800**	**42120**	**51480**	43994.2	117.3	OK	
Mn	**770**	**577.5**	**962.5**	722.2	26.9	OK	
Cr	17			43.6	5.9		
V	**120**	**102**	**138**	109.0	13.0	OK	
Ti	**6300**	**5670**	**6930**	5963.5	39.6	OK	
Sc	13	11.7	14.3	329.7	150.3		
Ca	**37200**	**33480**	**40920**	36679.3	210.4	OK	
K	**23900**	**21510**	**26290**	23022.4	218.8	OK	
S				0.0	133.5		<LOD

NCS DC 73309 180-727

Elem	Certified	Low	High	Measured	2-sigma		
Ba	260			284.1	22.6		
Cs				26.8	14.5		
Te				0.0	7.4		<LOD
Sb	14.9			0.0	4.8		<LOD
Sn	**370**	**333**	**407**	366.0	6.8	OK	
Cd	2.3			0.0	2.3		<LOD
Pd				0.0	1.3		<LOD
Ag	3.2			0.0	2.2		<LOD
Mo	**5.9**	**4.13**	**7.67**	7.1	1.3	OK	
Th	**23.3**	**11.65**	**34.95**	34.1	3.8	OK	
Zr	**153**	**137.7**	**168.3**	160.4	2.2	OK	
Sr	**29**	**23.2**	**34.8**	27.2	0.9	OK	
U	9.1			17.4	3.6		
Rb	**408**	**367.2**	**448.8**	393.4	4.1	OK	
As	**188**	**141**	**235**	201.5	11.2	OK	
Se	0.2			1.3	0.6		
Au				0.0	0.0		
Hg	0.072			8.7	4.5		
Pb	**636**	**572.4**	**699.6**	585.4	5.8	OK	
W	**126**	**100.8**	**151.2**	128.2	9.9	OK	
Zn	**373**	**298.4**	**447.6**	339.3	6.6	OK	
Cu	**79**	**59.25**	**98.75**	73.7	4.0	OK	
Ni	14.3			16.6	4.2		
Co	8.5			0.0	30.6		<LOD
Fe	**30705**	**27634.5**	**33775.5**	28776.1	97.3	OK	
Mn	**2490**	**1867.5**	**3112.5**	2036.6	39.6	OK	
Cr	40	36	44	71.8	4.8		
V	**47**	**42.3**	**51.7**	42.8	7.0		
Ti	**2100**	**1890**	**2310**	1976.7	20.7	OK	
Sc	**7.4**	**6.66**	**8.14**	0.0	53.4		<LOD
Ca	**2723**	**2042.25**	**3403.75**	2592.9	74.6	OK	
K	**27229**	**24506.1**	**29951.9**	24836.9	201.2	OK	
S	170			166.3	81.8		

NCS DC 93007 180-707

Elem	Certified	Low	High	Measured	2-sigma		
Ba				662.1	48.8		
Cs				107.6	30.5		
Te				32.9	15.8		
Sb				0.0	10.1		<LOD
Sn				56.3	10.5		
Cd				0.0	4.8		<LOD
Pd				0.0	3.4		<LOD
Ag	**26.2**	**19.65**	**32.75**	28.2	4.2	OK	
Mo				72.4	3.2		
Th				0.0	8.6		<LOD
Zr				38.7	2.9		
Sr				112.0	2.9		
U				0.0	8.8		<LOD
Rb				107.8	4.3		
As				45.2	14.3		
Se				4.7	1.3		
Au	37.3			19.1	10.8		
Hg				104.7	11.0		
Pb				317.1	8.3		
W				0.0	23.8		<LOD
Zn				896.4	21.3		
Cu				9353.5	59.5		
Ni				387.9	24.4		
Co				188.8	123.3		
Fe				312027.3	340.5		
Mn				489.2	38.4		
Cr				29.0	15.7		
V				50.0	21.3		
Ti				2241.0	61.2		
Sc				0.0	236.7		<LOD
Ca				11544.3	259.1		
K				22571.8	418.9		
S				203408.9	1258.9		

G310-10 180-728

Elem	Certified	Low	High	Measured	2-sigma		
Ba				540.7	23.3		
Cs				0.0	4.9		<LOD
Te				0.0	7.5		<LOD
Sb				0.0	4.9		<LOD
Sn				13.9	4.8		
Cd				0.0	2.3		<LOD
Pd				0.0	1.3		<LOD
Ag	*10.5*			8.3	1.7		
Mo				0.0	1.3		<LOD
Th				12.1	1.7		
Zr				126.3	2.1		
Sr				173.5	1.9		
U				14.6	3.1		
Rb				100.9	2.3		
As				0.0	3.5		<LOD
Se				0.0	0.6		<LOD
Au	**48**	**36**	**60**	45.4	5.8	OK	
Hg				8.5	3.2		
Pb				18.8	1.5		
W				0.0	0.0		
Zn				60.7	3.3		
Cu				28.2	3.3		
Ni				22.8	4.8		
Co				0.0	50.9		<LOD
Fe				44848.4	116.8		
Mn				681.9	26.1		
Cr				94.3	6.1		
V				128.3	12.4		
Ti				5978.7	36.6		
Sc				267.6	149.9		
Ca				37332.8	209.7		
K				18737.0	199.9		
S				305.4	98.2		

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Standards used for factory calibrations are either certified reference standards (CRM) or reference samples (RM).
Certificates of Analysis (CoA) are available on request, if available.
Values in italics are informational only (i.e. not certified)

Signed:

Lee A. Graham
Director of Quality, FSI

Thermo Fisher
SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy Light 8mm QC Sheet
Document: 140-00195
Revision: G
Release Date 10 June 2016

Serial Number: X500872 Model: Niton XL5- Software: 5372 Date of Q.C.: 23-Jul-18
Resolution: 159.806 148.86 Escale: 7.385 7.377 Spot Size: 8mm Inspector: Lam

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0004	<LOD
Pb			0.000	0.0008	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0030	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0007	<LOD
Sb			0.000	0.0014	<LOD
Sn			0.000	0.0015	<LOD
Cd			0.000	0.0014	<LOD
Ag			0.000	0.0016	<LOD
Pd			0.000	0.0014	<LOD
Ru			0.000	0.0004	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0003	<LOD
Zn			0.003	0.0010	
Cu			0.000	0.0015	<LOD
Ni			0.000	0.0072	<LOD
Co			0.000	0.0121	<LOD
Fe	0	0.02	0.000	0.0197	OK
Mn			0.000	0.0047	<LOD
Cr			0.000	0.0094	<LOD
V			0.000	0.0169	<LOD
Ti			0.000	0.0311	<LOD
S			0.000	0.0005	<LOD
P			0.000	0.0006	<LOD
Si			0.000	0.0074	<LOD
Al			0.044	0.0303	<LOD
Mg	99.85	100	99.98	0.0366	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0013	<LOD
Pb			0.000	0.0026	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0016	<LOD
W			0.000	0.0060	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0000	<LOD
Sb			0.000	0.0039	<LOD
Sn			0.000	0.0042	<LOD
Cd			0.000	0.0039	<LOD
Ag			0.000	0.0047	<LOD
Pd			0.000	0.0044	<LOD
Ru			0.000	0.0011	<LOD
Mo			0.000	0.0006	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0008	<LOD
Zn			0.000	0.0026	<LOD
Cu			0.000	0.0043	<LOD
Ni			0.051	0.0262	
Co			0.000	0.0449	<LOD
Fe	99.85	100	99.93	0.0737	OK
Mn			0.000	0.0095	<LOD
Cr			0.000	0.0144	<LOD
V			0.000	0.0195	<LOD
Ti			0.000	0.0321	<LOD
S			0.006	0.0019	
P			0.000	0.0022	<LOD
Si			0.019	0.0062	
Al			0.000	0.0282	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.0005	<LOD
Pb			0.000	0.0005	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0011	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0025	<LOD
Sb			0.000	0.0016	<LOD
Sn			0.000	0.0017	<LOD
Cd			0.000	0.0016	<LOD
Ag			0.000	0.0017	<LOD
Pd			0.000	0.0016	<LOD
Ru			0.000	0.0004	<LOD
Mo			0.000	0.0003	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0003	<LOD
Zn			0.000	0.0012	<LOD
Cu			0.000	0.0016	<LOD
Ni			0.000	0.0024	<LOD
Co			0.000	0.0031	<LOD
Fe			0.000	0.0058	<LOD
Mn			0.000	0.0107	<LOD
Cr			0.000	0.0446	<LOD
V			0.000	0.0700	<LOD
Ti	99.8	100	100.00	0.1095	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0107	<LOD
Al			0.000	0.0689	<LOD
Mg			0.000	0.0000	<LOD

Certificate of Calibration

Ti 6-6-2 — IARM 178B — 195-095

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.000	0.0007	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.006	0.0049	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0035	<LOD
Sb				0.000	0.0021	<LOD
Sn	1.99	1.750	2.229	2.148	0.01	OK
Cd				0.000	0.0020	<LOD
Ag				0.000	0.0019	<LOD
Pd				0.000	0.0019	<LOD
Ru				0.000	0.0006	<LOD
Mo	0.008	0.002	0.014	0.007	0.0004	OK
Nb				0.000	0.0002	<LOD
Zr	0.004	0.001	0.010	0.004	0.0003	OK
Y				0.000	0.0002	<LOD
Se				0.000	0.0004	<LOD
Zn				0.003	0.0017	<LOD
Cu	0.51	0.420	0.600	0.510	0.0090	OK
Ni	0.017	0.007	0.027	0.017	0.0035	OK
Co				0.000	0.0060	<LOD
Fe	0.56	0.420	0.640	0.560	0.0159	OK
Mn	0.003			0.000	0.0103	<LOD
Cr	0.015			0.000	0.0332	<LOD
V	5.51	5.210	5.810	5.513	0.0712	OK
Ti	85.5	83.790	87.210	85.965	0.1358	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.000	0.050	0.010	0.0113	OK
Al	5.57	5.124	6.016	5.258	0.1283	OK
Mg				0.000	0.0000	<LOD

AA 4032 — ALCOA SS-4032D — 195-093

	Certified	Low	High	Measured	Err	
Bi	0.0000			0.000	0.0002	<LOD
Pb	0.0006			0.002	0.0002	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0053	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0012	<LOD
Sb	0.000			0.000	0.0008	<LOD
Sn	0.0003			0.000	0.0008	<LOD
Cd	0.000			0.000	0.0008	<LOD
Ag	0.0001			0.000	0.0007	<LOD
Pd				0.000	0.0008	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0018			0.004	0.0001	
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	0.102	0.082	0.122	0.104	0.0021	OK
Cu	0.895	0.850	0.940	0.896	0.0079	OK
Ni	0.90	0.810	0.990	0.901	0.0090	OK
Co	0.0003			0.000	0.0024	<LOD
Fe	0.232	0.186	0.278	0.268	0.0063	OK
Mn	0.0307	0.015	0.043	0.026	0.0041	OK
Cr	0.0499	0.030	0.065	0.034	0.0094	OK
V	0.0099			0.000	0.0183	<LOD
Ti	0.012			0.000	0.0342	<LOD
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	12.20	11.712	12.688	12.21	0.0787	OK
Al	84.4	82.732	86.108	84.38	0.1006	OK
Mg	1.10	0.420	1.780	1.179	0.1312	OK

AA5083 — ALCAN 5083AF — 195-091

	Certified	Low	High	Measured	Err	
Bi	0.008			0.008	0.0006	
Pb	0.0077			0.013	0.0006	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0025	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0019	<LOD
Sb	0.0012			0.000	0.0010	<LOD
Sn	0.020	0.010	0.030	0.025	0.0011	OK
Cd	0.0012			0.003	0.0010	
Ag				0.000	0.0010	<LOD
Pd				0.005	0.0011	
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0002	
Nb				0.000	0.0002	<LOD
Zr	0.0035	0.002	0.005	0.004	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	0.050	0.040	0.060	0.055	0.002	OK
Cu	0.078	0.062	0.094	0.086	0.003	OK
Ni	0.03	0.010	0.050	0.035	0.0025	OK
Co				0.000	0.0038	<LOD
Fe	0.34	0.272	0.408	0.361	0.0106	OK
Mn	0.740	0.666	0.814	0.734	0.0148	OK
Cr	0.15	0.11	0.20	0.159	0.0160	OK
V	0.02			0.031	0.0266	<LOD
Ti	0.027			0.117	0.0496	
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	0.17	0.102	0.240	0.179	0.0121	OK
Al	93.4	91.532	95.268	93.267	0.1614	OK
Mg	4.85	4.365	5.335	4.941	0.1586	OK

CDA 642 — IARM 81B — 195-097

	Certified	Low	High	Measured	Err	
Bi				0.003	0.0020	<LOD
Pb	0.006			0.016	0.0030	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0337	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.013	0.0118	<LOD
Sb	0.003			0.008	0.0071	<LOD
Sn	0.008			0.015	0.0060	
Cd				0.000	0.0069	<LOD
Ag	0.004			0.000	0.0063	<LOD
Pd				0.006	0.0070	<LOD
Ru				0.000	0.0015	<LOD
Mo				0.000	0.0011	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.002	0.0013	<LOD
Y				0.000	0.0005	<LOD
Se				0.000	0.0042	<LOD
Zn	0.176	0.141	0.211	0.185	0.0191	OK
Cu	91.2	89.376	93.024	91.118	0.1153	OK
Ni	0.003			0.000	0.0103	<LOD
Co				0.000	0.0103	<LOD
Fe	0.047	0.027	0.067	0.048	0.0048	OK
Mn	0.012			0.012	0.0039	
Cr				0.000	0.0213	<LOD
V				0.000	0.0291	<LOD
Ti				0.000	0.0511	<LOD
S				0.038	0.0023	
P	0.004			0.014	0.0031	
Si	1.84	1.440	2.240	1.842	0.0239	OK
Al	6.70	6.030	7.370	6.707	0.0990	OK
Mg				0.000	0.0000	<LOD

CDA 922 — 32X PB11 F — 195-100

	Certified	Low	High	Measured	Err	
Bi	0.033			0.046	0.0065	

Nitronic 60 — IARM 18C — 195-089

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0005	<LOD

Certificate of Calibration

Pb	1.038	0.934	1.142	1.039	0.02	OK				0.000	0.0012	<LOD
Au				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Re				0.000		OK				0.000		OK
W				0.057	0.0313		0.05			0.088	0.0389	
Ta				0.000		OK				0.000		OK
Hf				0.000		OK				0.000		OK
Te				0.011	0.0118	<LOD				0.000	0.0000	<LOD
Sb	0.478	0.430	0.526	0.478	0.01	OK				0.000	0.0033	<LOD
Sn	3.40	3.060	3.740	3.414	0.02	OK	0.004			0.011	0.0030	
Cd				0.000	0.0062	<LOD				0.000	0.0029	<LOD
Ag				0.000	0.0066	<LOD				0.000	0.0030	<LOD
Pd				0.000	0.0071	<LOD				0.000	0.0027	<LOD
Ru				0.000	0.0018	<LOD				0.000	0.0008	<LOD
Mo				0.000	0.0010	<LOD	0.354	0.283	0.425	0.352	0.0026	OK
Nb				0.000	0.0008	<LOD	0.090	0.072	0.108	0.085	0.0012	
Zr				0.000	0.0012	<LOD				0.000	0.0003	<LOD
Y				0.000	0.0013	<LOD				0.000	0.0000	<LOD
Se				0.000	0.0022	<LOD				0.000	0.0014	<LOD
Zn	1.50	1.350	1.650	1.463	0.03	OK				0.000	0.0046	<LOD
Cu	90.54	88.729	92.351	90.770	0.08	OK	0.285	0.228	0.342	0.285	0.0145	OK
Ni	0.904	0.723	1.085	0.905	0.02	OK	8.05	7.648	8.453	8.062	0.0565	OK
Co	0.097	0.078	0.116	0.097	0.01	OK	0.060	0.000	0.150	0.000	0.0407	OK
Fe	0.566	0.453	0.679	0.566	0.01	OK	63.0	61.760	64.280	63.065	0.0847	OK
Mn	0.201	0.161	0.241	0.190	0.01	OK	7.69	7.306	8.075	7.695	0.0381	OK
Cr				0.000	0.0261	<LOD	16.19	15.785	16.595	16.210	0.0453	OK
V				0.000	0.0334	<LOD	0.099			0.136	0.0116	
Ti				0.074	0.0247		0.013			0.034	0.0130	
S	0.0227			0.000	0.0039	<LOD	0.0010			0.000	0.0036	<LOD
P	0.885	0.664	1.106	0.890	0.01		0.027			0.044	0.0033	
Si	0.099			0.018	0.01		3.80	3.420	4.180	3.886	0.0295	OK
Al				0.000	0.0398	<LOD	0.014			0.097	0.0292	
Mg	0.004			0.000	0.0000	<LOD				0.000	0.0000	<LOD

		RIFM T2/2		195-101			Ti6-2-4-2	IARM 177C		180-503		
	Certified	Low	High	Measured	Err		Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD				0.000	0.0013	<LOD
Pb				0.000	0.0024	<LOD				0.000	0.0015	<LOD
Au				0.000	0.0000	<LOD				0.000	0.0020	<LOD
Re				0.000		OK				0.000		OK
W				0.000	0.0129	<LOD				0.000	0.0023	<LOD
Ta				0.000		OK				0.000		OK
Hf				0.000		OK				0.000		OK
Te				0.000	0.0000	<LOD				0.000	0.0052	<LOD
Sb				0.000	0.0044	<LOD				0.000	0.0033	<LOD
Sn				0.005	0.0038	<LOD	2.02	1.919	2.121	1.942	0.0138	OK
Cd				0.000	0.0034	<LOD				0.000	0.0033	<LOD
Ag				0.000	0.0044	<LOD				0.000	0.0034	<LOD
Pd				0.000	0.0041	<LOD				0.000	0.0032	<LOD
Ru				0.000	0.0009	<LOD				0.000	0.0014	<LOD
Mo				0.013	0.0008		1.96	1.764	2.352	1.961	0.0099	OK
Nb				0.000	0.0006	<LOD				0.000	0.0009	<LOD
Zr				0.000	0.0004	<LOD	3.99	3.751	4.229	3.992	0.0169	OK
Y				0.000	0.0000	<LOD				0.000	0.0007	<LOD
Se				0.000	0.0007	<LOD				0.000	0.0008	<LOD
Zn				0.000	0.0029	<LOD				0.000	0.0021	<LOD
Cu	0.075			0.073	0.0073					0.000	0.0036	<LOD
Ni	0.74			0.078	0.0244					0.000	0.0072	<LOD
Co				0.000	0.0422	<LOD				0.000	0.0066	<LOD
Fe	95.5	94.259	96.742	95.672	0.0674	OK				0.000	0.0119	<LOD
Mn	0.28	0.238	0.322	0.273	0.0105	OK				0.000	0.0146	<LOD
Cr	0.065	0.035	0.095	0.054	0.0063	OK				0.000	0.0572	<LOD
V				0.000	0.0266	<LOD				0.000	0.1307	<LOD
Ti	0.037			0.037	0.0142		85.72	84.006	87.434	85.543	0.1825	OK
S	0.02			0.032	0.0019					0.000	0.0000	<LOD
P	0.012			0.008	0.0022					0.000	0.0000	<LOD
Si	3.84	3.648	4.032	3.752	0.0272	OK	0.086	0.000	0.160	0.119	0.0194	OK
Al				0.000	0.0243	<LOD	6.02	5.520	6.520	6.444	0.1473	OK
Mg				0.000	0.0000	<LOD				0.000	0.0000	<LOD

	SS416	IARM 10c		195-151			Iron	BAS SCRM 660/09		195-166		
	Certified	Low	High	Measured	Err		Certified	Low	High	Measured	Err	
Bi				0.000	0.0005	<LOD				0.000	0.0008	<LOD
Pb				0.000	0.0017	<LOD				0.000	0.0020	<LOD
Au				0.000	0.0000	<LOD				0.000	0.0015	<LOD
Re				0.000		OK				0.000		OK
W	0.011			0.012	0.0127	<LOD				0.000	0.0064	<LOD
Ta				0.000		OK				0.000		OK
Hf				0.000		OK				0.000		OK
Te				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Sb				0.009	0.0030					0.000	0.0040	<LOD
Sn	0.009			0.017	0.0032					0.000	0.0042	<LOD
Cd				0.000	0.0035	<LOD				0.004	0.0040	<LOD

ThermoFisher SCIENTIFIC

Certificate of Calibration

Ag				0.000	0.0032	<LOD
Pd				0.000	0.0034	<LOD
Ru				0.000	0.0009	<LOD
Mo	0.08	0.040	0.120	0.091	0.0014	OK
Nb	0.003			0.000	0.0004	<LOD
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0007	<LOD
Zn				0.005	0.0025	
Cu	0.155	0.110	0.200	0.156	0.0083	OK
Ni	0.24	0.160	0.310	0.257	0.0190	OK
Co	0.022			0.000	0.0434	
Fe	86.0	81.700	90.300	85.952	0.0747	OK
Mn	0.35	0.250	0.460	0.421	0.0223	OK
Cr	12.25	11.638	12.863	12.263	0.0398	OK
V	0.024			0.045	0.0096	
Ti	0.002			0.040	0.0129	
S	0.29	0.220	0.360	0.312	0.0046	OK
P	0.026			0.034	0.0028	
Si	0.37	0.310	0.430	0.392	0.0106	OK
Al	0.003			0.000	0.0248	<LOD
Mg				0.000	0.0000	<LOD

Ag				0.000	0.0045	<LOD
Pd				0.004	0.0040	<LOD
Ru				0.000	0.0014	<LOD
Mo				0.000	0.0006	<LOD
Nb				0.003	0.0005	
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0029	<LOD
Cu				0.000	0.0048	<LOD
Ni				0.061	0.0250	
Co				0.000	0.0443	<LOD
Fe	94.18	91.355	97.005	94.036	0.0814	OK
Mn	0.406	0.365	0.447	0.393	0.0121	OK
Cr				0.006	0.0144	<LOD
V				0.000	0.0216	<LOD
Ti				0.000	0.0400	<LOD
S	0.105	0.079	0.131	0.103	0.0033	OK
P	0.153	0.122	0.184	0.153	0.0046	OK
Si	1.70	1.274	2.124	1.710	0.0216	OK
Al				0.034	0.0368	<LOD
Mg				0.000	0.0000	<LOD

	LAS	BS15a		195-167		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb				0.000	0.0025	<LOD
Au				0.000	0.0018	<LOD
Re				0.000		OK
W				0.000	0.0063	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0039	<LOD
Sn				0.000	0.0041	<LOD
Cd				0.000	0.0038	<LOD
Ag				0.000	0.0043	<LOD
Pd				0.000	0.0042	<LOD
Ru				0.000	0.0009	<LOD
Mo				0.007	0.0008	
Nb				0.043	0.0012	
Zr				0.021	0.0010	
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0027	<LOD
Cu				0.032	0.0062	
Ni				0.190	0.0252	
Co				0.000	0.0445	<LOD
Fe	*98.4*	95.448	100.000	98.095	0.0724	OK
Mn	1.12	1.008	1.232	1.156	0.0172	OK
Cr				0.044	0.0063	
V				0.000	0.0187	<LOD
Ti				0.000	0.0315	<LOD
S				0.017	0.0022	
P				0.033	0.0029	
Si	0.058	0.030	0.100	0.088	0.0071	OK
Al				0.065	0.0280	
Mg				0.000	0.0000	<LOD

	Mar-M 247	IARM 333a		195-173		
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0017	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	*0.01*			0.000	0.0231	
W	*9.7*	8.730	10.670	9.901	0.1900	OK
Ta	*3.15*	2.835	3.465	2.853	0.0690	OK
Hf	*1.4*	1.260	1.540	1.417	0.0320	OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0044	<LOD
Sn				0.007	0.0048	<LOD
Cd				0.005	0.0052	<LOD
Ag				0.000	0.0051	<LOD
Pd				0.000	0.0048	<LOD
Ru				0.000	0.0013	<LOD
Mo	*0.49*	0.466	0.515	0.503	0.0046	OK
Nb	*0.005*			0.003	0.0006	
Zr	*0.009*			0.002	0.0007	
Y				0.000	0.0000	<LOD
Se				0.000	0.0105	<LOD
Zn				0.000		OK
Cu	*0.01*			0.000		OK
Ni	*61.1*	58.045	64.155	60.803	0.1843	OK
Co	*9.4*	8.930	9.870	9.438	0.0493	OK
Fe	*0.036*	0.016	0.056	0.035	0.0062	OK
Mn	*0.005*			0.026	0.0299	<LOD
Cr	*8.32*	7.904	8.736	8.462	0.0517	OK
V				0.000	0.0351	<LOD
Ti	*0.73*	0.621	0.840	0.719	0.0324	OK
S				0.045	0.0053	
P	*0.004*			0.116	0.0067	
Si	*0.08*			0.000	0.0491	
Al	*5.53*	5.254	5.807	5.683	0.1007	OK
Mg				0.000	0.0000	<LOD

Certificate of Calibration

	CMSX-4	IARM 332a		195-174		
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0016	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	2.9	2.610	3.190	2.919	0.0473	OK
W	6.5	5.850	7.150	6.416	0.2049	OK
Ta	6.51	5.859	7.161	6.713	0.0764	OK
Hf	0.098			0.072	0.0327	
Te				0.000	0.0000	<LOD
Sb				0.013	0.0045	
Sn				0.016	0.0049	
Cd				0.000	0.0063	<LOD
Ag				0.000	0.0052	<LOD
Pd				0.000	0.0043	<LOD
Ru				0.000	0.0014	<LOD
Mo	0.61	0.549	0.671	0.608	0.0052	
Nb				0.004	0.0007	
Zr				0.003	0.0006	
Y				0.000	0.0000	<LOD
Se				0.000	0.0105	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	61	59.780	62.220	60.536	0.1840	OK
Co	9.4	8.930	9.588	9.532	0.0489	OK
Fe	0.023	0.003	0.043	0.025	0.0059	OK
Mn				0.020	0.0263	<LOD
Cr	6.31	5.679	6.941	6.292	0.0469	OK
V				0.025	0.0369	<LOD
Ti	0.99	0.891	1.089	1.010	0.0371	OK
S				0.034	0.0057	
P				0.128	0.0083	
Si				0.000	0.0491	
Al	5.8	5.220	6.380	5.712	0.0997	OK
Mg				0.000	0.0000	<LOD

	Cu-Cd	MBH 36X CCD2		195-156		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0024	<LOD
Pb				0.005	0.0028	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.064	0.0279	
Ta				0.000		OK
Hf				0.000		OK
Te				0.013	0.0103	<LOD
Sb				0.020	0.0089	
Sn	0.2	0.180	0.220	0.200	0.0086	OK
Cd	1.18	1.062	1.298	1.180	0.0141	OK
Ag	0.0012			0.000	0.0084	<LOD
Pd				0.006	0.0070	<LOD
Ru				0.000	0.0018	<LOD
Mo				0.000	0.0011	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.001	0.0011	<LOD
Y				0.000	0.0006	<LOD
Se				0.000	0.0017	<LOD
Zn	0.0019			0.000	0.0199	<LOD
Cu	98.6	98.000	99.200	98.379	0.0842	
Ni				0.000	0.0093	<LOD
Co				0.000	0.0118	<LOD
Fe				0.000	0.0120	<LOD
Mn				0.000	0.0074	<LOD
Cr				0.000	0.0242	<LOD
V				0.013	0.0288	<LOD
Ti				0.000	0.0521	<LOD
S				0.053	0.0022	
P				0.014	0.0029	
Si				0.000	0.0070	<LOD
Al				0.108	0.0331	
Mg				0.000	0.0000	<LOD

	AA7075		ALC 7075 AF		180-505	
	Cert	Low	High	Measured	Err	
Bi	0.007			0.007	0.0006	
Pb	0.0073			0.014	0.0006	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0099	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0018	<LOD
Sb				0.000	0.0012	<LOD
Sn	0.014	0.004	0.024	0.016	0.0012	OK
Cd				0.000	0.0011	<LOD
Ag				0.000	0.0011	<LOD
Pd				0.000	0.0011	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0024	0.001	0.003	0.003	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn	5.75	5.578	5.923	5.767	0.0329	OK
Cu	1.750	1.663	1.838	1.755	0.0131	OK
Ni	0.027	0.007	0.047	0.021	0.0018	OK
Co				0.000	0.0023	<LOD
Fe	0.17	0.136	0.204	0.164	0.0052	OK
Mn	0.031	0.016	0.046	0.030	0.0042	OK
Cr	0.22	0.187	0.253	0.236	0.0113	OK
V	0.020			0.022	0.0236	<LOD
Ti	0.092	0.012	0.172	0.092	0.0290	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.114	0.266	0.241	0.0133	OK
Al	89	87.220	90.780	89.139	0.1409	OK
Mg	2.66	2.261	3.059	2.508	0.1731	OK

	CDA510	IARM 77B		195-177		
	Certified	Low	High	Measured	Err	
Bi				0.004	0.0012	
Pb	0.016	0.008	0.024	0.026	0.0017	
Au				0.000	0.0000	<LOD
Re				0.000		<LOD
W				0.086	0.0150	
Ta				0.000		<LOD
Hf				0.000		<LOD
Te				0.010	0.0017	
Sb				0.000	0.0039	<LOD
Sn	4.66	4.520	4.800	4.653	0.0073	OK
Cd				0.000	0.0047	<LOD
Ag				0.000	0.0048	<LOD
Pd				0.000	0.0046	<LOD
Ru				0.000	0.0014	<LOD
Mo				0.000	0.0045	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0080	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0012	<LOD
Zn				0.086	0.0035	
Cu	95.2	94.248	96.152	94.934	0.0085	
Ni				0.000	0.0206	<LOD
Co				0.000	0.0427	<LOD
Fe				0.000	0.0778	<LOD
Mn				0.000	0.0177	<LOD
Cr				0.000	0.0298	<LOD
V				0.000	0.0642	<LOD
Ti				0.030	0.0763	<LOD
S				0.040	0.0030	
P	0.148	0.118	0.178	0.120	0.0027	OK
Si				0.000	0.0436	<LOD
Al				0.000	0.0880	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Certificate of Calibration

Serial Number: X500872 Model: Niton XL5- Software: 5372 Date of Q.C.: 23-Jul-18

Resolution: 159.806 148.860 Escale: 7.385 7.377 Spot Size: 8mm Inspector: Lam

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0013	<LOD
Pb			0.000	0.0026	<LOD
Au			0.000	0.0011	<LOD
Re			0.000		OK
W			0.000	0.0060	<LOD
Ta			0.000	0.0677	OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0039	<LOD
Sn			0.000	0.0042	<LOD
Cd			0.000	0.0039	<LOD
Ag			0.000	0.0047	<LOD
Pd			0.000	0.0044	<LOD
Ru			0.000	0.0011	<LOD
Mo			0.000	0.0006	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0008	<LOD
Zn			0.000	0.0026	<LOD
Cu			0.000	0.0043	<LOD
Ni			0.051	0.0263	
Co			0.000	0.0449	<LOD
Fe	99.85	100.000	99.938	0.0677	OK
Mn			0.000	0.0095	<LOD
Cr			0.000	0.0144	<LOD
V			0.000	0.0195	<LOD
Ti			0.000	0.0321	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.000	0.0042	<LOD
Pb			0.000	0.0000	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0037	<LOD
W			0.000	0.1170	<LOD
Ta	99.5	100	99.993	0.1369	OK
Hf			0.000	0.0691	<LOD
Te			0.000	0.0136	<LOD
Sb			0.000	0.0088	<LOD
Sn			0.000	0.0110	<LOD
Cd			0.000	0.0085	<LOD
Ag			0.000	0.0117	<LOD
Pd			0.008	0.0093	<LOD
Ru			0.003	0.0025	<LOD
Mo			0.000	0.0014	<LOD
Nb			0.000	0.0018	<LOD
Zr			0.000	0.0015	<LOD
Y			0.000	0.0011	<LOD
Se			0.000	0.0269	<LOD
Zn			0.000	0.0000	OK
Cu			0.000	0.0000	OK
Ni			0.000	0.0164	<LOD
Co			0.000	0.0293	<LOD
Fe			0.000	0.0186	<LOD
Mn			0.000	0.0214	<LOD
Cr			0.000	0.0370	<LOD
V			0.000	0.0616	<LOD
Ti			0.000	0.0910	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.000	0.0037	<LOD
Pb			0.000	0.0037	<LOD
Au			0.000	0.0121	<LOD
Re			0.000		OK
W			0.000	0.0000	<LOD
Ta			0.000	0.0000	OK
Hf			0.000		OK
Te			0.000	0.0285	<LOD
Sb			0.000	0.0183	<LOD
Sn	99	100.000	100.000	0.4282	OK
Cd			0.000	0.0155	<LOD
Ag			0.000	0.0106	<LOD
Pd			0.000	0.0087	<LOD
Ru			0.000	0.0026	<LOD
Mo			0.000	0.0014	<LOD
Nb			0.000	0.0009	<LOD
Zr			0.000	0.0013	<LOD
Y			0.000	0.0009	<LOD
Se			0.000	0.0030	<LOD
Zn			0.000	0.0079	<LOD
Cu			0.000	0.0124	<LOD
Ni			0.000	0.0169	<LOD
Co			0.000	0.0274	<LOD
Fe			0.000	0.0374	<LOD
Mn			0.000	0.0442	<LOD
Cr			0.000	0.0861	<LOD
V			0.000	0.1817	<LOD
Ti			0.000	0.3641	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.002	<LOD
Pb			0.003	0.003	<LOD
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.037	0.033	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.009	<LOD
Sb			0.000	0.006	<LOD
Sn			0.000	0.007	<LOD
Cd			0.000	0.006	<LOD
Ag			0.000	0.007	<LOD
Pd			0.000	0.006	<LOD
Ru			0.000	0.001	<LOD
Mo			0.000	0.001	<LOD
Nb			0.000	0.001	<LOD
Zr			0.002	0.001	<LOD
Y			0.000	0.001	<LOD
Se			0.000	0.004	<LOD
Zn			0.000	0.020	<LOD
Cu	99.85	100	99.983	0.076	OK
Ni			0.000	0.010	<LOD
Co			0.000	0.007	<LOD
Fe			0.000	0.011	<LOD
Mn			0.000	0.012	<LOD
Cr			0.000	0.021	<LOD
V			0.000	0.030	<LOD
Ti			0.000	0.047	<LOD
Al (Bal)			0.000	0.000	<LOD
LEC					

ThermoFisher SCIENTIFIC

Certificate of Calibration

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.000	0.0019	<LOD
Pb			0.000	0.0027	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.5064	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0051	<LOD
Sn			0.000	0.0055	<LOD
Cd			0.000	0.0051	<LOD
Ag			0.000	0.0058	<LOD
Pd			0.000	0.0051	<LOD
Ru			0.000	0.0012	<LOD
Mo			0.000	0.0007	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0151	<LOD
Zn			0.000	0.0639	<LOD
Cu			0.104	0.0290	
Ni	99.85	100.000	99.907	0.5151	OK
Co			0.000	0.0105	<LOD
Fe			0.000	0.0100	<LOD
Mn			0.000	0.0055	<LOD
Cr			0.000	0.0187	<LOD
V			0.000	0.0257	<LOD
Ti			0.000	0.0503	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.001	<LOD
Pb			0.000	0.001	<LOD
Au			0.000	0.001	<LOD
Re			0.000		OK
W			0.000	0.001	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.002	<LOD
Sb			0.000	0.002	<LOD
Sn			0.000	0.002	<LOD
Cd			0.000	0.002	<LOD
Ag			0.000	0.002	<LOD
Pd			0.000	0.002	<LOD
Ru			0.000	0.000	<LOD
Mo			0.000	0.000	<LOD
Nb			0.000	0.000	<LOD
Zr			0.000	0.000	<LOD
Y			0.000	0.000	<LOD
Se			0.000	0.000	<LOD
Zn			0.000	0.001	<LOD
Cu			0.000	0.002	<LOD
Ni			0.000	0.002	<LOD
Co			0.000	0.003	<LOD
Fe			0.000	0.006	<LOD
Mn			0.000	0.011	<LOD
Cr			0.000	0.045	<LOD
V			0.000	0.070	<LOD
Ti	99.85	100	100.000	0.084	OK
Al (Bal)			0.000	0.000	<LOD
LEC					

20Cb3 **IARM 25C** 180-509

	Certified	Low	High	Measured	Err	
Bi				0.002	0.0010	
Pb				0.000	0.0015	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.080			0.218	0.0982	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0046	<LOD
Sn	0.01	0.002	0.020	0.012	0.0036	OK
Cd				0.000	0.0033	<LOD
Ag				0.000	0.0037	<LOD
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0016	<LOD
Mo	2.26	2.030	2.480	2.274	0.0090	OK
Nb	0.58	0.480	0.680	0.572	0.0036	OK
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0032	<LOD
Zn				0.000	0.0115	<LOD
Cu	3.51	3.260	3.760	3.543	0.0364	OK
Ni	33.30	31.640	35.640	33.172	0.1228	OK
Co	0.091	0.020	0.200	0.122	0.0369	OK
Fe	38.80	36.800	40.800	38.079	0.0724	OK
Mn	0.90	0.400	1.400	0.929	0.0253	OK
Cr	19.97	19.570	20.570	20.441	0.0561	OK
V	0.095	0.035	0.155	0.137	0.0145	OK
Ti	0.003			0.018	0.0157	<LOD
Al (Bal)	0.019			0.000	0.00	<LOD
LEC				0.500		

Stellite 6B **IARM 95B** 180-502

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0009	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re				0.015	0.0124	
W	3.42	3.120	3.720	3.426	0.0514	OK
Ta				0.000	0.0280	<LOD
Hf				0.206	0.0359	
Te				0.000	0.0000	<LOD
Sb				0.005	0.0031	
Sn				0.008	0.0033	
Cd				0.000	0.0036	<LOD
Ag				0.000	0.0035	<LOD
Pd				0.000	0.0030	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.83	0.700	0.960	0.831	0.0046	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.002			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0035	<LOD
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	2.25	1.913	2.588	2.254	0.0425	OK
Co	60.90	59.682	61.814	59.902	0.1049	OK
Fe	1.10	0.990	1.210	1.102	0.0234	OK
Mn	0.99	0.891	1.089	0.992	0.0235	OK
Cr	28.90	28.467	29.334	28.947	0.0624	OK
V	0.002			0.045	0.0129	
Ti	0.004			0.050	0.0143	
Al (Bal)	0.07			0.000	0.00	<LOD
LEC		2.250	2.250	2.250		

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	*0.01*			0.045	0.0103	
Pb	**5.03**	**4.680**	**5.440**	5.022	0.0411	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.086	0.0308	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0150	<LOD
Sb	0.143	0.122	0.164	0.145	0.0080	OK
Sn	**4.37**	**3.460**	**5.380**	4.374	0.0275	OK
Cd				0.000	0.0066	<LOD
Ag	*0.02*			0.000	0.0072	<LOD
Pd				0.000	0.0077	<LOD
Ru				0.000	0.0020	<LOD
Mo				0.000	0.0010	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.002	0.0014	<LOD
Y				0.000	0.0027	<LOD
Se				0.000	0.0034	<LOD
Zn	**5.38**	**4.790**	**6.080**	5.364	0.0353	OK
Cu	**84.6**	**82.600**	**86.600**	84.399	0.0846	OK
Ni	**0.27**	**0.100**	**0.400**	0.269	0.0117	OK
Co				0.000	0.0065	<LOD
Fe	**0.24**	**0.210**	**0.270**	0.242	0.0090	OK
Mn	0.002			0.000	0.0116	<LOD
Cr				0.000	0.0262	<LOD
V				0.000	0.0412	<LOD
Ti				0.051	0.0486	<LOD
Al (Bal)	0.002			0.000	0.00	<LOD
LEC						

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb	0.0009			0.000	0.0023	
Au				0.000	0.0000	
Re				0.000		OK
W	0.004			0.000	0.0101	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0040	<LOD
Sn	0.002			0.000	0.0041	<LOD
Cd				0.000	0.0038	<LOD
Ag				0.000	0.0042	<LOD
Pd				0.000	0.0038	<LOD
Ru				0.000	0.0012	<LOD
Mo	**0.47**	**0.430**	**0.530**	0.498	0.0041	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.001			0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0032	<LOD
Cu	0.033	0.018	0.048	0.029	0.0061	OK
Ni	0.071			0.143	0.0254	
Co	0.004			0.000	0.0452	<LOD
Fe	**96.96**	**95.900**	**98.000**	96.869	0.0684	OK
Mn	**0.56**	**0.350**	**0.750**	0.581	0.0155	OK
Cr	**1.11**	**0.999**	**1.221**	1.112	0.0164	OK
V	0.004			0.000	0.0156	<LOD
Ti	0.0016			0.000	0.0306	<LOD
Al (Bal)	0.028			0.000	0.00	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0017	<LOD
Pb				0.000	0.0025	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**0.62**	**0.320**	**0.920**	0.584	0.1636	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0054	<LOD
Sn	0.002			0.000	0.0055	<LOD
Cd				0.000	0.0053	<LOD
Ag				0.000	0.0056	<LOD
Pd				0.000	0.0050	<LOD
Ru				0.000	0.0035	<LOD
Mo	**8.30**	**7.720**	**8.890**	8.283	0.0326	OK
Nb	**0.09**	**0.030**	**0.150**	0.072	0.0020	OK
Zr	0.004			0.002	0.0009	
Y				0.000	0.0000	<LOD
Se				0.000	0.0059	<LOD
Zn				0.000	0.0213	<LOD
Cu				0.174	0.0281	
Ni	**48.80**	**46.800**	**50.760**	48.037	0.1938	OK
Co	**1.11**	**0.930**	**1.350**	1.172	0.0388	OK
Fe	**18.30**	**17.390**	**19.220**	18.258	0.0667	OK
Mn	**0.47**	**0.200**	**0.900**	0.469	0.0285	OK
Cr	**21.60**	**20.740**	**22.470**	22.384	0.0748	OK
V	0.03			0.077	0.0182	
Ti	0.02			0.035	0.0408	<LOD
Al (Bal)	0.12			0.00	0.00	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.000	0.0028	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**6.30**	**5.800**	**6.870**	6.623	0.0751	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0047	<LOD
Sn	0.01			0.000	0.0048	<LOD
Cd				0.000	0.0045	<LOD
Ag				0.000	0.0050	<LOD
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0025	<LOD
Mo	**4.85**	**4.610**	**5.150**	4.830	0.0168	OK
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0007	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0059	<LOD
Zn				0.028	0.0168	
Cu	**0.13**	**0.104**	**0.156**	0.133	0.0129	OK
Ni	**0.35**	**0.280**	**0.420**	0.330	0.0208	OK
Co	**0.31**	**0.217**	**0.403**	0.226	0.0480	OK
Fe	**80.59**	**78.590**	**82.590**	80.114	0.1009	OK
Mn	**0.29**	**0.240**	**0.340**	0.327	0.0201	OK
Cr	**3.98**	**3.590**	**4.420**	4.125	0.0364	OK
V	**2.03**	**1.570**	**2.460**	2.025	0.0366	OK
Ti				0.000	0.0359	<LOD
Al (Bal)	0.02			0.00	0.00	<LOD
LEC				1.24		

Certificate of Calibration

SS321 — IARM 6D — 180-512

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0004	<LOD
Pb				0.000	0.0013	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09			0.110	0.0414	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0027	<LOD
Sn	0.013	0.003	0.023	0.021	0.0030	OK
Cd				0.000	0.0031	<LOD
Ag				0.000	0.0030	<LOD
Pd				0.000	0.0028	<LOD
Ru				0.000	0.0009	<LOD
Mo	**0.358**	**0.290**	**0.440**	0.371	0.0026	OK
Nb	**0.039**	**0.010**	**0.060**	0.038	0.0008	OK
Zr	***0.002***			0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0050	<LOD
Cu	**0.302**	**0.150**	**0.500**	0.333	0.0152	OK
Ni	**9.42**	**9.000**	**9.800**	9.353	0.0588	OK
Co	**0.182**	**0.109**	**0.255**	0.204	0.0409	OK
Fe	**69.40**	**68.400**	**70.400**	68.909	0.0843	OK
Mn	**1.52**	**1.250**	**1.850**	1.623	0.0264	OK
Cr	**17.45**	**17.100**	**18.000**	17.724	0.0462	OK
V	**0.128**	**0.077**	**0.179**	0.166	0.0130	OK
Ti	**0.63**	**0.378**	**0.882**	0.617	0.0206	OK
Al (Bal)	0.11			0.00	0.00	<LOD
LEC				0.50		OK

Ti 6-2-4-2 — IARM 177C — 180-503

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.000	0.0017	<LOD
Au				0.000	0.0022	<LOD
Re				0.000		OK
W				0.000	0.0026	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0060	<LOD
Sb				0.000	0.0038	<LOD
Sn	**2.02**	**1.919**	**2.121**	1.958	0.0140	OK
Cd				0.000	0.0039	<LOD
Ag				0.000	0.0039	<LOD
Pd				0.000	0.0037	<LOD
Ru				0.000	0.0016	<LOD
Mo	**1.96**	**1.764**	**2.156**	1.960	0.0097	OK
Nb				0.000	0.0011	<LOD
Zr	**3.99**	**3.751**	**4.229**	3.990	0.0156	OK
Y				0.000	0.0008	<LOD
Se				0.000	0.0009	<LOD
Zn				0.000	0.0024	<LOD
Cu	0.003			0.000	0.0041	<LOD
Ni	0.011			0.000	0.0081	<LOD
Co				0.000	0.0074	<LOD
Fe	0.033	0.023	0.053	0.000	0.0136	<LOD
Mn	0.0015			0.000	0.0165	<LOD
Cr				0.000	0.0649	<LOD
V	0.02			0.000	0.1403	<LOD
Ti	**85.72**	**84.006**	**87.434**	86.091	0.1486	OK
Al (Bal)	6.02			0.00	0.00	<LOD
LEC				6.0		OK

AA7075 — ALC 7075 AF — 180-505

	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.008	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0085	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0015	<LOD
Sb				0.000	0.0010	<LOD
Sn	0.014	0.007	0.021	0.015	0.0010	OK
Cd				0.000	0.0010	<LOD
Ag				0.000	0.0009	<LOD
Pd				0.000	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0002	
Nb				0.000	0.0001	<LOD
Zr	0.0024	0.001	0.003	0.0026	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	**5.75**	**5.578**	**5.923**	5.751	0.0112	OK
Cu	**1.750**	**1.663**	**1.838**	1.750	0.0082	OK
Ni	0.027	0.007	0.047	0.021	0.0017	OK
Co				0.000	0.0020	<LOD
Fe	**0.17**	**0.136**	**0.204**	0.170	0.0047	OK
Mn	0.031	0.016	0.046	0.029	0.0038	OK
Cr	**0.22**	**0.187**	**0.253**	0.238	0.0104	OK
V	0.020			0.020	0.0214	<LOD
Ti	**0.092**	**0.012**	**0.172**	0.070	0.0266	OK
Al (Bal)	***91.7***	**89.827**	**93.493**	91.93	0.07	OK
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

1.25Cr 0.5Mo — IARM35H — 195-019

	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb	0.001			0.000	0.0038	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0151	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0059	<LOD
Sn	0.002			0.000	0.0063	<LOD
Cd				0.000	0.0058	<LOD
Ag				0.000	0.0066	<LOD
Pd				0.000	0.0067	<LOD
Ru				0.000	0.0017	<LOD
Mo	0.47	0.432	0.508	0.474	0.0060	OK
Nb	0.002			0.000	0.0009	<LOD
Zr	0.001			0.000	0.0008	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.000	0.0053	<LOD
Cu	0.032	0.012	0.052	0.035	0.0093	OK
Ni	0.071			0.069	0.0379	
Co	0.004			0.000	0.0680	<LOD
Fe	96.96	95.990	97.930	96.932	0.0836	OK
Mn	0.56	0.476	0.644	0.559	0.0230	OK
Cr	1.11	0.999	1.221	1.151	0.0062	OK
V	0.004			0.000	0.0017	<LOD
Ti	0.002			0.001	0.0013	<LOD
Al (Bal)	0.028			0.00	0.00	<LOD
LEC	0.75			0.750		OK

Tool steel T-1 — IARM 48C — 195-152

	Certified	Low	High	Measured	Err	
Bi				0.006	0.0015	
Pb				0.000	0.0045	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	17.50	16.625	18.375	17.721	0.1249	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.008	0.0069	<LOD
Sn	0.012			0.029	0.0063	
Cd				0.000	0.0067	<LOD
Ag				0.000	0.0067	<LOD
Pd				0.000	0.0070	<LOD
Ru				0.003	0.0018	
Mo	0.17	0.150	0.190	0.156	0.0033	OK
Nb	0.005	0.001	0.010	0.004	0.0008	OK
Zr				0.002	0.0007	
Y				0.000	0.0000	<LOD
Se				0.000	0.0125	<LOD
Zn				0.000	0.0342	<LOD
Cu	0.13	0.090	0.170	0.128	0.0211	OK
Ni	0.204	0.143	0.265	0.157	0.0165	OK
Co	0.22	0.120	0.320	0.267	0.0624	OK
Fe	74.5	73.383	75.618	74.343	0.1469	OK
Mn	0.39	0.304	0.476	0.437	0.0281	OK
Cr	4.24	3.901	4.579	4.463	0.0516	OK
V	1.27	1.143	1.397	1.262	0.0083	OK
Ti	0.006			0.000	0.0019	<LOD
Al (Bal)	0.017			0.00	0.00	<LOD
LEC	1.025			1.025		OK

Custom 455 — IARM16B — 195-142

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0004	<LOD
Pb				0.000	0.0015	<LOD
Au				0.000	0.0014	<LOD
Re				0.000		OK
W	0.011			0.143	0.0284	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.008	0.0031	
Sn	0.004			0.012	0.0032	
Cd				0.003	0.0033	<LOD
Ag				0.000	0.0034	<LOD
Pd				0.004	0.0033	<LOD
Ru				0.000	0.0007	<LOD
Mo	0.016	0.010	0.022	0.017	0.0007	OK
Nb	0.25	0.225	0.275	0.261	0.0022	OK
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.000	0.0054	<LOD
Cu	2.23	2.119	2.342	2.207	0.0287	OK
Ni	8.28	7.866	8.694	8.399	0.0607	OK
Co	0.027			0.000	0.0507	<LOD
Fe	76.4	72.580	80.220	76.159	0.0393	OK
Mn	0.026			0.088	0.0204	
Cr	11.44	10.868	12.012	11.630	0.0393	OK
V	0.067			0.046	0.0041	
Ti	1.11	1.055	1.166	1.110	0.0084	OK
Al (Bal)	0.062			0.000	0.00	<LOD

AA7075 — ALC 7075 AF — 180-505

	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.008	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0085	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0015	<LOD
Sb				0.000	0.0010	<LOD
Sn	0.014	0.007	0.021	0.016	0.0010	OK
Cd				0.000	0.0010	<LOD
Ag				0.000	0.0009	<LOD
Pd				0.000	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0002	
Nb				0.000	0.0001	<LOD
Zr	0.0024	0.000	0.004	0.003	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	5.75	5.578	5.923	5.754	0.0110	OK
Cu	1.750	1.663	1.838	1.751	0.0082	OK
Ni	0.027	0.007	0.047	0.021	0.0017	OK
Co				0.000	0.0425	<LOD
Fe	0.17	0.136	0.204	0.170	0.0047	OK
Mn	0.031	0.016	0.046	0.029	0.0038	OK
Cr	0.22	0.198	0.242	0.220	0.0023	OK
V	0.020			0.041	0.0015	
Ti	0.092	0.072	0.112	0.092	0.0019	OK
Al (Bal)	91.7	89.827	93.493	91.888	0.01	OK

ThermoFisher SCIENTIFIC

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

ThermoFisher SCIENTIFIC

Certificate of Calibration

Serial Number: X500872 Model: Niton XL5- Software: 5372 Date of Q.C.: 23-Jul-18
Resolution: 159.8059 148.8597 Escale: 7.385 7.377 Spot Size: 3mm Inspector: Lam

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0002	<LOD
Pb			0.000	0.0002	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0020	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0012	<LOD
Sb			0.000	0.0008	<LOD
Sn			0.000	0.0007	<LOD
Cd			0.000	0.0010	<LOD
Ag			0.000	0.0007	<LOD
Pd			0.000	0.0011	<LOD
Ru			0.000	0.0003	<LOD
Mo			0.000	0.0001	<LOD
Nb			0.000	0.0001	<LOD
Zr			0.000	0.0001	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0001	<LOD
Zn			0.003	0.0007	
Cu			0.000	0.0009	<LOD
Ni			0.000	0.0011	<LOD
Co			0.000	0.0017	<LOD
Fe	0	0.02	0.000	0.0030	<LOD
Mn			0.000	0.0053	<LOD
Cr			0.000	0.0117	<LOD
V			0.000	0.0242	<LOD
Ti			0.000	0.0479	<LOD
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0139	<LOD
Al			0.105	0.0660	
Mg	99.85	100	99.96	0.0873	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.003	0.0008	
Pb			0.000	0.0026	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0167	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0054	<LOD
Sn			0.008	0.0040	
Cd			0.006	0.0056	<LOD
Ag			0.000	0.0050	<LOD
Pd			0.005	0.0052	<LOD
Ru			0.000	0.0014	<LOD
Mo			0.000	0.0008	<LOD
Nb			0.000	0.0008	<LOD
Zr			0.000	0.0007	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0012	<LOD
Zn			0.000	0.0039	<LOD
Cu			0.000	0.0070	<LOD
Ni			0.047	0.0280	
Co			0.000	0.0562	<LOD
Fe	99.75	100	99.92	0.1023	OK
Mn			0.000	0.0184	<LOD
Cr			0.000	0.0193	<LOD
V			0.000	0.0256	<LOD
Ti			0.037	0.0408	<LOD
S			0.000	0.0044	<LOD
P			0.000	0.0034	<LOD
Si			0.000	0.0139	<LOD
Al			0.000	0.0501	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.0009	<LOD
Pb			0.000	0.0008	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0086	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0035	<LOD
Sb			0.000	0.0024	<LOD
Sn			0.000	0.0023	<LOD
Cd			0.000	0.0026	<LOD
Ag			0.000	0.0025	<LOD
Pd			0.000	0.0030	<LOD
Ru			0.000	0.0007	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0003	<LOD
Se			0.000	0.0006	<LOD
Zn			0.002	0.0019	<LOD
Cu			0.000	0.0035	<LOD
Ni			0.000	0.0047	<LOD
Co			0.000	0.0052	<LOD
Fe			0.020	0.0123	
Mn			0.000	0.0166	<LOD
Cr			0.000	0.0775	<LOD
V			0.000	0.1030	<LOD
Ti	99.7	100	99.99	0.1469	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0128	<LOD
Al			0.000	0.0643	<LOD
Mg			0.000	0.0000	<LOD

Thermo Scientific
Portable Analytical Instruments
2 Radcliff Road
Tewksbury MA 01876
USA
+1 978 670-7460 ph
+1 978 670-7430 fax
www.thermoscientific.com/pai

Certificate of Calibration

	Ti 6-6-2	IARM 178B		195-095		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0011	<LOD
Pb				0.000	0.0009	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.013	0.0101	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0040	<LOD
Sb				0.000	0.0028	<LOD
Sn	1.99	1.70	2.30	1.994	0.0120	OK
Cd				0.000	0.0031	<LOD
Ag				0.000	0.0027	<LOD
Pd				0.000	0.0035	<LOD
Ru				0.000	0.0009	<LOD
Mo	0.008	0.002	0.014	0.008	0.0006	OK
Nb				0.000	0.0006	<LOD
Zr	0.004	0.001	0.01	0.004	0.0006	OK
Y				0.000	0.0003	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0029	OK
Cu	0.51	0.40	0.60	0.510	0.0147	OK
Ni	0.017	0.005	0.030	0.010	0.0053	OK
Co				0.000	0.0094	<LOD
Fe	0.56	0.42	0.64	0.560	0.0272	OK
Mn	0.003			0.000	0.0198	<LOD
Cr	0.015			0.000	0.0583	<LOD
V	5.51	5.21	5.81	5.514	0.1213	OK
Ti	85.5	83.79	87.21	85.986	0.1836	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.00	0.05	0.016	0.0127	<LOD
Al	5.57	5.15	6.09	5.394	0.1422	OK
Mg				0.000	0.0000	<LOD

	AA 4032	ALCOA SS-4032D		195-093		
	Certified	Low	High	Measured	Err	
Bi	0.0000			0.000	0.0003	<LOD
Pb	0.0006			0.001	0.0003	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0112	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0017	<LOD
Sb	0.000			0.000	0.0012	<LOD
Sn	0.0003			0.000	0.0010	<LOD
Cd	0.000			0.000	0.0013	<LOD
Ag	0.0001			0.000	0.0010	<LOD
Pd				0.000	0.0014	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0018			0.006	0.0003	
Y				0.000	0.0002	<LOD
Se				0.000	0.0003	<LOD
Zn	0.102	0.051	0.153	0.097	0.0032	OK
Cu	0.895	0.81	0.98	0.883	0.0127	OK
Ni	0.90	0.77	1.04	0.900	0.0135	OK
Co	0.0003			0.000	0.0036	<LOD
Fe	0.232	0.162	0.302	0.268	0.0105	OK
Mn	0.0307	0.015	0.043	0.027	0.0079	
Cr	0.0499	0.030	0.065	0.024	0.0156	
V	0.0099			0.000	0.0299	<LOD
Ti	0.012			0.000	0.0573	<LOD
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	12.20	11.47	12.93	12.20	0.1338	OK
Al	84.4	81.04	87.80	84.52	0.1730	OK
Mg	1.10	0.350	1.850	1.063	0.2294	OK

	AA5083	ALCAN 5083AF		195-091		
	Certified	Low	High	Measured	Err	
Bi	0.008			0.013	0.0011	
Pb	0.0077			0.010	0.0009	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0049	
Ta				0.000		OK
Hf				0.000		OK
Te				0.006	0.0025	
Sb	0.0012			0.000	0.0016	<LOD
Sn	0.020			0.025	0.0016	
Cd	0.0012			0.005	0.0018	
Ag				0.000	0.0014	<LOD
Pd				0.008	0.0021	
Ru				0.000	0.0006	<LOD
Mo				0.001	0.0003	<LOD
Nb				0.000	0.0003	<LOD
Zr	0.0035			0.006	0.0030	
Y				0.000	0.0002	<LOD
Se				0.000	0.0003	<LOD
Zn	0.050	0.04	0.06	0.058	0.0030	OK
Cu	0.078	0.06	0.09	0.077	0.0048	OK
Ni	0.03			0.034	0.0039	
Co				0.000	0.0055	<LOD
Fe	0.34	0.27	0.41	0.371	0.0181	OK
Mn	0.740	0.67	0.81	0.712	0.0303	OK
Cr	0.15	0.08	0.21	0.175	0.0279	OK
V	0.02			0.083	0.0464	
Ti	0.027			0.200	0.0878	
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	0.17	0.09	0.26	0.14	0.0207	OK
Al	93.4	88.73	98.07	93.57	0.2973	OK
Mg	4.85	4.12	5.58	4.49	0.2974	OK

	CDA 642	IARM 81B		195-097		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0021	<LOD
Pb	0.006			0.009	0.0027	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0340	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.009	0.0089	<LOD
Sb	0.003			0.000	0.0066	<LOD
Sn	0.008			0.013	0.0048	
Cd				0.000	0.0059	<LOD
Ag	0.004			0.000	0.0054	<LOD
Pd				0.000	0.0080	<LOD
Ru				0.000	0.0021	<LOD
Mo				0.000	0.0012	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.000	0.0011	<LOD
Y				0.000	0.0007	<LOD
Se				0.000	0.0043	<LOD
Zn	0.176	0.132	0.220	0.177	0.0191	OK
Cu	91.2	89.38	93.02	91.135	0.2038	OK
Ni	0.003			0.000	0.0100	
Co				0.000	0.0093	<LOD
Fe	0.047	0.022	0.072	0.055	0.0050	
Mn	0.012			0.015	0.0049	
Cr				0.000	0.0279	<LOD
V				0.000	0.0332	<LOD
Ti				0.000	0.0680	
S				0.046	0.0046	
P	0.004			0.012	0.0048	
Si	1.84	1.44	2.24	1.842	0.0451	OK
Al	6.70	5.36	8.04	6.706	0.1906	OK
Mg				0.000	0.0000	<LOD

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy Light 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

	CDA 922	32X PB11 F		195-100		
	Certified	Low	High	Measured	Err	
Bi	0.033			0.041	0.0069	
Pb	1.038	0.88	1.19	0.97	0.0188	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.052	0.0328	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0083	
Sb	0.478	0.41	0.55	0.478	0.0100	OK
Sn	3.40	2.89	3.91	3.325	0.0214	OK
Cd				0.000	0.0061	
Ag				0.000	0.0057	<LOD
Pd				0.000	0.0072	<LOD
Ru				0.000	0.0017	<LOD
Mo				0.000	0.0010	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0015	<LOD
Y				0.000	0.0016	<LOD
Se				0.000	0.0024	<LOD
Zn	1.50	1.28	1.73	1.56	0.0252	OK
Cu	90.54	87.82	93.26	90.80	0.0975	OK
Ni	0.904	0.68	1.13	0.90	0.0167	OK
Co	0.097	0.073	0.121	0.097	0.0061	
Fe	0.566	0.42	0.71	0.57	0.0125	OK
Mn	0.201	0.15	0.25	0.20	0.0101	OK
Cr				0.000	0.0220	<LOD
V				0.000	0.0399	<LOD
Ti				0.062	0.0271	
S	0.0227			0.000	0.0085	<LOD
P	0.885	0.62	1.15	0.90	0.0195	OK
Si	0.099			0.05	0.0190	
Al				0.000	0.0681	<LOD
Mg	0.004			0.000	0.0000	<LOD

	Nitronic 60	IARM 18C		195-089		
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0013	
Pb				0.000	0.0012	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.098	0.0696	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0044	<LOD
Sn	0.004			0.009	0.0035	
Cd				0.000	0.0039	<LOD
Ag				0.000	0.0038	<LOD
Pd				0.000	0.0042	<LOD
Ru				0.000	0.0013	
Mo	0.354	0.27	0.44	0.351	0.0039	OK
Nb	0.090	0.068	0.113	0.090	0.0023	
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0020	<LOD
Zn				0.000	0.0063	<LOD
Cu	0.285	0.21	0.36	0.275	0.0209	OK
Ni	8.05	7.25	8.86	8.048	0.0762	OK
Co	0.060	0.00	0.15	0.000	0.0629	OK
Fe	63.0	61.13	64.91	63.264	0.1349	OK
Mn	7.69	6.92	8.46	7.678	0.0665	OK
Cr	16.19	15.70	16.68	16.179	0.0711	OK
V	0.099			0.131	0.0174	
Ti	0.013			0.056	0.0197	
S	0.0010			0.000	0.0073	<LOD
P	0.027			0.035	0.0050	
Si	3.80	3.04	4.56	3.826	0.0531	OK
Al	0.014			0.000	0.0532	<LOD
Mg				0.000	0.0000	<LOD

		RIFM T2/2		195-101		
	Certified	Low	High	Measured	Err	
Bi				0.001	0.0008	
Pb				0.000	0.0020	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0168	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.008	0.0041	
Sn				0.012	0.0149	<LOD
Cd				0.007	0.0054	<LOD
Ag				0.000	0.0045	<LOD
Pd				0.007	0.0048	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.014	0.0010	
Nb				0.001	0.0007	
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.000	0.0037	<LOD
Cu	0.075			0.078	0.0102	
Ni	0.74			0.067	0.0227	
Co				0.056	0.0587	<LOD
Fe	95.5	93.59	97.41	95.395	0.1062	OK
Mn	0.28	0.22	0.34	0.288	0.0165	OK
Cr	0.065			0.063	0.0090	
V				0.000	0.0315	
Ti	0.037			0.130	0.0206	
S	0.02			0.034	0.0045	
P	0.012			0.023	0.0041	
Si	3.84	3.57	4.11	3.884	0.0554	OK
Al				0.000	0.0546	<LOD
Mg				0.000	0.0000	<LOD

	Ti6-2-4-2	IARM 177C		180-503		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0017	<LOD
Pb				0.000	0.0015	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0108	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0051	<LOD
Sb				0.000	0.0034	<LOD
Sn	2.02	1.82	2.22	2.019	0.0140	OK
Cd				0.000	0.0038	<LOD
Ag				0.000	0.0048	<LOD
Pd				0.000	0.0040	<LOD
Ru				0.000	0.0018	<LOD
Mo	1.96	1.67	2.25	1.961	0.0114	OK
Nb				0.000	0.0014	
Zr	3.99	3.59	4.39	3.993	0.0229	OK
Y				0.000	0.0010	<LOD
Se				0.000	0.0009	<LOD
Zn				0.000	0.0030	<LOD
Cu				0.000	0.0050	<LOD
Ni				0.000	0.0071	<LOD
Co				0.000	0.0080	<LOD
Fe				0.000	0.0174	<LOD
Mn				0.000	0.0202	<LOD
Cr				0.000	0.0745	<LOD
V				0.000	0.1336	<LOD
Ti	85.72	83.15	88.29	85.772	0.1939	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.00	0.16	0.064	0.0187	OK
Al	6.02	5.52	6.52	6.191	0.1509	OK
Mg				0.000	0.0000	<LOD

ThermoFisher SCIENTIFIC

Certificate of Calibration

	SS416 Certified	IARM 10c Low	High	195-151 Measured	Err	
Bi				0.004	0.0013	
Pb				0.000	0.0014	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.000	0.0175	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.010	0.0037	
Sn	0.009			0.017	0.0036	
Cd				0.005	0.0046	<LOD
Ag				0.000	0.0040	<LOD
Pd				0.000	0.0063	<LOD
Ru				0.000	0.0014	<LOD
Mo	0.08	0.04	0.14	0.092	0.0020	OK
Nb	0.003			0.001	0.0006	
Zr				0.000	0.0008	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.000	0.0053	<LOD
Cu	0.155	0.11	0.20	0.174	0.0123	OK
Ni	0.24	0.16	0.31	0.254	0.0237	OK
Co	0.022			0.000	0.0640	
Fe	86.0	81.70	90.30	85.946	0.1160	OK
Mn	0.35	0.25	0.46	0.406	0.0379	OK
Cr	12.25	11.64	12.86	12.258	0.0600	OK
V	0.024			0.055	0.0142	
Ti	0.002			0.060	0.0193	
S	0.29	0.20	0.38	0.334	0.0093	OK
P	0.026			0.034	0.0044	
Si	0.37	0.31	0.43	0.361	0.0200	OK
Al	0.003			0.000	0.0478	<LOD
Mg				0.000	0.0000	<LOD

	Iron Certified	BAS SCRM 660/09 Low	High	195-166 Measured	Err	
Bi				0.003	0.0014	
Pb				0.000	0.0020	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0166	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0042	<LOD
Sn				0.010	0.0042	
Cd				0.005	0.0047	<LOD
Ag				0.000	0.0046	<LOD
Pd				0.006	0.0051	<LOD
Ru				0.000	0.0015	<LOD
Mo				0.002	0.0007	
Nb				0.004	0.0008	
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0038	<LOD
Cu				0.000	0.0072	<LOD
Ni				0.040	0.0291	<LOD
Co				0.000	0.0573	<LOD
Fe	94.18	90.41	97.95	94.179	0.1007	OK
Mn	0.406	0.37	0.45	0.407	0.0181	OK
Cr				0.014	0.0077	
V				0.000	0.0286	<LOD
Ti				0.064	0.0192	
S	0.105	0.053	0.158	0.105	0.0065	OK
P	0.153	0.077	0.230	0.136	0.0071	OK
Si	1.70	1.19	2.21	1.544	0.0385	OK
Al				0.000	0.0542	<LOD
Mg				0.000	0.0000	<LOD

	LAS Certified	BS15a Low	High	195-167 Measured	Err	
Bi				0.002	0.0008	
Pb				0.000	0.0022	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0162	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0046	<LOD
Sn				0.006	0.0039	
Cd				0.000	0.0052	<LOD
Ag				0.000	0.0053	<LOD
Pd				0.000	0.0057	<LOD
Ru				0.000	0.0013	<LOD
Mo				0.008	0.0010	
Nb				0.047	0.0018	
Zr				0.028	0.0015	
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.005	0.0053	<LOD
Cu				0.021	0.0085	
Ni				0.121	0.0269	
Co				0.000	0.0560	<LOD
Fe	98.4	95.45	100.0	98.203	0.0965	OK
Mn	1.12	1.01	1.23	1.175	0.0251	OK
Cr				0.046	0.0082	
V				0.000	0.0344	<LOD
Ti				0.042	0.0176	
S				0.011	0.0042	
P				0.022	0.0044	
Si	0.058	0.03	0.1	0.049	0.0127	OK
Al				0.000	0.0522	<LOD
Mg				0.000	0.0000	<LOD

	Mar-M 247 Provisional	IARM 333a Low	High	195-173 Measured		
Bi				0.000	0.0021	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	*0.01*			0.000	0.0352	
W	*9.7*	8.73	10.67	9.856	0.2922	OK
Ta	*3.15*	2.84	3.47	3.027	0.1223	OK
Hf	*1.4*	1.260	1.540	1.496	0.0556	OK
Te				0.000	0.0000	<LOD
Sb				0.007	0.0061	<LOD
Sn				0.012	0.0061	
Cd				0.008	0.0080	<LOD
Ag				0.000	0.0070	<LOD
Pd				0.000	0.0075	<LOD
Ru				0.000	0.0022	<LOD
Mo	*0.49*	0.44	0.54	0.488	0.0077	OK
Nb	*0.005*			0.005	0.0014	
Zr	*0.009*			0.004	0.0015	
Y				0.000	0.0000	<LOD
Se				0.000	0.0161	<LOD
Zn				0.000		OK
Cu	*0.01*			0.000		OK
Ni	*61.1*	54.99	67.21	60.717	0.2891	OK
Co	*9.4*	8.46	10.34	9.662	0.0845	OK
Fe	*0.036*	0.016	0.056	0.038	0.0110	OK
Mn	*0.005*			0.000	0.0714	<LOD
Cr	*8.32*	7.49	9.15	8.511	0.0882	OK
V				0.050	0.0276	
Ti	*0.73*	0.621	0.840	0.747	0.0582	OK
S				0.043	0.0103	
P	*0.004*			0.070	0.0096	
Si	*0.08*			0.000	0.0828	
Al	*5.53*	4.98	6.08	5.270	0.1710	OK
Mg				0.000	0.0000	<LOD

Thermo Scientific
Portable Analytical Instruments
2 Radcliff Road
Tewksbury, MA 01876
USA
+1 978 670-7460 ph
+1 978 670-7430 fax
www.thermoscientific.com/pai

Certificate of Calibration

	CMSX-4 Provisional	IARM 332a Low	High	195-174 Measured	Err	
Bi				0.000	0.0022	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	2.9	2.465	3.335	2.977	0.0596	OK
W	6.5	5.525	7.475	6.733	0.2548	OK
Ta	6.51	5.534	7.487	6.955	0.1090	OK
Hf	0.098			0.082	0.0362	
Te				0.000	0.0000	<LOD
Sb				0.000	0.0065	<LOD
Sn				0.013	0.0050	
Cd				0.006	0.0060	<LOD
Ag				0.000	0.0056	<LOD
Pd				0.000	0.0056	<LOD
Ru				0.000	0.0019	<LOD
Mo	0.61	0.488	0.732	0.615	0.0012	OK
Nb				0.007	0.0012	
Zr				0.004	0.0009	
Y				0.000	0.0000	<LOD
Se				0.000	0.0130	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	61	59.17	62.83	59.469	0.2445	OK
Co	9.4	8.46	10.34	9.646	0.0689	OK
Fe	0.023			0.029	0.0083	
Mn				0.045	0.0375	<LOD
Cr	6.31	5.36	7.26	6.396	0.0659	OK
V				0.029	0.0472	<LOD
Ti	0.99	0.84	1.14	1.039	0.0546	OK
S				0.054	0.0120	
P				0.096	0.0135	
Si				0.000	0.0925	
Al	5.8	4.93	6.67	5.900	0.1843	OK
Mg				0.000	0.0000	<LOD

	Cu-Cd Certified	MBH 36X CCD2 Low	High	195-156 Measured	Err	
Bi				0.000	0.0022	<LOD
Pb				0.000	0.0026	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.062	0.0289	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0109	<LOD
Sb				0.014	0.0084	
Sn	0.2	0.16	0.24	0.196	0.0071	OK
Cd	1.18	1.003	1.357	1.180	0.0151	OK
Ag	0.0012			0.000	0.0057	<LOD
Pd				0.000	0.0080	<LOD
Ru				0.000	0.0023	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0013	<LOD
Y				0.000	0.0009	<LOD
Se				0.000	0.0017	<LOD
Zn	0.0019			0.000	0.0196	<LOD
Cu	98.6	98	99.2	98.481	0.1143	OK
Ni				0.000	0.0086	<LOD
Co				0.000	0.0104	<LOD
Fe				0.000	0.0115	<LOD
Mn				0.000	0.0189	<LOD
Cr				0.000	0.0219	<LOD
V				0.000	0.0393	<LOD
Ti				0.000	0.0702	<LOD
S				0.051	0.0044	
P				0.012	0.0046	
Si				0.000	0.0141	<LOD
Al				0.000	0.0647	<LOD
Mg				0.000	0.0000	<LOD

	AA7075 Cert	Low	ALC 7075 AF High	Measured	180-505 Err	
Bi	0.007			0.009	0.0012	
Pb	0.0073			0.008	0.0011	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0134	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0032	<LOD
Sb				0.000	0.0026	<LOD
Sn	0.014	0.004	0.024	0.015	0.0020	
Cd				0.000	0.0027	<LOD
Ag				0.000	0.0020	<LOD
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0009	<LOD
Mo				0.001	0.0004	<LOD
Nb				0.000	0.0003	<LOD
Zr	0.0024			0.004	0.0004	
Y				0.000	0.0003	<LOD
Se				0.000	0.0006	<LOD
Zn	5.75	5.463	6.038	5.524	0.0568	OK
Cu	1.750	1.575	1.925	1.684	0.0245	OK
Ni	0.027			0.024	0.0034	
Co				0.000	0.0059	OK
Fe	0.17	0.1275	0.2125	0.164	0.0108	OK
Mn	0.031			0.033	0.0106	
Cr	0.22	0.187	0.253	0.208	0.0251	OK
V	0.020			0.082	0.0345	
Ti	0.092	0.012	0.172	0.123	0.0582	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.095	0.285	0.227	0.0217	OK
Al	89	86.33	91.67	89.309	0.2461	OK
Mg	2.66	2.128	3.192	2.599	0.2966	OK

	CDA510 Certified	IARM 77b Low	High	195-177 Measured	Err	
Bi				0.000	0.0041	<LOD
Pb	0.016	0.008	0.024	0.019	0.0048	OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0000	<LOD
W				0.045	0.0477	<LOD
Ta				0.000	0.1250	<LOD
Hf				0.000	0.0116	<LOD
Te				0.000	0.0111	<LOD
Sb				0.000	0.0079	<LOD
Sn	4.66	4.520	4.800	4.627	0.0343	OK
Cd				0.000	0.0084	<LOD
Ag				0.000	0.0109	<LOD
Pd				0.000	0.0092	<LOD
Ru				0.000	0.0026	<LOD
Mo				0.000	0.0014	<LOD
Nb				0.000	0.0017	<LOD
Zr				0.000	0.0016	<LOD
Y				0.000	0.0010	<LOD
Se				0.000	0.0038	<LOD
Zn				0.000	0.0326	<LOD
Cu	95.2	94.248	96.152	95.082	0.1250	OK
Ni				0.000	0.0116	<LOD
Co				0.000	0.0143	<LOD
Fe				0.000	0.0187	<LOD
Mn				0.000	0.0210	<LOD
Cr				0.000	0.0359	<LOD
V				0.000	0.0472	<LOD
Ti				0.049	0.0553	<LOD
S				0.041	0.0041	
P	0.148	0.118	0.178	0.163	0.0101	OK
Si				0.000	0.0139	<LOD
Al				0.000	0.0709	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

Serial Number: X500872 | Model: Niton XL5 | Software: 5372 | Date of Q.C.: 23-Jul-18
Resolution: 159.8059 148.8597 | Escale: 7.385 7.377 | Spot Size: 3mm | Inspector: Lam

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.003	0.0008	
Pb			0.000	0.0026	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0167	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0054	<LOD
Sn			0.006	0.0040	
Cd			0.006	0.0056	<LOD
Ag			0.000	0.0050	<LOD
Pd			0.005	0.0052	<LOD
Ru			0.000	0.0014	<LOD
Mo			0.000	0.0008	<LOD
Nb			0.000	0.0008	<LOD
Zr			0.000	0.0007	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0012	<LOD
Zn			0.000	0.0039	<LOD
Cu			0.000	0.0070	<LOD
Ni			0.046	0.0280	
Co			0.000	0.0562	<LOD
Fe	99.75	100	99.928	0.0878	OK
Mn			0.000	0.0184	<LOD
Cr			0.000	0.0193	<LOD
V			0.000	0.0256	<LOD
Ti			0.029	0.0408	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.002	0.0050	<LOD
Pb			0.000		OK
Au			0.000	0.0000	<LOD
Re			0.000	0.0219	<LOD
W			0.222	0.1378	
Ta	99.4	100	99.675	0.2592	OK
Hf			0.000	0.1205	<LOD
Te			0.014	0.0125	<LOD
Sb			0.000	0.0107	<LOD
Sn			0.000	0.0117	<LOD
Cd			0.015	0.0097	
Ag			0.000	0.0114	<LOD
Pd			0.000	0.0097	<LOD
Ru			0.000	0.0035	<LOD
Mo			0.000	0.0017	<LOD
Nb			0.000	0.0022	<LOD
Zr			0.000	0.0021	<LOD
Y			0.000	0.0013	<LOD
Se			0.000	0.0309	<LOD
Zn			0.000		OK
Cu			0.000		OK
Ni			0.000	0.0153	<LOD
Co			0.000	0.0343	<LOD
Fe			0.017	0.0235	<LOD
Mn			0.000	0.0367	<LOD
Cr			0.000	0.0602	<LOD
V			0.000	0.0790	<LOD
Ti			0.101	0.1306	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.000	0.0040	<LOD
Pb			0.000	0.0039	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0306	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0293	<LOD
Sb			0.000	0.0202	<LOD
Sn	99	100	99.968	0.4963	OK
Cd			0.000	0.0151	<LOD
Ag			0.000	0.0083	<LOD
Pd			0.000	0.0084	<LOD
Ru			0.000	0.0025	<LOD
Mo			0.002	0.0010	
Nb			0.000	0.0013	<LOD
Zr			0.000	0.0019	<LOD
Y			0.000	0.0015	<LOD
Se			0.000	0.0027	<LOD
Zn			0.007	0.0093	<LOD
Cu			0.000	0.0154	<LOD
Ni			0.000	0.0160	<LOD
Co			0.000	0.0233	<LOD
Fe			0.000	0.0445	<LOD
Mn			0.000	0.0615	<LOD
Cr			0.084	0.1035	<LOD
V			0.000	0.1885	<LOD
Ti			0.000	0.4338	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.0020	<LOD
Pb			0.003	0.0021	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.038	0.0279	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0071	<LOD
Sb			0.000	0.0051	<LOD
Sn			0.000	0.0047	<LOD
Cd			0.000	0.0052	<LOD
Ag			0.000	0.0054	<LOD
Pd			0.000	0.0056	<LOD
Ru			0.000	0.0015	<LOD
Mo			0.000	0.0011	<LOD
Nb			0.000	0.0012	<LOD
Zr			0.000	0.0017	<LOD
Y			0.000	0.0007	<LOD
Se			0.000	0.0016	<LOD
Zn			0.000	0.0191	<LOD
Cu	99.8	100	99.956	0.0814	OK
Ni			0.009	0.0082	<LOD
Co			0.000	0.0091	<LOD
Fe			0.000	0.0123	<LOD
Mn			0.000	0.0137	<LOD
Cr			0.000	0.0200	<LOD
V			0.000	0.0317	<LOD
Ti			0.000	0.0576	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Certificate of Calibration

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.000	0.0019	<LOD
Pb			0.000		<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.7090	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.006	0.0065	<LOD
Sn			0.000	0.0052	<LOD
Cd			0.000	0.0072	<LOD
Ag			0.000	0.0064	<LOD
Pd			0.000	0.0069	<LOD
Ru			0.000	0.0018	<LOD
Mo			0.000	0.0009	<LOD
Nb			0.000	0.0010	<LOD
Zr			0.003	0.0006	
Y			0.000	0.0000	<LOD
Se			0.000	0.0167	<LOD
Zn			0.000	0.0615	<LOD
Cu			0.000	0.0331	<LOD
Ni	99.7	100	99.991	0.7161	OK
Co			0.000	0.0124	<LOD
Fe			0.000	0.0116	<LOD
Mn			0.000	0.0142	<LOD
Cr			0.000	0.0210	<LOD
V			0.016	0.0303	<LOD
Ti			0.000	0.0479	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.0009	<LOD
Pb			0.000		<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0087	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0035	<LOD
Sb			0.000	0.0024	<LOD
Sn			0.000	0.0023	<LOD
Cd			0.000	0.0026	<LOD
Ag			0.000	0.0025	<LOD
Pd			0.000	0.0030	<LOD
Ru			0.000	0.0007	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0003	<LOD
Se			0.000	0.0006	<LOD
Zn			0.002	0.0019	<LOD
Cu			0.000	0.0035	<LOD
Ni			0.000	0.0047	<LOD
Co			0.000	0.0052	<LOD
Fe			0.019	0.0123	
Mn			0.000	0.0167	<LOD
Cr			0.000	0.0776	<LOD
V			0.000	0.1031	<LOD
Ti	99.75	100	99.993	0.1315	OK
Al (Bal)			0.000	0.0000	<LOD
LEC					

20Cb3 IARM 25C 180-509

	Certified	Low	High	Measured	Err	
Bi				0.003	0.0016	
Pb				0.000	0.0018	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.08			0.187	0.1321	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.000	0.0046	
Sn	0.01	0.002	0.020	0.007	0.0040	
Cd				0.000	0.0043	
Ag				0.000	0.0043	<LOD
Pd				0.000	0.0048	<LOD
Ru				0.000	0.0023	<LOD
Mo	2.26	2.03	2.48	2.219	0.0122	OK
Nb	0.58	0.48	0.68	0.565	0.0063	OK
Zr				0.000	0.0010	
Y				0.000	0.0000	
Se				0.000	0.0042	
Zn				0.000	0.0142	
Cu	3.51	3.26	3.76	3.481	0.0495	OK
Ni	33.30	31.64	35.64	33.064	0.1578	OK
Co	0.091			0.179	0.0529	
Fe	38.80	36.8	40.8	38.692	0.1016	OK
Mn	0.90	0.40	1.40	0.938	0.0418	OK
Cr	19.97	19.57	20.57	19.907	0.0802	OK
V	0.095	0.035	0.155	0.122	0.0202	
Ti	0.003			0.048	0.0228	
Al (Bal)	0.019			0.000		<LOD
LEC				0.500		

Stellite 6B IARM 95B 180-502

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0018	
Pb				0.000		OK
Au				0.000	0.0000	
Re				0.000	0.0138	
W	3.42	3.12	3.72	3.448	0.0735	OK
Ta				0.000	0.0327	<LOD
Hf				0.134	0.0632	
Te				0.000	0.0000	
Sb				0.007	0.0046	
Sn				0.010	0.0038	
Cd				0.000	0.0044	
Ag				0.000	0.0043	<LOD
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0016	<LOD
Mo	0.83	0.70	0.96	0.837	0.0066	OK
Nb	0.002			0.002	0.0009	
Zr	0.002			0.000	0.0011	
Y				0.000	0.0000	
Se				0.000	0.0055	
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	2.25	1.80	2.70	2.268	0.0536	OK
Co	60.90	59.68	62.12	59.802	0.1550	
Fe	1.10	0.94	1.27	1.109	0.0339	OK
Mn	0.99	0.84	1.14	0.998	0.0400	OK
Cr	28.90	28.32	29.48	29.135	0.0942	OK
V	0.002			0.031	0.0264	
Ti	0.004			0.032	0.0214	
Al (Bal)	0.07			0.000		<LOD
LEC				2.250		

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	*0.01*			0.039	0.0115	
Pb	**5.03**	**4.68**	**5.44**	4.736	0.0386	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.060	0.0323	
Ta				0.000		OK
Hf				0.000		OK
Te				0.010	0.0113	
Sb	0.143	0.114	0.172	0.140	0.0074	OK
Sn	**4.37**	**3.46**	**5.38**	4.326	0.0250	OK
Cd				0.006	0.0083	<LOD
Ag	*0.02*			0.000	0.0062	<LOD
Pd				0.000	0.0086	<LOD
Ru				0.003	0.0022	<LOD
Mo				0.000	0.0011	<LOD
Nb				0.000	0.0011	<LOD
Zr				0.003	0.0019	<LOD
Y				0.000	0.0032	<LOD
Se				0.000	0.0035	<LOD
Zn	**5.38**	**4.79**	**6.08**	5.216	0.0354	OK
Cu	**84.6**	**82.60**	**86.60**	84.876	0.0797	OK
Ni	**0.27**	**0.10**	**0.40**	0.269	0.0107	OK
Co				0.000	0.0099	<LOD
Fe	**0.24**	**0.21**	**0.27**	0.238	0.0094	OK
Mn	0.002			0.000	0.0172	<LOD
Cr				0.000	0.0265	<LOD
V				0.000	0.0474	<LOD
Ti				0.057	0.0301	
Al (Bal)	0.002			0.000	0.0000	<LOD
LEC				#DIV/0!		

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.004	0.0008	
Pb	0.0009			0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0163	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0040	<LOD
Sn	0.002			0.000	0.0045	<LOD
Cd				0.000	0.0044	<LOD
Ag				0.000	0.0053	<LOD
Pd				0.000	0.0048	<LOD
Ru				0.000	0.0015	<LOD
Mo	**0.47**	**0.43**	**0.53**	0.497	0.0050	OK
Nb	0.002			0.000	0.0009	<LOD
Zr	0.001			0.000	0.0007	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0043	<LOD
Cu	0.033	0.013	0.053	0.026	0.0085	OK
Ni	0.071			0.093	0.0271	
Co	0.004			0.000	0.0571	<LOD
Fe	**96.96**	**95.9**	**98**	96.889	0.0841	OK
Mn	**0.56**	**0.35**	**0.75**	0.596	0.0228	OK
Cr	**1.11**	**0.89**	**1.33**	1.108	0.0213	OK
V	0.004			0.000	0.0305	<LOD
Ti	0.0016			0.022	0.0249	<LOD
Al (Bal)	0.028			0.000	0.0000	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0022	<LOD
Pb				0.000	0.0024	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**0.62**	**0.32**	**0.92**	0.745	0.1919	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0055	<LOD
Sn	0.002			0.000	0.0052	<LOD
Cd				0.000	0.0060	<LOD
Ag				0.000	0.0056	<LOD
Pd				0.000	0.0063	<LOD
Ru				0.000	0.0045	<LOD
Mo	**8.30**	**7.72**	**8.89**	8.444	0.0387	OK
Nb	**0.09**	**0.03**	**0.15**	0.092	0.0031	OK
Zr	0.004			0.000	0.0018	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0067	<LOD
Zn				0.000	0.0221	<LOD
Cu				0.000	0.0391	<LOD
Ni	**48.80**	**46.80**	**50.76**	47.641	0.2230	OK
Co	**1.11**	**0.93**	**1.35**	1.166	0.0493	OK
Fe	**18.30**	**17.39**	**19.22**	18.619	0.0835	OK
Mn	**0.47**	**0.20**	**0.90**	0.478	0.0419	OK
Cr	**21.60**	**20.74**	**22.47**	22.214	0.0938	OK
V	0.03			0.092	0.0227	
Ti	0.02			0.037	0.0469	<LOD
Al (Bal)	0.12			0.00	0.0000	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0019	<LOD
Pb				0.000	0.0026	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**6.30**	**5.8**	**6.87**	6.567	0.0915	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0050	<LOD
Sn	0.01			0.005	0.0048	<LOD
Cd				0.000	0.0053	<LOD
Ag				0.000	0.0053	<LOD
Pd				0.000	0.0058	<LOD
Ru				0.000	0.0035	<LOD
Mo	**4.85**	**4.61**	**5.15**	5.114	0.0214	OK
Nb				0.000	0.0016	<LOD
Zr				0.000	0.0010	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0069	<LOD
Zn				0.000	0.0201	<LOD
Cu	**0.13**	**0.091**	**0.169**	0.129	0.0153	OK
Ni	**0.35**	**0.245**	**0.455**	0.316	0.0224	OK
Co	**0.31**	**0.217**	**0.403**	0.363	0.0603	OK
Fe	**80.59**	**78.59**	**82.59**	80.023	0.1244	OK
Mn	**0.29**	**0.23**	**0.35**	0.319	0.0292	OK
Cr	**3.98**	**3.59**	**4.42**	4.058	0.0466	OK
V	**2.03**	**1.57**	**2.46**	1.831	0.0467	OK
Ti				0.052	0.0406	<LOD
Al (Bal)	0.02			0.00	0.0000	<LOD
LEC				1.24		

Certificate of Calibration

	SS321		IARM 6D		180-512	
	Certified	Low	High	Measured	Err	
Bi				0.004	0.0013	
Pb				0.000	0.0014	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09	0.030	0.190	0.164	0.0626	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0043	<LOD
Sn	0.013			0.013	0.0036	
Cd				0.004	0.0038	<LOD
Ag				0.000	0.0038	<LOD
Pd				0.000	0.0050	<LOD
Ru				0.000	0.0013	<LOD
Mo	0.358	0.29	0.44	0.365	0.0040	OK
Nb	0.039	0.01	0.06	0.039	0.0016	OK
Zr	0.002			0.001	0.0007	
Y				0.000	0.0000	<LOD
Se				0.000	0.0021	<LOD
Zn				0.000	0.0069	<LOD
Cu	0.302	0.15	0.5	0.293	0.0224	OK
Ni	9.42	9	9.8	9.296	0.0801	OK
Co	0.182	0.091	0.273	0.173	0.0632	
Fe	69.40	68.4	70.4	69.209	0.1285	OK
Mn	1.52	1.25	1.85	1.591	0.0459	OK
Cr	17.45	17.1	18	17.554	0.0731	OK
V	0.128	0.0768	0.1792	0.149	0.0202	
Ti	0.63	0.43	0.83	0.646	0.0334	OK
Al (Bal)	0.11			0.00	0.0000	<LOD
LEC				0.50		OK

	Ti 6-2-4-2		IARM 177C		180-503	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0019	<LOD
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0120	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0057	<LOD
Sb				0.000	0.0039	<LOD
Sn	2.02	1.818	2.222	2.025	0.0144	OK
Cd				0.000	0.0043	<LOD
Ag				0.000	0.0054	<LOD
Pd				0.000	0.0045	<LOD
Ru				0.000	0.0021	<LOD
Mo	1.96	1.725	2.195	1.960	0.0115	OK
Nb				0.000	0.0016	<LOD
Zr	3.99	3.59	4.39	3.990	0.0220	OK
Y				0.000	0.0011	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0034	<LOD
Cu	0.003			0.000	0.0055	<LOD
Ni	0.011			0.000	0.0078	<LOD
Co				0.000	0.0088	<LOD
Fe	0.033			0.000	0.0193	<LOD
Mn	0.0015			0.000	0.0224	<LOD
Cr				0.000	0.0826	<LOD
V	0.02			0.000	0.1418	<LOD
Ti	85.72	83.15	88.29	86.025	0.1601	OK
Al (Bal)	6.02			0.00		<LOD
LEC				6.0		OK

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007			0.009	0.0008	
Pb	0.0073			0.008	0.0007	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0089	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0020	<LOD
Sb				0.000	0.0014	<LOD
Sn	0.014	0.004	0.024	0.009	0.0013	OK
Cd				0.000	0.0015	<LOD
Ag				0.000	0.0012	<LOD
Pd				0.000	0.0017	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024			0.0024	0.0003	
Y				0.000	0.0002	<LOD
Se				0.000	0.0003	<LOD
Zn	5.75	5.463	6.038	5.750	0.0166	OK
Cu	1.750	1.575	1.925	1.754	0.0126	OK
Ni	0.027			0.027	0.0023	
Co				0.000	0.0032	<LOD
Fe	0.17	0.1445	0.1955	0.165	0.0075	OK
Mn	0.031			0.030	0.0071	
Cr	0.22	0.187	0.253	0.223	0.0174	OK
V	0.020			0.026	0.0288	<LOD
Ti	0.092	0.012	0.172	0.076	0.0435	OK
Al (Bal)	91.7	88.9102	94.4098	91.94	0.1103	OK
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

1.25Cr 0.5Mo	Provisional	Low	IARM35H High	Measured	195-019 Err	
Bi				0.004	0.0008	
Pb	0.001			0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0164	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb	0.002			0.000	0.0041	<LOD
Sn	0.002			0.000	0.0046	<LOD
Cd				0.000	0.0044	<LOD
Ag				0.000	0.0053	<LOD
Pd				0.000	0.0048	<LOD
Ru				0.000	0.0015	<LOD
Mo	0.47	0.423	0.517	0.500	0.0050	OK
Nb	0.002			0.000	0.0009	<LOD
Zr	0.001			0.000	0.0007	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0043	<LOD
Cu	0.032	0.017	0.077	0.026	0.0086	OK
Ni	0.071			0.094	0.0273	
Co	0.004			0.000	0.0572	<LOD
Fe	96.96	95.021	98.899	96.870	0.0705	OK
Mn	0.56	0.45	0.67	0.599	0.0229	OK
Cr	1.11	0.89	1.33	1.110	0.0088	OK
V	0.004			0.022	0.0029	
Ti	0.002			0.002	0.0022	<LOD
Al (Bal)	0.028			0.00	0.0000	<LOD
LEC	0.75			0.750		OK

Tool steel T-1	Certified	Low	IARM 48C High	Measured	195-152 Err	
Bi				0.007	0.0018	
Pb				0.000	0.0036	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	17.50	16.63	18.38	17.473	0.1188	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.011	0.0046	
Sn	0.012			0.022	0.0048	
Cd				0.006	0.0065	<LOD
Ag				0.000	0.0053	<LOD
Pd				0.000	0.0076	<LOD
Ru				0.000	0.0017	<LOD
Mo	0.17	0.150	0.190	0.173	0.0032	OK
Nb	0.005	0.001	0.010	0.005	0.0010	OK
Zr				0.002	0.0008	
Y				0.000	0.0000	<LOD
Se				0.000	0.0114	<LOD
Zn				0.000	0.0372	<LOD
Cu	0.13			0.074	0.0184	
Ni	0.204			0.157	0.0232	
Co	0.22			0.195	0.0608	
Fe	74.5	73.3825	75.618	74.641	0.1419	OK
Mn	0.39	0.27	0.51	0.444	0.0321	OK
Cr	4.24	3.90	4.58	4.495	0.0518	OK
V	1.27	1.08	1.46	1.270	0.0136	OK
Ti	0.006			0.000	0.0032	<LOD
Al (Bal)	0.017			0.00	0.0000	<LOD
LEC	1.025			1.025		OK

Custom 455	Certified	Low	IARM16B High	Measured	195-142 Err	
Bi				0.005	0.0015	
Pb				0.000	0.0010	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.094	0.0616	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.009	0.0038	
Sn	0.004			0.010	0.0037	
Cd				0.008	0.0047	
Ag				0.000	0.0042	<LOD
Pd				0.007	0.0053	<LOD
Ru				0.000	0.0012	<LOD
Mo	0.016	0.010	0.022	0.001	0.0010	<LOD
Nb	0.25	0.20	0.30	0.264	0.0041	OK
Zr				0.000	0.0008	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0021	<LOD
Zn				0.000	0.0080	<LOD
Cu	2.23	1.90	2.56	2.246	0.0410	OK
Ni	8.28	7.45	9.11	8.252	0.0788	OK
Co	0.027			0.083	0.0625	<LOD
Fe	76.4	72.58	80.22	76.408	0.1212	OK
Mn	0.026			0.066	0.0350	
Cr	11.44	10.52	12.36	11.411	0.0600	OK
V	0.067			0.060	0.0058	
Ti	1.11	0.999	1.221	1.112	0.0121	OK
Al (Bal)	0.062			0.000	0.0000	<LOD
LEC						

AA7075	Certified	Low	ALC 7075 AF High	Measured	180-505 Err	
Bi	0.007			0.009	0.0008	
Pb	0.0073			0.008	0.0007	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0089	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0020	<LOD
Sb				0.000	0.0014	<LOD
Sn	0.014	0.007	0.021	0.009	0.0013	OK
Cd				0.000	0.0015	<LOD
Ag				0.000	0.0012	<LOD
Pd				0.000	0.0017	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024	0.0004	0.0044	0.002	0.0003	OK
Y				0.000	0.0002	<LOD
Se				0.000	0.0003	<LOD
Zn	5.75	5.463	6.038	5.749	0.0164	OK
Cu	1.750	1.575	1.925	1.754	0.0126	OK
Ni	0.027			0.027	0.0023	
Co				0.000	0.0301	<LOD
Fe	0.17	0.1445	0.1955	0.165	0.0075	OK
Mn	0.031			0.030	0.0071	
Cr	0.22	0.187	0.253	0.220	0.0044	OK
V	0.020			0.030	0.0026	
Ti	0.092	0.062	0.122	0.092	0.0036	OK
Al (Bal)	91.7	88.9102	94.4098	91.908	0.0942	OK

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Small Spot Locator Sample (30s main filter only)

	Low	High	Measured	Err	
Cu	93	100	97.196	0.0786	OK
Ti			2.430	0.0596	
Al			0.000	0.0000	

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

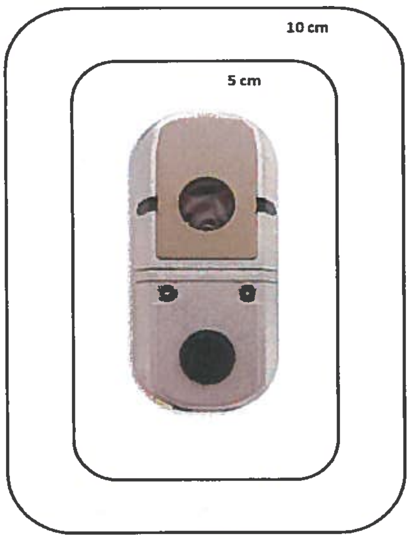
ThermoFisher
SCIENTIFIC

The world leader
in serving science

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model:	XL5 580-09131
Instrument S/N:	X500940

	RadEye
Detector Model:	B20-ER
Detector S/N:	0216
Calibration Date:	March 31, 2017



Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
706	173

• All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Steve DeSimone

Survey Date: August 28, 2017

Thermo Scientific
Portable Analytical Instruments

2 Radcliff Road, Tewksbury
Massachussetts 01876 USA

+1 978-670-7460
+1 978-670-7430 fax

www.thermoscientific.com/pai
800-875-1578 (toll free)

ThermoFisher SCIENTIFIC

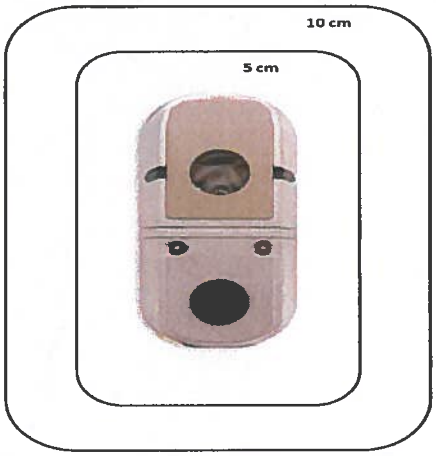
The world leader in serving science

Save Cert | Back | Clear Form

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model: XL5
Instrument S/N: 500875

Detector Model: RadEye
Detector S/N: 0216
Calibration Date: 4/24/2018



Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	**10 cm**
772	161

• All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Perry Pulicari

Survey 5/17/2018

ThermoFisher SCIENTIFIC

Certificate of Calibration

Serial Number: X500875 Model: Niton XL5 Software: 5372 Date of Q.C.: Thu Jun 21, 2018 - 15:2
Resolution: 170.736 149.377 Escale: 7.40897 7.4296 Inspector: VK

180 second analysis time, 60 seconds per filter, all 3 filters switched on, all results in ppm

SiO2 blank 180-615

Elem	Certified	Low	High	Measured	2-sigma		
Ba	0	0	20	11.5	9.3	OK	<LOD
Cs	0	0	20	0.0	11.0	OK	<LOD
Te	0	0	20	0.0	3.8	OK	<LOD
Sb	0	0	20	0.0	2.7	OK	<LOD
Sn	0	0	20	0.0	3.7	OK	<LOD
Cd	0	0	20	2.0	1.2	OK	
Pd	0	0	20	0.0	0.8	OK	<LOD
Ag	0	0	20	0.8	0.8	OK	<LOD
Mo	0	0	10	0.0	0.5	OK	<LOD
Th	0	0	10	0.0	0.7	OK	<LOD
Zr	0	0	10	0.0	0.5	OK	<LOD
Sr	0	0	10	0.0	0.2	OK	<LOD
U	0	0	10	0.0	1.0	OK	<LOD
Rb	0	0	10	0.0	0.4	OK	<LOD
As	0	0	10	0.0	0.4	OK	<LOD
Se	0	0	10	0.0	0.2	OK	<LOD
Au	0	0	10	0.0	1.6	OK	<LOD
Hg	0	0	30	0.0	2.2	OK	<LOD
Pb	0	0	10	0.0	0.5	OK	<LOD
W	0	0	10	0.0	4.6	OK	<LOD
Zn	0	0	10	0.0	0.8	OK	<LOD
Cu	0	0	10	0.0	2.0	OK	<LOD
Ni	0	0	20	0.0	3.9	OK	<LOD
Co	0	0	20	0.0	3.6	OK	<LOD
Fe	0	0	20	0.0	7.6	OK	<LOD
Mn	0	0	20	0.0	10.5	OK	<LOD
Cr	0	0	20	0.0	3.0	OK	<LOD
V	0	0	20	0.0	2.7	OK	<LOD
Ti	0	0	20	0.0	8.4	OK	<LOD
Sc	0	0	20	0.0	2.1	OK	<LOD
Ca	0	0	100	0.0	5.3	OK	<LOD
K	0	0	50	0.0	12.3	OK	<LOD
S	0	0	60	0.0	30.1	OK	<LOD

NIST 2710 180-427

Elem	Certified	Low	High	Measured	2-sigma		
Ba	707	530.3	883.8	796.6	19.5	OK	
Cs	107	96.3	117.7	107.9	14.4	OK	
Te				0.0	7.1		
Sb	38.4	19.2	57.6	26.5	4.6	OK	
Sn				21.8	4.3		
Cd	21.8	15.26	28.34	18.2	2.4	OK	
Pd				0.0	1.3		
Ag	35.3	28.24	42.36	34.2	2.0	OK	
Mo	19	13.3	24.7	19.6	1.2	OK	
Th	13			28.2	7.7		
Zr				155.5	2.7		
Sr	330	247.5	412.5	393.1	2.6	OK	
U	25			42.2	4.0		
Rb	120	78	162	147.8	2.7	OK	
As	626			841.2	16.0		
Se				4.4	1.0		
Au	0.6			0.0	8.0		<LOD
Hg	32.6	26.08	39.12	34.6	8.8	OK	
Pb	5532	4425.6	6638.4	6141.4	20.3	OK	
W	93			152.3	23.6		
Zn	6952	5561.6	8342.4	7115.9	19.5	OK	
Cu	2950	2655	3245	2981.1	23.2	OK	
Ni	14.3			49.4	8.7		
Co	10			0.0	37.2		<LOD
Fe	33800	25350	42250	41251.6	119.3	OK	
Mn	10100	8080	12120	10137.7	83.4	OK	
Cr	39			57.7	6.1		
V	76.6	57.45	95.75	85.9	9.6	OK	
Ti	2830	2264	3396	3300.0	32.8	OK	
Sc	8.7			52.0	31.1		
Ca	12500	10000	15000	14202.9	141.3	OK	
K	21100	16880	25320	24772.0	206.8	OK	
S	2400			5394.0	205.5		

NIST 2711a 180-688

Elem	Certified	Low	High	Measured	2-sigma		
Ba	730	547.5	912.5	707.2	14.7	OK	
Cs				48.4	10.7		
Te				0.0	5.4		
Sb	23.8			14.9	3.5		
Sn				18.1	3.2		
Cd	54.1	45.99	62.22	48.5	2.1	OK	
Pd				0.0	1.0		<LOD
Ag	6			5.4	1.1		
Mo				0.0	0.8		<LOD
Th	15	7.5	11.25	14.4	3.2		
Zr				328.9	2.6		
Sr	242	193.6	290.4	235.7	1.6	OK	
U	3			6.8	2.2		
Rb	120			116.7	1.8		
As	107	85.6	128.4	121.0	6.3	OK	
Se	2			2.2	0.5		
Au				0.0	3.5		<LOD
Hg	7.42			6.4	3.5		
Pb	1400	1120	1680	1359.9	8.2	OK	
W				0.0	7.2		<LOD
Zn	414	331.2	496.8	365.1	4.0	OK	
Cu	140	110.6	169.4	114.1	4.7	OK	
Ni	21.7			20.1	6.3		
Co	9.9			0.0	36.9		<LOD
Fe	28200	25380	31020	28110.3	88.7	OK	
Mn	675	337.5	1012.5	558.9	22.2	OK	
Cr	52.3	26.15	78.45	72.1	4.2	OK	
V	80.47	64.376	96.564	82.2	7.1	OK	
Ti	3170	2853	3487	3043.9	24.3	OK	
Sc	8.5			66.1	32.4		
Ca	24200	20570	27830	26749.3	143.1	OK	
K	25300	22770	27830	25261.1	164.6	OK	
S				1276.7	102.1		

NIST 2709 180-425

Elem	Certified	Low	High	Measured	2-sigma		
Ba	968	658.24	1277.76	685.5	15.2	OK	
Cs	5.3			14.6	11.0		
Te				0.0	5.5		
Sb	7.9			0.0	3.5		<LOD
Sn				4.9	3.3		
Cd	0.38			0.0	1.7		<LOD
Pd				0.0	1.0		<LOD
Ag	0.41			0.0	1.1		<LOD
Mo	2			0.0	1.1		<LOD
Th	11			10.2	1.5		
Zr	160	128	192	144.2	2.0	OK	
Sr	231	196.35	265.65	214.0	1.8	OK	
U	3			4.7	2.2		
Rb	96	76.8	115.2	85.6	1.8	OK	
As	17.7	12.39	23.01	17.7	1.2	OK	
Se	1.57			0.9	0.3		
Au	0.3			0.0	2.4		<LOD
Hg	1.4			0.0	5.4		<LOD
Pb	18.9	14.18	23.63	15.5	1.3	OK	
W	2			0.0	7.2		<LOD
Zn	106	74.2	137.8	88.1	2.4	OK	
Cu	34.6	20.76	48.44	26.9	3.6	OK	
Ni	88	61.6	114.4	88.0	8.6		
Co	13.4			0.0	44.1		<LOD
Fe	35000	31500	38500	32564.9	105.7	OK	
Mn	538	376.6	699.4	458.9	23.7	OK	
Cr	130	91	169	110.8	5.4	OK	
V	112	84	140	101.4	8.7	OK	
Ti	3420	2804.4	4035.6	3007.8	29.3	OK	
Sc	12			44.1	32.9		<LOD
Ca	18900	17010	20790	19705.7	147.7	OK	
K	20300	18270	22330	16635.8	164.3		
S	890	801	979	763.0	107.2		

Thermo Scientific
Field and Safety Instruments
2 Radcliff Road
Tewksbury, MA 01876
USA
+1 978 670-7460 ph
+1 978 670-7430 fax
www.thermoscientific.com/pai

DL-1a 180-612

Elem	Certified	Low	High	Measured	2-sigma		
Ba				306.4	12.6		
Cs				29.4	9.6		
Te				0.0	4.9		<LOD
Sb				0.0	3.1		<LOD
Sn				7.9	2.9		
Cd				0.0	1.5		<LOD
Pd				0.0	0.9		<LOD
Ag				0.0	0.9		<LOD
Mo				3.2	0.8		
Th	76	64.6	87.4	70.0	2.4	OK	
Zr				78.1	1.4		
Sr				15.9	0.5		
U	116	104.4	127.6	115.2	3.9	OK	
Rb				97.2	2.0		
As				0.0	2.2		<LOD
Se				1.1	0.4		
Au				0.0	0.0		
Hg				1.7	3.0		<LOD
Pb				67.1	2.2		
W				0.0	6.3		<LOD
Zn				57.1	1.9		
Cu				7.7	2.8		
Ni				0.0	8.2		<LOD
Co				0.0	20.2		<LOD
Fe	*9300*			7027.4	53.5		
Mn				45.1	14.2		
Cr				66.9	3.4		
V				27.8	4.2		
Ti				858.2	14.6		
Sc				0.0	12.1		<LOD
Ca				2987.2	58.5		
K				22169.0	142.5		
S	*4100*			1381.3	76.5		

TILL 4 180-646

Elem	Certified	Low	High	Measured	2-sigma		
Ba	395	237	553	418.0	15.6	OK	
Cs	12			47.7	11.8		
Te				0.0	5.9		
Sb	1			0.0	3.7		<LOD
Sn				22.7	3.6		
Cd				0.0	1.8		<LOD
Pd				0.0	1.1		<LOD
Ag				0.0	1.1		<LOD
Mo	16	8	24	13.4	1.1	OK	
Th	17.4	8.7	26.1	20.2	2.8	OK	
Zr	385	346.5	423.5	372.0	3.1	OK	
Sr	109	98.1	119.9	114.3	1.4	OK	
U	5			4.7	2.4		
Rb	161	144.9	177.1	156.5	2.4	OK	
As	111	83.25	138.75	108.2	2.5	OK	
Se				2.5	0.5		
Au				5.5	3.4		
Hg				3.3	5.1		
Pb	50	42.5	57.5	46.6	2.1	OK	
W	204	183.6	224.4	205.5	11.8	OK	
Zn	70	52.5	87.5	55.2	2.3	OK	
Cu	237.0	189.6	284.4	198.3	6.8	OK	
Ni	17			16.2	7.8		
Co	8			0.0	54.0		<LOD
Fe	39378	35440.2	43315.8	39480.6	116.7	OK	
Mn	490	343	637	425.6	24.0	OK	
Cr	53			70.7	5.3		
V	67	46.9	87.1	82.3	9.6	OK	
Ti	4840	3872	5324	4332.1	32.3	OK	
Sc	10			0.0	30.8		<LOD
Ca	8934	7147.2	10720.8	8540.3	114.9	OK	
K	26980	22933	31027	24320.7	204.0	OK	
S	800	600	1000	788.2	116.3		

NIST 2780 180-601

Elem	Certified	Low	High	Measured	2-sigma		
Ba	993	695.1	1290.9	1064.5	20.4	OK	
Cs	*13*			60.4	14.5		
Te	*5*			0.0	7.2		<LOD
Sb	*160*	144	176	162.1	5.4	OK	
Sn				25.5	4.4		
Cd	12.1			6.7	2.3		
Pd				0.0	1.3		<LOD
Ag	27	18.9	35.1	24.2	1.8	OK	
Mo	*11*	7.7	14.3	8.8	1.1	OK	
Th	12			21.9	7.4		
Zr	*176*	132	220	199.0	2.9	OK	
Sr	217	173.6	260.4	245.0	2.2	OK	
U	*4*	3.2	4.8	11.8	3.3		
Rb	*175*	140	210	185.1	3.0	OK	
As	48.8			32.3	14.8		
Se	*5*			6.8	1.0		
Au	0.18			0.0	10.7		<LOD
Hg	0.71			0.0	6.5		<LOD
Pb	5770	4904.5	6635.5	5073.8	19.6	OK	
W				30.3	15.5		
Zn	2570	1799	3341	2227.8	12.0	OK	
Cu	215.5	150.85	280.15	159.0	6.9	OK	
Ni	*12*			0.0	13.3		<LOD
Co	*2.2*			51.8	34.2		
Fe	27840	25056	30624	29021.8	114.2	OK	
Mn	462	369.6	554.4	532.5	28.1	OK	
Cr	*44*			61.4	5.7		
V	268	241.2	294.8	264.9	12.8	OK	
Ti	6990	6291	7689	7113.6	40.9	OK	
Sc	*23*			0.0	19.7		<LOD
Ca	1950			2878.6	90.9		
K	33800	30420	37180	35521.7	236.7	OK	
S	12630	11367	13893	12638.4	254.9	OK	

JSAC 403 180-726

Elem	Certified	Low	High	Measured	2-sigma		
Ba				384.4	14.9		
Cs				36.9	11.3		
Te				0.0	5.7		<LOD
Sb				0.0	3.7		<LOD
Sn				8.2	3.4		
Cd	183	164.7	201.3	184.3	3.3	OK	
Pd				0.0	1.2		<LOD
Ag				1.3	1.2		<LOD
Mo				0.0	0.9		<LOD
Th				12.6	2.1		
Zr				295.2	2.7		
Sr				52.3	0.9		
U				4.9	2.1		
Rb				80.6	1.8		
As	199	159.2	238.8	198.6	3.8	OK	
Se	169	152.1	185.9	169.0	1.4	OK	
Au				0.0	5.6		<LOD
Hg	11.1	3.33	19.98	6.5	3.4	OK	
Pb	224	179.2	268.8	196.1	4.0	OK	
W				0.0	0.0		
Zn	91.8	68.85	114.75	72.5	2.3	OK	
Cu	26	13.1	39.3	21.1	3.5	OK	
Ni	26.2			21.2	7.6		
Co				0.0	52.4		<LOD
Fe				37421.8	112.5		
Mn	252	189	315	262.7	21.3	OK	
Cr	257	205.6	308.4	251.7	6.3	OK	
V	101	75.75	126.25	107.9	9.6	OK	
Ti				4539.9	31.8		
Sc				0.0	18.9		<LOD
Ca				4080.9	80.7		
K				14207.4	157.4		
S				380.6	106.5		

AGV-2 180-678

Elem	Certified	Low	High	Measured	2-sigma		
Ba	1140	912	1368	1139.5	18.6	OK	
Cs				68.2	12.9		
Te				0.0	6.4		<LOD
Sb	0.6			0.0	4.0		<LOD
Sn	2.3			16.3	3.8		
Cd				0.0	1.9		<LOD
Pd				0.0	1.2		<LOD
Ag				0.0	1.3		<LOD
Mo				0.0	1.0		<LOD
Th	6.1	4.27	7.93	4.7	1.4		
Zr	230	207	253	243.9	3.0		
Sr	658	592.2	723.8	624.4	3.2		
U	1.88			6.8	2.9		
Rb	68.6	61.74	75.46	62.4	1.7		
As				0.0	1.4		<LOD
Se				0.0	0.4		<LOD
Au				0.0	2.7		<LOD
Hg				0.0	3.8		<LOD
Pb	13	7.8	18.2	12.5	1.4	OK	
W				0.0	8.0		<LOD
Zn	86	68.8	103.2	67.4	2.4		
Cu	53	37.1	68.9	38.7	4.2	OK	
Ni	19			18.6	8.4		
Co	16			52.1	39.1		<LOD
Fe	46800	42120	51480	43178.0	125.6	OK	
Mn	770	577.5	962.5	661.0	28.6	OK	
Cr	17			45.7	5.7		
V	120	102	138	103.1	11.7	OK	
Ti	6300	5670	6930	5713.4	40.8	OK	
Sc	13	11.7	14.3	110.8	49.2		
Ca	37200	33480	40920	36165.5	209.2	OK	
K	23900	21510	26290	23377.9	206.3	OK	
S				0.0	112.8		<LOD

NCS DC 73309 180-727

Elem	Certified	Low	High	Measured	2-sigma		
Ba	260			281.4	16.3		
Cs				32.8	12.7		
Te				0.0	6.2		<LOD
Sb	14.9			0.0	3.9		<LOD
Sn	370	333	407	370.0	5.6	OK	
Cd	2.3			0.0	2.3		<LOD
Pd				0.0	1.1		<LOD
Ag	3.2			3.2	1.2		
Mo	5.9	4.13	7.67	4.5	0.9	OK	
Th	23.3	11.65	34.95	33.3	3.8	OK	
Zr	153	137.7	168.3	147.1	2.0	OK	
Sr	29	23.2	34.8	29.0	0.8	OK	
U	9.1			14.0	3.0		
Rb	408	367.2	448.8	399.7	3.8	OK	
As	188	141	235	195.4	5.4	OK	
Se	0.2			2.3	0.5		
Au				0.0	0.0		
Hg	0.072			4.5	4.8		
Pb	636	572.4	699.6	610.2	6.5	OK	
W	126	100.8	151.2	123.6	11.0	OK	
Zn	373	298.4	447.6	326.6	4.4	OK	
Cu	79	59.25	98.75	66.0	4.6	OK	
Ni	14.3			12.0	7.3		
Co	8.5			0.0	40.0		<LOD
Fe	30705	27634.5	33775.5	30314.2	106.3	OK	
Mn	2490	1867.5	3112.5	2030.7	42.2	OK	
Cr	40	36	44	78.9	4.8		
V	47	42.3	51.7	52.2	6.9		
Ti	2100	1890	2310	2061.5	23.0	OK	
Sc	7.4	6.66	8.14	0.0	16.7		<LOD
Ca	2723	2042.25	3403.75	2794.9	77.8	OK	
K	27229	24506.1	29951.9	27814.6	201.4	OK	
S	170			364.6	99.6		

NCS DC 93007 180-707

Elem	Certified	Low	High	Measured	2-sigma		
Ba				641.7	34.5		
Cs				117.7	25.9		
Te				30.6	13.0		
Sb				0.0	8.0		<LOD
Sn				54.3	8.1		
Cd				0.0	3.9		<LOD
Pd				3.6	2.5		<LOD
Ag	26.2	19.65	32.75	29.7	3.4	OK	
Mo				60.2	2.2		
Th				0.0	5.5		<LOD
Zr				37.0	2.6		
Sr				104.5	2.4		
U				6.1	4.6		<LOD
Rb				92.9	3.6		
As				26.1	6.2		
Se				11.0	1.2		
Au	37.3			34.1	8.6		
Hg				47.2	12.0		
Pb				292.8	8.5		
W				0.0	33.4		<LOD
Zn				618.6	12.2		
Cu				8416.1	66.6		
Ni				395.1	38.7		
Co				344.6	122.8		
Fe				300382.3	356.9		
Mn				411.2	42.7		
Cr				31.6	15.3		
V				50.7	19.2		
Ti				2151.0	64.5		
Sc				0.0	78.1		<LOD
Ca				11340.9	254.5		
K				23422.4	394.3		
S				205949.6	1374.9		

G310-10 180-728

Elem	Certified	Low	High	Measured	2-sigma		
Ba				538.7	17.0		
Cs				0.0	3.9		<LOD
Te				0.0	6.3		<LOD
Sb				0.0	3.9		<LOD
Sn				20.0	3.8		
Cd				0.0	1.9		<LOD
Pd				0.0	1.1		<LOD
Ag	10.5			8.7	1.4		
Mo				0.0	0.9		<LOD
Th				12.5	1.7		
Zr				130.3	2.1		
Sr				174.6	1.7		
U				9.6	2.5		
Rb				99.6	2.1		
As				0.0	1.3		<LOD
Se				0.0	0.5		<LOD
Au	48	36	60	48.0	4.4	OK	
Hg				0.0	4.6		<LOD
Pb				20.8	1.6		
W				0.0	0.0		
Zn				63.6	2.3		
Cu				26.5	3.8		
Ni				29.9	8.5		
Co				45.1	39.3		<LOD
Fe				45081.1	125.7		
Mn				631.7	27.9		
Cr				95.4	5.9		
V				124.0	11.4		
Ti				5829.0	37.7		
Sc				118.9	49.9		
Ca				37611.4	211.3		
K				18724.5	187.9		
S				208.9	115.5		

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Standards used for factory calibrations are either certified reference standards (CRM) or reference samples (RM).
Certificates of Analysis (CoA) are available on request, if available.
Values in italics are informational only (i.e. not certified)

Signed

Lee A. Graham
Director of Quality, FSI

Thermo Fisher SCIENTIFIC

Certificate of Calibration

XL5 PMA 8mm QC Sheet
Document: 140-00243c
Release Date: 9 May 2016

Serial Number: X500875 Model XL5: Software: 5372 Date of Q.C.: 21-Jun-18

Resolution: 173.4495 148.8837 Escale: 7.4089 7.4292 8mm spot size Inspector: VK

30 second analysis times

195-080 Pure Au (avg of 3)

	Low	High	Measured	Err	
Sn	0	0.05	0.000	0.006	<LOD
In	0	0.05	0.000	0.005	<LOD
Cd	0	0.05	0.000	0.008	<LOD
Ag	0	0.04	0.000	0.005	<LOD
Pd	0	0.03	0.000	0.011	<LOD
Rh	0	0.03	0.000	0.005	<LOD
Ru	0	0.06	0.000	0.012	<LOD
Mo	0	0.03	0.000	0.021	<LOD
Nb	0	0.03	0.000	0.012	<LOD
Zr	0	0.03	0.000	0.006	<LOD
Pb	0	0.05	0.000	0.024	<LOD
Au	99.7	100.0	99.98	0.436	OK
Pt	0	0.40	0.000	0.165	<LOD
Ir	0	0.10	0.000	0.044	<LOD
W	0	0.10	0.000	0.005	<LOD
Ge	0	0.40	0.000	0.105	<LOD
Ga	0	0.05	0.000	0.023	<LOD
Zn	0	0.10	0.000	0.048	<LOD
Cu	0	0.05	0.000	0.022	<LOD
Ni	0	0.07	0.000	0.024	<LOD
Co	0	0.07	0.000	0.029	<LOD
Fe	0	0.09	0.000	0.044	<LOD
Mn	0	0.05	0.015	0.059	<LOD
Cr	0	0.10	0.000	0.095	<LOD
V	0	0.30	0.000	0.152	<LOD
Ti	0	0.40	0.000	0.325	<LOD
Al	0	0.50	0.000	0.005	<LOD
Karat			23.997		

195-074 Pure Pt (avg of 3)

	Low	High	Measured	Err	
Sn	0	0.05	0.000	0.006	<LOD
In	0	0.05	0.000	0.005	<LOD
Cd	0	0.05	0.000	0.005	<LOD
Ag	0	0.10	0.000	0.010	<LOD
Pd	0	0.02	0.000	0.006	<LOD
Rh	0	0.04	0.000	0.010	<LOD
Ru	0	0.07	0.005	0.009	<LOD
Mo	0	0.03	0.000	0.021	<LOD
Nb	0	0.03	0.000	0.012	<LOD
Zr	0	0.03	0.000	0.006	<LOD
Pb	0	0.10	0.000	0.043	<LOD
Au	0	0.60	0.000	0.087	<LOD
Pt	99.5	100.0	99.72	0.436	OK
Ir	0	0.50	0.241	0.153	<LOD
W	0	0.20	0.029	0.109	<LOD
Ge	0	0.10	0.000	0.029	<LOD
Ga	0	0.20	0.000	0.083	<LOD
Zn	0	0.06	0.000	0.018	<LOD
Cu	0	0.10	0.000	0.048	<LOD
Ni	0	0.06	0.000	0.022	<LOD
Co	0	0.07	0.007	0.024	<LOD
Fe	0	0.09	0.000	0.043	<LOD
Mn	0	0.10	0.000	0.069	<LOD
Cr	0	0.10	0.000	0.083	<LOD
V	0	0.30	0.000	0.130	<LOD
Ti	0	0.30	0.000	0.315	<LOD
Al	0	0.40	0.000	0.005	<LOD

60 second analysis times

195-079 Pt Ir Foil 90:10

	Expected	Low	High	Measured	Err	
Sn		0	0.03	0.000	0.005	<LOD
In		0	0.03	0.000	0.005	<LOD
Cd		0	0.03	0.000	0.005	<LOD
Ag		0	0.15	0.000	0.007	<LOD
Pd		0	0.05	0.000	0.005	<LOD
Rh		0.00	0.03	0.000	0.006	<LOD
Ru		0	0.03	0.000	0.008	<LOD
Mo		0	0.03	0.000	0.013	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.05	0.039	0.039	<LOD
Au		0	0.15	0.000	0.061	<LOD
Pt	90.0	89.20	90.80	89.913	0.271	OK
Ir	10.0	9.60	10.40	9.940	0.121	OK
W		0	0.03	0.094	0.055	<LOD
Ge		0	0.1	0.000	0.019	<LOD
Ga		0	0.10	0.000	0.087	<LOD
Zn		0	0.03	0.014	0.010	<LOD
Cu		0	0.05	0.000	0.046	<LOD
Ni		0	0.03	0.000	0.014	<LOD
Co		0	0.03	0.000	0.019	<LOD
Fe		0	0.05	0.000	0.020	<LOD
Mn		0	0.05	0.000	0.056	<LOD
Cr		0	0.05	0.000	0.080	<LOD
V		0	0.20	0.000	0.109	<LOD
Ti		0	0.15	0.000	0.178	<LOD
Al		0	0.05	0.000	0.005	<LOD

195-078 Pd Ag Foil 75:25

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.036	<LOD
In		0	0.10	0.000	0.048	<LOD
Cd		0	0.05	0.000	0.012	<LOD
Ag	25	24.00	26.00	25.381	0.201	OK
Pd	75	74.25	75.75	74.384	0.549	OK
Rh		0	0.05	0.000	0.016	<LOD
Ru		0	0.05	0.000	0.010	<LOD
Mo		0	0.05	0.000	0.013	<LOD
Nb		0	0.05	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.05	0.000	0.006	<LOD
Au		0	0.05	0.000	0.016	<LOD
Pt		0	0.10	0.026	0.011	OK
Ir		0	0.05	0.000	0.022	<LOD
W		0	0.06	0.000	0.034	<LOD
Ge		0	0.05	0.000	0.009	<LOD
Ga		0	0.05	0.000	0.009	<LOD
Zn		0	0.05	0.000	0.017	<LOD
Cu		0	0.05	0.000	0.020	<LOD
Ni		0	0.05	0.000	0.028	<LOD
Co		0	0.05	0.000	0.038	<LOD
Fe		0	0.08	0.000	0.094	<LOD
Mn		0	0.10	0.000	0.154	<LOD
Cr		0	0.20	0.000	0.124	<LOD
V		0	0.40	0.209	0.183	<LOD
Ti		0	0.40	0.000	0.668	<LOD
Al		0	0.05	0.000	0.005	<LOD

ThermoFisher SCIENTIFIC

Certificate of Calibration

195-171 FLX 0738-16 14K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.024	<LOD
In		0	0.10	0.000	0.005	<LOD
Cd		0	0.10	0.000	0.005	<LOD
Ag	19.8	19.21	20.39	19.692	0.089	OK
Pd		0	0.05	0.000	0.006	<LOD
Rh		0	0.05	0.000	0.006	<LOD
Ru		0	0.05	0.000	0.009	<LOD
Mo		0	0.03	0.000	0.010	<LOD
Nb		0	0.03	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.010	<LOD
Au	58.6	57.72	59.48	58.648	0.173	OK
Pt		0	0.40	0.000	0.079	<LOD
Ir		0	0.05	0.000	0.040	<LOD
W		0	0.03	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.060	<LOD
Ga		0	0.05	0.000	0.017	<LOD
Zn	0.52	0.26	0.78	0.593	0.031	OK
Cu	21.1	20.79	21.41	21.067	0.084	OK
Ni		0	0.05	0.000	0.014	<LOD
Co		0	0.05	0.000	0.018	<LOD
Fe		0	0.05	0.000	0.037	<LOD
Mn		0	0.10	0.000	0.061	<LOD
Cr		0	0.10	0.000	0.049	<LOD
V		0	0.20	0.000	0.089	<LOD
Ti		0	0.30	0.000	0.173	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	14.06	13.85	14.27	14.076		OK

180-655 FLX 0704-16 18K Au Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.008	<LOD
In		0	0.10	0.037	0.015	OK
Cd		0	0.10	0.000	0.005	<LOD
Ag	3.0	2.79	3.21	2.898	0.026	OK
Pd	12.53	12.28	12.78	12.435	0.065	OK
Rh		0	0.05	0.000	0.006	<LOD
Ru		0	0.05	0.000	0.007	<LOD
Mo		0	0.03	0.000	0.012	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.012	<LOD
Au	75.1	73.60	76.60	75.177	0.211	OK
Pt		0	0.40	0.000	0.086	<LOD
Ir		0	0.05	0.000	0.029	<LOD
W		0	0.03	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.066	<LOD
Ga		0	0.05	0.000	0.014	<LOD
Zn		0	0.25	0.000	0.025	<LOD
Cu	9.4	8.98	9.82	9.452	0.061	OK
Ni		0	0.05	0.000	0.015	<LOD
Co		0	0.05	0.000	0.019	<LOD
Fe		0	0.05	0.000	0.035	<LOD
Mn		0	0.10	0.000	0.062	<LOD
Cr		0	0.10	0.000	0.054	<LOD
V		0	0.20	0.000	0.097	<LOD
Ti		0	0.30	0.000	0.191	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	18.02	17.66	18.38	18.043		OK

180-656 FLX 0715-16 14K Au Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.005	<LOD
In		0	0.10	0.000	0.005	<LOD
Cd		0	0.10	0.000	0.005	<LOD
Ag		0	0.20	0.000	0.005	<LOD
Pd		0	0.05	0.000	0.005	<LOD
Rh		0	0.05	0.035	0.005	OK
Ru		0	0.05	0.000	0.005	<LOD
Mo		0	0.03	0.000	0.010	<LOD
Nb		0	0.03	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.05	0.000	0.010	<LOD
Au	58.7	57.82	59.58	57.852	0.146	OK
Pt		0	0.05	0.000	0.069	<LOD
Ir		0	0.05	0.000	0.023	<LOD
W		0	0.03	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.053	<LOD
Ga		0	0.07	0.000	0.015	<LOD
Zn	9.00	8.55	9.45	9.322	0.055	OK
Cu	26.3	25.25	27.35	26.460	0.082	OK
Ni	5.99	5.69	6.29	6.096	0.047	OK
Co		0	0.05	0.013	0.009	<LOD
Fe		0	0.05	0.017	0.013	<LOD
Mn		0	0.10	0.043	0.018	OK
Cr		0	0.10	0.062	0.025	OK
V		0	0.20	0.000	0.092	<LOD
Ti		0	0.30	0.101	0.091	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	14.09	13.88	14.30	13.88		OK

195-XXX MBH 132X AGB87a

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.045	<LOD
In		0	0.1	0.000	0.018	<LOD
Cd		0	0.1	0.016	0.011	<LOD
Ag	87.3	86.28	88.38	87.683	0.497	OK
Pd		0	0.05	0.000	0.014	<LOD
Rh		0	0.05	0.000	0.012	<LOD
Ru		0	0.05	0.000	0.006	<LOD
Mo		0	0.05	0.000	0.012	<LOD
Nb		0	0.03	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.009	<LOD
Au		0.00	0.05	0.012	0.009	<LOD
Pt		0	0.05	0.000	0.016	<LOD
Ir		0	0.05	0.019	0.015	<LOD
W		0	0.05	0.000	0.035	<LOD
Ge		0	0.05	0.000	0.010	<LOD
Ga		0	0.05	0.000	0.016	<LOD
Zn		0	0.05	0.000	0.046	<LOD
Cu	12.6	11.71	13.41	12.271	0.101	OK
Ni		0	0.05	0.000	0.029	<LOD
Co		0	0.05	0.000	0.034	<LOD
Fe		0	0.05	0.000	0.087	<LOD
Mn		0	0.10	0.000	0.079	<LOD
Cr		0	0.10	0.000	0.111	<LOD
V		0	0.30	0.000	0.207	<LOD
Ti		0	0.30	0.000	0.412	OK
Al		0	0.05	0.000	0.005	<LOD
Karat				0.00		

Thermo Scientific
Portable Analytical Instruments
2 Radcliff Road
Tewksbury, MA 01876
USA
+1 978 670-7460 ph
+1 978 670-7430 fax
www.thermoscientific.com/pai

ThermoFisher SCIENTIFIC

Certificate of Calibration

180-669 FLX 0732-16 9K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.050	<LOD
In		0	0.1	0.000	0.009	<LOD
Cd		0	0.1	0.000	0.008	<LOD
Ag	58.61	58.20	59.02	58.249	0.282	OK
Pd		0	0.05	0.000	0.011	<LOD
Rh		0	0.05	0.000	0.010	<LOD
Ru		0	0.05	0.000	0.006	<LOD
Mo		0	0.03	0.000	0.013	<LOD
Nb		0	0.03	0.000	0.009	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.010	<LOD
Au	33.3	32.86	33.80	33.574	0.138	OK
Pt		0	0.05	0.000	0.076	<LOD
Ir		0	0.05	0.000	0.040	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.059	<LOD
Ga		0	0.05	0.000	0.018	<LOD
Zn		0	0.05	0.000	0.038	<LOD
Cu	8.1	7.90	8.22	8.178	0.074	OK
Ni		0	0.05	0.000	0.020	<LOD
Co		0	0.05	0.000	0.026	<LOD
Fe		0	0.05	0.000	0.042	<LOD
Mn		0	0.10	0.000	0.059	<LOD
Cr		0	0.10	0.000	0.078	<LOD
V		0	0.20	0.000	0.142	<LOD
Ti		0	0.30	0.000	0.279	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	8.00	7.89	8.11	8.058		OK

180-670 FLX 0734-16 8K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.008	<LOD
In		0	0.1	0.000	0.005	<LOD
Cd		0	0.1	0.000	0.005	<LOD
Ag	6.2	5.99	6.49	6.258	0.033	OK
Pd		0	0.05	0.000	0.005	<LOD
Rh		0	0.05	0.023	0.005	OK
Ru		0	0.05	0.023	0.005	OK
Mo		0	0.03	0.000	0.008	<LOD
Nb		0	0.03	0.000	0.005	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.021	0.008	OK
Au	33.5	33.10	33.94	33.614	0.123	OK
Pt		0	0.05	0.000	0.058	<LOD
Ir		0	0.05	0.000	0.020	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.045	<LOD
Ga		0	0.05	0.000	0.014	<LOD
Zn	10.42	10.06	10.78	10.449	0.058	OK
Cu	49.8	49.32	50.32	49.570	0.107	OK
Ni		0	0.05	0.000	0.012	<LOD
Co		0	0.05	0.000	0.014	<LOD
Fe		0	0.05	0.000	0.018	<LOD
Mn		0	0.10	0.000	0.036	<LOD
Cr		0	0.10	0.042	0.021	<LOD
V		0	0.20	0.000	0.067	<LOD
Ti		0	0.20	0.000	0.130	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	8.04	7.94	8.15	8.07		OK

180-671 FLX 0743-16 19.2K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.005	<LOD
In		0	0.1	0.000	0.005	<LOD
Cd		0	0.1	0.000	0.005	<LOD
Ag		0	0.13	0.000	0.005	<LOD
Pd		0	0.05	0.000	0.005	<LOD
Rh		0	0.05	0.018	0.005	OK
Ru		0	0.05	0.000	0.006	<LOD
Mo		0	0.03	0.000	0.012	<LOD
Nb		0	0.03	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.011	<LOD
Au	80.2	79.75	80.55	80.315	0.270	OK
Pt		0	0.05	0.000	0.080	<LOD
Ir		0	0.05	0.000	0.027	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.062	<LOD
Ga		0	0.05	0.000	0.013	<LOD
Zn	4.27	3.97	4.57	4.167	0.042	OK
Cu	1.05	0.89	1.21	1.015	0.026	OK
Ni	14.53	14.24	14.82	14.379	0.073	OK
Co		0	0.05	0.016	0.012	<LOD
Fe		0	0.05	0.000	0.033	<LOD
Mn		0	0.10	0.043	0.024	<LOD
Cr		0	0.10	0.048	0.033	<LOD
V		0	0.15	0.000	0.123	<LOD
Ti		0	0.30	0.000	0.228	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	19.24	19.14	19.33	19.276		OK

180-672 FLX 0744-16 13.3K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.022	<LOD
In		0	0.1	0.013	0.013	<LOD
Cd		0	0.1	0.000	0.006	<LOD
Ag	26.3	25.22	27.32	26.847	0.127	OK
Pd	6.56	6.232	6.89	6.548	0.043	OK
Rh		0	0.05	0.000	0.008	<LOD
Ru		0	0.05	0.000	0.006	<LOD
Mo		0	0.03	0.000	0.010	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.011	<LOD
Au	55.5	54.98	56.10	55.893	0.175	OK
Pt		0	0.05	0.000	0.084	<LOD
Ir		0	0.05	0.000	0.029	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.065	<LOD
Ga		0	0.05	0.000	0.014	<LOD
Zn	1.38	1.18	1.58	1.204	0.035	OK
Cu	10.3	9.48	11.02	9.495	0.069	OK
Ni		0	0.05	0.000	0.016	<LOD
Co		0	0.05	0.000	0.021	<LOD
Fe		0	0.05	0.000	0.034	<LOD
Mn		0	0.10	0.000	0.047	<LOD
Cr		0	0.10	0.000	0.077	<LOD
V		0	0.15	0.000	0.111	<LOD
Ti		0	0.30	0.000	0.215	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	13.33	13.20	13.46	13.415		OK

Thermo Scientific
Portable Analytical Instruments
2 Radcliff Road
Tewksbury, MA 01876
USA
+1 978 670-7460 ph
+1 978 670 7430 fax
www.thermoscientific.com/pai

Standards used for factory calibrations are certified reference materials (CRM) or reference materials (RM) where available
Certificates of Analysis are available upon request

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Signed:

Stephen Elbeery
Director, Quality

ThermoFisher SCIENTIFIC

Certificate of Calibration

XL5 PMA 3mm QC Sheet
Document: 140-00243c
Release Date: 9 May 2016

Serial Number: X500875 Model XL5: Software: 5372 Date of Q.C.: 21-Jun-18

Resolution: 171.354 148.8837 Escale: 7.4087 7.4293 3mm spot size Inspector: VK

30 second analysis times

195-080 Pure Au (avg of 3)

	Low	High	Measured	Err	
Sn	0	0.05	0.000	0.009	<LOD
In	0	0.05	0.000	0.006	<LOD
Cd	0	0.05	0.000	0.007	<LOD
Ag	0	0.04	0.000	0.006	<LOD
Pd	0	0.03	0.000	0.011	<LOD
Rh	0	0.03	0.000	0.008	<LOD
Ru	0	0.06	0.000	0.012	<LOD
Mo	0	0.03	0.000	0.037	<LOD
Nb	0	0.03	0.000	0.012	<LOD
Zr	0	0.03	0.000	0.006	<LOD
Pb	0	0.05	0.000	0.026	<LOD
Au	99.0	100.0	99.98	0.506	OK
Pt	0	0.40	0.000	0.241	<LOD
Ir	0	0.10	0.000	0.060	<LOD
W	0	0.10	0.000	0.005	<LOD
Ge	0	0.40	0.000	0.141	<LOD
Ga	0	0.05	0.000	0.029	<LOD
Zn	0	0.10	0.000	0.078	<LOD
Cu	0	0.05	0.000	0.029	<LOD
Ni	0	0.07	0.000	3.161	<LOD
Co	0	0.07	0.000	0.038	<LOD
Fe	0	0.09	0.000	0.065	<LOD
Mn	0	0.05	0.020	0.073	<LOD
Cr	0	0.10	0.000	0.107	<LOD
V	0	0.30	0.000	0.185	<LOD
Ti	0	0.40	0.000	0.323	<LOD
Al	0	0.05	0.000	0.005	<LOD
Karat			23.996		

195-074 Pure Pt (avg of 3)

	Low	High	Measured	Err	
Sn	0	0.05	0.000	0.010	<LOD
In	0	0.05	0.000	0.006	<LOD
Cd	0	0.05	0.000	0.006	<LOD
Ag	0	0.10	0.000	0.008	<LOD
Pd	0	0.02	0.000	0.009	<LOD
Rh	0	0.04	0.000	0.010	<LOD
Ru	0	0.07	0.000	0.013	<LOD
Mo	0	0.03	0.000	0.036	<LOD
Nb	0	0.03	0.000	0.012	<LOD
Zr	0	0.03	0.000	0.007	<LOD
Pb	0	0.10	0.000	0.064	<LOD
Au	0	0.60	0.000	0.135	<LOD
Pt	99.0	100.0	99.98	0.606	OK
Ir	0	0.50	0.000	0.261	<LOD
W	0	0.20	0.000	0.189	<LOD
Ge	0	0.10	0.000	0.043	<LOD
Ga	0	0.20	0.000	0.124	<LOD
Zn	0	0.06	0.000	0.027	<LOD
Cu	0	0.10	0.000	0.080	<LOD
Ni	0	0.06	0.000	0.030	<LOD
Co	0	0.07	0.000	0.037	<LOD
Fe	0	0.09	0.000	0.071	<LOD
Mn	0	0.10	0.019	0.089	<LOD
Cr	0	0.10	0.000	0.111	<LOD
V	0	0.30	0.000	0.184	<LOD
Ti	0	0.30	0.000	0.385	<LOD
Al	0	0.05	0.000	0.005	<LOD

60 second analysis times

195-079 Pt Ir Foil 90:10

	Expected	Low	High	Measured	Err	
Sn		0	0.03	0.000	0.007	<LOD
In		0	0.03	0.000	0.005	<LOD
Cd		0	0.03	0.000	0.005	<LOD
Ag		0	0.15	0.000	0.005	<LOD
Pd		0	0.05	0.000	0.005	<LOD
Rh		0.00	0.03	0.000	0.010	<LOD
Ru		0	0.03	0.000	0.011	<LOD
Mo		0	0.03	0.000	0.020	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.05	0.000	0.055	<LOD
Au		0	0.15	0.000	0.089	<LOD
Pt	90.0	89.20	90.80	89.991	0.418	OK
Ir	10.0	9.60	10.40	10.009	0.180	OK
W		0	0.03	0.000	0.109	<LOD
Ge		0	0.1	0.000	0.027	<LOD
Ga		0	0.30	0.000	0.094	<LOD
Zn		0	0.03	0.000	0.025	<LOD
Cu		0	0.05	0.000	0.042	<LOD
Ni		0	0.03	0.000	0.020	<LOD
Co		0	0.03	0.000	0.033	<LOD
Fe		0	0.05	0.000	0.026	<LOD
Mn		0	0.05	0.000	0.093	<LOD
Cr		0	0.05	0.000	0.070	<LOD
V		0	0.20	0.000	0.178	<LOD
Ti		0	0.15	0.000	0.307	<LOD
Al		0	0.05	0.000	0.005	<LOD

195-078 Pd Ag Foil 75:25

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.037	<LOD
In		0	0.10	0.000	0.051	<LOD
Cd		0	0.05	0.000	0.012	<LOD
Ag	25	24.00	26.00	24.880	0.139	OK
Pd	75	74.25	75.75	74.518	0.356	OK
Rh		0	0.05	0.000	0.016	<LOD
Ru		0	0.05	0.000	0.011	<LOD
Mo		0	0.05	0.000	0.014	<LOD
Nb		0	0.05	0.000	0.005	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.05	0.000	0.006	<LOD
Au		0	0.05	0.015	0.009	<LOD
Pt		0	0.10	0.081	0.013	OK
Ir		0	0.05	0.000	0.022	<LOD
W		0	0.08	0.000	0.037	<LOD
Ge		0	0.03	0.000	0.009	<LOD
Ga		0	0.05	0.000	0.021	<LOD
Zn		0	0.05	0.000	0.013	<LOD
Cu		0	0.05	0.000	0.020	<LOD
Ni		0	0.05	0.000	0.028	<LOD
Co		0	0.05	0.000	0.036	<LOD
Fe		0	0.08	0.043	0.041	<LOD
Mn		0	0.10	0.000	0.083	<LOD
Cr		0	0.20	0.000	0.119	<LOD
V		0	0.35	0.000	0.297	<LOD
Ti		0	0.40	0.462	0.308	<LOD
Al		0	0.05	0.000	0.005	<LOD

Certificate of Calibration

195-171 FLX 0738-16 14K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.030	<LOD
In		0	0.10	0.000	0.006	<LOD
Cd		0	0.10	0.000	0.006	<LOD
Ag	19.8	19.21	20.39	19.663	0.116	OK
Pd		0	0.05	0.000	0.008	<LOD
Rh		0	0.05	0.000	0.008	<LOD
Ru		0	0.05	0.000	0.007	<LOD
Mo		0	0.03	0.000	0.015	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.014	<LOD
Au	58.6	57.72	59.48	58.674	0.221	OK
Pt		0	0.40	0.000	0.108	<LOD
Ir		0	0.05	0.000	0.039	<LOD
W		0	0.03	0.000	0.005	<LOD
Ge		0	0.06	0.000	0.083	<LOD
Ga		0	0.06	0.000	0.022	<LOD
Zn	0.52	0.26	0.78	0.615	0.044	OK
Cu	21.1	20.79	21.41	21.022	0.116	OK
Ni		0	0.05	0.000	0.021	<LOD
Co		0	0.05	0.000	0.025	<LOD
Fe		0	0.05	0.026	0.025	<LOD
Mn		0	0.10	0.000	0.050	<LOD
Cr		0	0.10	0.000	0.086	<LOD
V		0	0.20	0.000	0.114	<LOD
Ti		0	0.30	0.000	0.201	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	14.064	13.85	14.27	14.082		OK

180-655 FLX 0704-16 18K Au Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.011	<LOD
In		0	0.10	0.033	0.022	<LOD
Cd		0	0.10	0.000	0.006	<LOD
Ag	3.0	2.79	3.21	2.898	0.036	OK
Pd	12.53	12.28	12.78	12.382	0.086	OK
Rh		0	0.05	0.000	0.008	<LOD
Ru		0	0.05	0.000	0.009	<LOD
Mo		0	0.03	0.000	0.017	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.015	<LOD
Au	75.1	73.60	76.60	75.349	0.262	OK
Pt		0	0.40	0.000	0.119	<LOD
Ir		0	0.05	0.000	0.062	<LOD
W		0	0.03	0.000	0.005	<LOD
Ge		0	0.08	0.000	0.091	<LOD
Ga		0	0.05	0.000	0.023	<LOD
Zn		0	0.25	0.000	0.035	<LOD
Cu	9.4	8.98	9.82	9.386	0.084	OK
Ni		0	0.05	0.000	0.019	<LOD
Co		0	0.05	0.000	0.025	<LOD
Fe		0	0.05	0.000	0.038	<LOD
Mn		0	0.10	0.000	0.071	<LOD
Cr		0	0.10	0.000	0.068	<LOD
V		0	0.20	0.000	0.117	<LOD
Ti		0	0.30	0.000	0.217	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	18.024	17.66	18.38	18.084		OK

180-656 FLX 0715-16 14K Au Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.10	0.000	0.005	<LOD
In		0	0.10	0.000	0.005	<LOD
Cd		0	0.10	0.000	0.005	<LOD
Ag		0	0.20	0.000	0.005	<LOD
Pd		0	0.05	0.000	0.005	<LOD
Rh		0	0.05	0.012	0.005	OK
Ru		0	0.05	0.000	0.006	<LOD
Mo		0	0.05	0.000	0.016	<LOD
Nb		0	0.03	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.05	0.000	0.013	<LOD
Au	58.7	57.82	59.58	57.889	0.214	OK
Pt		0	0.05	0.000	0.106	<LOD
Ir		0	0.05	0.000	0.035	<LOD
W		0	0.03	0.000	0.005	<LOD
Ge		0	0.07	0.000	0.082	<LOD
Ga		0	0.07	0.000	0.020	<LOD
Zn	9.00	8.55	9.45	9.353	0.085	OK
Cu	26.3	25.25	27.35	26.495	0.125	OK
Ni	5.99	5.69	6.29	6.086	0.073	OK
Co		0	0.05	0.000	0.027	<LOD
Fe		0	0.05	0.000	0.042	<LOD
Mn		0	0.10	0.053	0.027	<LOD
Cr		0	0.10	0.046	0.037	<LOD
V		0	0.20	0.067	0.064	<LOD
Ti		0	0.20	0.000	0.160	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	14.088	13.88	14.30	13.89		OK

195-XXX MBH 132X AGB87a

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.054	<LOD
In		0	0.1	0.000	0.012	<LOD
Cd		0	0.1	0.000	0.011	<LOD
Ag	87.3	86.28	88.38	87.901	0.443	OK
Pd		0	0.05	0.000	0.015	<LOD
Rh		0	0.05	0.000	0.013	<LOD
Ru		0	0.05	0.000	0.007	<LOD
Mo		0	0.05	0.000	0.013	<LOD
Nb		0	0.03	0.000	0.006	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.006	<LOD
Au		0.00	0.05	0.010	0.009	<LOD
Pt		0	0.05	0.000	0.012	<LOD
Ir		0	0.05	0.000	0.023	<LOD
W		0	0.05	0.000	0.038	<LOD
Ge		0	0.05	0.000	0.010	<LOD
Ga		0	0.05	0.000	0.021	<LOD
Zn		0	0.05	0.000	0.041	<LOD
Cu	12.6	11.71	13.41	12.090	0.103	OK
Ni		0	0.05	0.000	0.026	<LOD
Co		0	0.05	0.000	0.040	<LOD
Fe		0	0.05	0.000	0.054	<LOD
Mn		0	0.10	0.000	0.089	<LOD
Cr		0	0.10	0.000	0.122	<LOD
V		0	0.20	0.000	0.191	<LOD
Ti		0	0.30	0.000	0.349	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat				0.00		

ThermoFisher SCIENTIFIC

Certificate of Calibration

180-669 FLX 0732-16 9K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.042	<LOD
In		0	0.1	0.000	0.011	<LOD
Cd		0	0.1	0.000	0.010	<LOD
Ag	58.61	58.20	59.02	58.242	0.299	OK
Pd		0	0.05	0.000	0.013	<LOD
Rh		0	0.05	0.000	0.012	<LOD
Ru		0	0.05	0.000	0.008	<LOD
Mo		0	0.03	0.000	0.024	<LOD
Nb		0	0.02	0.000	0.007	<LOD
Zr		0	0.02	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.011	<LOD
Au	33.3	32.86	33.80	33.575	0.157	OK
Pt		0	0.05	0.000	0.088	<LOD
Ir		0	0.05	0.000	0.032	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.068	<LOD
Ga		0	0.05	0.000	0.019	<LOD
Zn		0	0.05	0.000	0.045	<LOD
Cu	8.1	7.90	8.22	8.184	0.085	OK
Ni		0	0.05	0.000	0.022	<LOD
Co		0	0.05	0.000	0.029	<LOD
Fe		0	0.05	0.000	0.044	<LOD
Mn		0	0.10	0.000	0.066	<LOD
Cr		0	0.10	0.000	0.095	<LOD
V		0	0.20	0.000	0.151	<LOD
Ti		0	0.30	0.000	0.279	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	8.00	7.89	8.11	8.058		OK

180-670 FLX 0734-16 8K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.016	0.012	<LOD
In		0	0.1	0.000	0.005	<LOD
Cd		0	0.1	0.000	0.005	<LOD
Ag	6.2	5.99	6.49	6.274	0.046	OK
Pd		0	0.05	0.000	0.005	<LOD
Rh		0	0.05	0.012	0.005	OK
Ru		0	0.05	0.012	0.005	OK
Mo		0	0.02	0.000	0.012	<LOD
Nb		0	0.02	0.000	0.006	<LOD
Zr		0	0.02	0.000	0.005	<LOD
Pb		0	0.03	0.011	0.010	<LOD
Au	33.5	33.10	33.94	33.703	0.169	OK
Pt		0	0.05	0.000	0.084	<LOD
Ir		0	0.05	0.000	0.030	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.065	<LOD
Ga		0	0.05	0.000	0.018	<LOD
Zn	10.42	10.06	10.78	10.477	0.085	OK
Cu	49.8	49.32	50.32	49.418	0.151	OK
Ni		0	0.05	0.019	0.012	<LOD
Co		0	0.05	0.000	0.028	<LOD
Fe		0	0.05	0.000	0.034	<LOD
Mn		0	0.10	0.000	0.054	<LOD
Cr		0	0.10	0.000	0.062	<LOD
V		0	0.20	0.055	0.051	<LOD
Ti		0	0.30	0.000	0.150	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	8.04	7.94	8.15	8.09		OK

180-671 FLX 0743-16 19.2K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.008	<LOD
In		0	0.1	0.000	0.005	<LOD
Cd		0	0.1	0.000	0.005	<LOD
Ag		0	0.13	0.000	0.005	<LOD
Pd		0	0.05	0.000	0.005	<LOD
Rh		0	0.05	0.000	0.005	<LOD
Ru		0	0.05	0.000	0.008	<LOD
Mo		0	0.05	0.000	0.019	<LOD
Nb		0	0.02	0.000	0.007	<LOD
Zr		0	0.02	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.016	<LOD
Au	80.2	79.75	80.55	80.385	0.298	OK
Pt		0	0.05	0.000	0.120	<LOD
Ir		0	0.05	0.000	0.051	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.092	<LOD
Ga		0	0.05	0.000	0.018	<LOD
Zn	4.27	3.97	4.57	4.160	0.062	OK
Cu	1.05	0.89	1.21	1.004	0.038	OK
Ni	14.53	14.24	14.82	14.388	0.108	OK
Co		0	0.05	0.000	0.038	<LOD
Fe		0	0.05	0.000	0.054	<LOD
Mn		0	0.10	0.064	0.035	<LOD
Cr		0	0.10	0.000	0.071	<LOD
V		0	0.12	0.000	0.133	<LOD
Ti		0	0.30	0.000	0.197	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	19.24	19.14	19.33	19.293		OK

180-672 FLX 0744-16 13.3K Gold Reference Material

	Expected	Low	High	Measured	Err	
Sn		0	0.1	0.000	0.042	<LOD
In		0	0.1	0.018	0.018	<LOD
Cd		0	0.1	0.000	0.008	<LOD
Ag	26.3	24.96	27.58	26.793	0.156	OK
Pd	6.56	6.232	6.89	6.572	0.056	OK
Rh		0	0.05	0.000	0.010	<LOD
Ru		0	0.05	0.000	0.008	<LOD
Mo		0	0.05	0.000	0.014	<LOD
Nb		0	0.03	0.000	0.007	<LOD
Zr		0	0.03	0.000	0.005	<LOD
Pb		0	0.03	0.000	0.014	<LOD
Au	55.5	54.98	56.10	55.949	0.213	OK
Pt		0	0.05	0.000	0.107	<LOD
Ir		0	0.05	0.000	0.051	<LOD
W		0	0.05	0.000	0.005	<LOD
Ge		0	0.05	0.000	0.083	<LOD
Ga		0	0.05	0.000	0.022	<LOD
Zn	1.38	1.18	1.58	1.197	0.045	OK
Cu	10.3	9.43	11.07	9.472	0.088	OK
Ni		0	0.05	0.000	0.030	<LOD
Co		0	0.05	0.000	0.035	<LOD
Fe		0	0.05	0.000	0.041	<LOD
Mn		0	0.10	0.000	0.061	<LOD
Cr		0	0.10	0.000	0.096	<LOD
V		0	0.20	0.000	0.128	<LOD
Ti		0	0.30	0.000	0.236	<LOD
Al		0	0.05	0.000	0.005	<LOD
Karat	13.33	13.20	13.46	13.428		OK

ThermoFisher SCIENTIFIC

Certificate of Calibration

Small Spot Locator Sample (30s main filter only)

	Low	High	Measured	Err	
Cu	93	100	93.309	0.2761	OK
Ti			6.078	0.2064	
Al			0.000	0.0050	

Standards used for factory calibrations are certified reference materials (CRM) or reference materials (RM) where available
Certificates of Analysis are available upon request

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Signed:

Stephen Elbeery
Director, Quality

ThermoFisher SCIENTIFIC

Certificate of Calibration

Serial Number: X500875 | Model: Niton XL5 | Software: 5372 | Date of Q.C.: 13-Jun-18

Resolution: 173.0218 148.9466 | Escale: 7.409 7.430 | Spot Size: 3mm | Inspector: VK

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.001	0.0005	
Pb			0.000	0.0022	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0157	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0041	<LOD
Sn			0.000	0.0036	<LOD
Cd			0.000	0.0037	<LOD
Ag			0.000	0.0047	<LOD
Pd			0.000	0.0052	<LOD
Ru			0.000	0.0010	<LOD
Mo			0.000	0.0007	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0005	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0010	<LOD
Zn			0.000	0.0037	<LOD
Cu			0.000	0.0062	<LOD
Ni			0.029	0.0270	<LOD
Co			0.000	0.0536	<LOD
Fe	99.75	100	99.980	0.0818	OK
Mn			0.000	0.0170	<LOD
Cr			0.000	0.0156	<LOD
V			0.000	0.0196	<LOD
Ti			0.000	0.0415	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.001	0.0055	<LOD
Pb			0.000		OK
Au			0.000	0.0000	<LOD
Re			0.000	0.0212	<LOD
W			0.265	0.1430	
Ta	99.4	100	99.832	0.2424	OK
Hf			0.000	0.1045	<LOD
Te			0.000	0.0100	<LOD
Sb			0.000	0.0081	<LOD
Sn			0.000	0.0089	<LOD
Cd			0.000	0.0073	<LOD
Ag			0.000	0.0102	<LOD
Pd			0.000	0.0078	<LOD
Ru			0.000	0.0019	<LOD
Mo			0.000	0.0009	<LOD
Nb			0.000	0.0011	<LOD
Zr			0.000	0.0013	<LOD
Y			0.000	0.0010	<LOD
Se			0.000	0.0299	<LOD
Zn			0.000		OK
Cu			0.000		OK
Ni			0.000	0.0158	<LOD
Co			0.019	0.0408	<LOD
Fe			0.000	0.0206	<LOD
Mn			0.000	0.0278	<LOD
Cr			0.000	0.0377	<LOD
V			0.000	0.0791	<LOD
Ti			0.000	0.1179	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.000	0.0038	<LOD
Pb			0.000	0.0043	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0273	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0205	<LOD
Sb			0.000	0.0246	<LOD
Sn	99	100	99.992	0.4200	OK
Cd			0.000	0.0131	<LOD
Ag			0.000	0.0092	<LOD
Pd			0.000	0.0078	<LOD
Ru			0.000	0.0016	<LOD
Mo			0.000	0.0016	<LOD
Nb			0.000	0.0010	<LOD
Zr			0.000	0.0011	<LOD
Y			0.000	0.0009	<LOD
Se			0.000	0.0026	<LOD
Zn			0.000	0.0092	<LOD
Cu			0.000	0.0131	<LOD
Ni			0.000	0.0198	<LOD
Co			0.024	0.0263	<LOD
Fe			0.000	0.0518	<LOD
Mn			0.000	0.0548	<LOD
Cr			0.000	0.0806	<LOD
V			0.000	0.1568	<LOD
Ti			0.000	0.3683	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.0017	<LOD
Pb			0.000	0.0023	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.034	0.0302	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0068	<LOD
Sb			0.000	0.0055	<LOD
Sn			0.000	0.0055	<LOD
Cd			0.000	0.0044	<LOD
Ag			0.000	0.0055	<LOD
Pd			0.000	0.0056	<LOD
Ru			0.000	0.0011	<LOD
Mo			0.000	0.0007	<LOD
Nb			0.000	0.0012	<LOD
Zr			0.003	0.0013	
Y			0.000	0.0005	<LOD
Se			0.000	0.0037	<LOD
Zn			0.000	0.0192	<LOD
Cu	99.8	100	99.986	0.0879	OK
Ni			0.000	0.0108	<LOD
Co			0.000	0.0092	<LOD
Fe			0.000	0.0098	<LOD
Mn			0.000	0.0170	<LOD
Cr			0.000	0.0195	<LOD
V			0.000	0.0344	<LOD
Ti			0.000	0.0633	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Certificate of Calibration

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.000	0.0018	<LOD
Pb			0.000		<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.7841	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0057	<LOD
Sn			0.000	0.0057	<LOD
Cd			0.000	0.0049	<LOD
Ag			0.000	0.0057	<LOD
Pd			0.000	0.0064	<LOD
Ru			0.000	0.0013	<LOD
Mo			0.000	0.0008	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0011	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0182	<LOD
Zn			0.000	0.0548	<LOD
Cu			0.000	0.0338	<LOD
Ni	99.7	100	99.992	0.7903	OK
Co			0.000	0.0122	<LOD
Fe			0.000	0.0101	<LOD
Mn			0.000	0.0152	<LOD
Cr			0.000	0.0259	<LOD
V			0.000	0.0304	<LOD
Ti			0.025	0.0445	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC			0.000		

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.0007	<LOD
Pb			0.000		<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0091	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0032	<LOD
Sb			0.000	0.0026	<LOD
Sn			0.000	0.0023	<LOD
Cd			0.000	0.0022	<LOD
Ag			0.000	0.0026	<LOD
Pd			0.000	0.0034	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0003	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0003	<LOD
Se			0.000	0.0007	<LOD
Zn			0.000	0.0026	<LOD
Cu			0.000	0.0047	<LOD
Ni			0.000	0.0045	<LOD
Co			0.000	0.0062	<LOD
Fe			0.000	0.0101	<LOD
Mn			0.000	0.0200	<LOD
Cr			0.134	0.0709	
V			0.000	0.1140	<LOD
Ti	99.75	100	99.955	0.1373	OK
Al (Bal)			0.000	0.0000	<LOD
LEC			0.000		

20Cb3 IARM 25C 180-509

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.08			0.183	0.1340	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.000	0.0042	
Sn	0.01	0.002	0.020	0.011	0.0040	
Cd				0.000	0.0037	
Ag				0.000	0.0044	<LOD
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0019	<LOD
Mo	2.26	2.03	2.48	2.196	0.0121	OK
Nb	0.58	0.48	0.68	0.573	0.0055	OK
Zr				0.000	0.0007	
Y				0.000	0.0000	
Se				0.000	0.0045	
Zn				0.000	0.0142	
Cu	3.51	3.26	3.76	3.508	0.0477	OK
Ni	33.30	31.64	35.64	33.168	0.1631	OK
Co	0.091			0.166	0.0516	
Fe	38.80	36.8	40.8	38.455	0.0977	OK
Mn	0.90	0.40	1.40	0.938	0.0442	OK
Cr	19.97	19.57	20.57	20.110	0.0722	OK
V	0.095	0.035	0.155	0.137	0.0196	
Ti	0.003			0.024	0.0299	
Al (Bal)	0.019			0.000		<LOD
LEC				0.500		

Stellite 6B IARM 95B 180-502

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	
Pb				0.000		OK
Au				0.000	0.0000	
Re				0.000	0.0177	
W	3.42	3.12	3.72	3.424	0.0729	OK
Ta				0.000	0.0326	<LOD
Hf				0.000	0.0508	<LOD
Te				0.000	0.0000	
Sb				0.005	0.0042	
Sn				0.010	0.0037	
Cd				0.000	0.0038	
Ag				0.000	0.0042	<LOD
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0013	<LOD
Mo	0.83	0.70	0.96	0.831	0.0063	OK
Nb	0.002			0.002	0.0008	
Zr	0.002			0.000	0.0008	
Y				0.000	0.0000	
Se				0.000	0.0050	
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	2.25	1.80	2.70	2.252	0.0522	OK
Co	60.90	59.68	62.12	60.141	0.1443	
Fe	1.10	0.94	1.27	1.101	0.0332	OK
Mn	0.99	0.84	1.14	0.991	0.0414	OK
Cr	28.90	28.32	29.48	28.930	0.0840	OK
V	0.002			0.028	0.0183	
Ti	0.004			0.036	0.0232	
Al (Bal)	0.07			0.000		<LOD
LEC				2.250		

Thermo Fisher SCIENTIFIC

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	0.01			0.044	0.0103	
Pb	5.03	4.68	5.44	4.990	0.0434	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.041	0.0343	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.014	0.0070	
Sb	0.143	0.114	0.172	0.138	0.0074	OK
Sn	4.37	3.46	5.38	4.309	0.0258	OK
Cd				0.000	0.0066	<LOD
Ag	0.02			0.000	0.0060	<LOD
Pd				0.000	0.0076	<LOD
Ru				0.000	0.0013	<LOD
Mo				0.000	0.0007	<LOD
Nb				0.000	0.0005	<LOD
Zr				0.003	0.0014	
Y				0.000	0.0027	<LOD
Se				0.000	0.0042	<LOD
Zn	5.38	4.79	6.08	5.866	0.0356	OK
Cu	84.6	82.60	86.60	84.097	0.0930	OK
Ni	0.27	0.10	0.40	0.268	0.0114	OK
Co				0.000	0.0076	<LOD
Fe	0.24	0.21	0.27	0.246	0.0097	OK
Mn	0.002			0.000	0.0205	<LOD
Cr				0.011	0.0210	<LOD
V				0.000	0.0479	<LOD
Ti				0.000	0.0719	<LOD
Al (Bal)	0.002			0.000	0.0000	<LOD
LEC				#DIV/0!		

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0008	
Pb	0.0009			0.000	0.0019	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0186	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0040	<LOD
Sn	0.002			0.004	0.0048	<LOD
Cd				0.000	0.0039	<LOD
Ag				0.000	0.0041	<LOD
Pd				0.000	0.0045	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.47	0.43	0.53	0.488	0.0047	OK
Nb	0.002			0.000	0.0006	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.004	0.0042	<LOD
Cu	0.033	0.013	0.053	0.030	0.0079	OK
Ni	0.071			0.127	0.0263	
Co	0.004			0.000	0.0564	<LOD
Fe	96.96	95.9	98	96.993	0.0874	OK
Mn	0.56	0.35	0.75	0.558	0.0239	OK
Cr	1.11	0.89	1.33	1.081	0.0178	OK
V	0.004			0.000	0.0214	<LOD
Ti	0.0016			0.041	0.0419	<LOD
Al (Bal)	0.028			0.000	0.0000	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0018	<LOD
Pb				0.000	0.0025	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.62	0.32	0.92	0.570	0.1947	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0058	<LOD
Sn	0.002			0.000	0.0052	<LOD
Cd				0.000	0.0051	<LOD
Ag				0.000	0.0057	<LOD
Pd				0.000	0.0063	<LOD
Ru				0.000	0.0036	<LOD
Mo	8.30	7.72	8.89	8.269	0.0409	OK
Nb	0.09	0.03	0.15	0.074	0.0026	OK
Zr	0.004			0.000	0.0013	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0071	<LOD
Zn				0.000	0.0278	<LOD
Cu				0.000	0.0318	<LOD
Ni	48.80	46.80	50.76	48.656	0.2322	OK
Co	1.11	0.93	1.35	1.198	0.0480	OK
Fe	18.30	17.39	19.22	18.228	0.0800	OK
Mn	0.47	0.20	0.90	0.468	0.0435	OK
Cr	21.60	20.74	22.47	21.970	0.0854	OK
V	0.03			0.057	0.0218	
Ti	0.02			0.000	0.0696	<LOD
Al (Bal)	0.12			0.00	0.0000	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0018	<LOD
Pb				0.000	0.0024	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	6.30	5.8	6.87	6.558	0.0907	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0051	<LOD
Sn	0.01			0.006	0.0065	<LOD
Cd				0.000	0.0044	<LOD
Ag				0.000	0.0052	<LOD
Pd				0.000	0.0055	<LOD
Ru				0.000	0.0027	<LOD
Mo	4.85	4.61	5.15	4.850	0.0201	OK
Nb				0.000	0.0013	<LOD
Zr				0.000	0.0008	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0073	<LOD
Zn				0.000	0.0256	<LOD
Cu	0.13	0.091	0.169	0.124	0.0141	OK
Ni	0.35	0.245	0.455	0.301	0.0225	OK
Co	0.31	0.217	0.403	0.293	0.0593	OK
Fe	80.59	78.59	82.59	80.317	0.1229	OK
Mn	0.29	0.23	0.35	0.292	0.0312	OK
Cr	3.98	3.59	4.42	4.018	0.0406	OK
V	2.03	1.57	2.46	2.000	0.0414	OK
Ti				0.029	0.0430	<LOD
Al (Bal)	0.02			0.00	0.0000	<LOD
LEC				1.24		

Thermo Scientific
Portable Analytical Instruments
2 Radcliff Road
Tewksbury, MA 01876
USA
+1 978 670-7460 ph
+1 978 670 7430 fax
www.thermoscientific.com/pai

Certificate of Calibration

	SS321		IARM 6D		180-512	
	Certified	Low	High	Measured	Err	
Bi				0.003	0.0012	
Pb				0.000	0.0013	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09	0.030	0.190	0.158	0.0625	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0045	<LOD
Sn	0.013			0.019	0.0035	
Cd				0.000	0.0042	<LOD
Ag				0.000	0.0038	<LOD
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0012	<LOD
Mo	**0.358**	**0.29**	**0.44**	0.357	0.0038	OK
Nb	**0.039**	**0.01**	**0.06**	0.039	0.0013	OK
Zr	***0.002***			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0023	<LOD
Zn				0.000	0.0068	<LOD
Cu	**0.302**	**0.15**	**0.5**	0.319	0.0215	OK
Ni	**9.42**	**9**	**9.8**	9.361	0.0808	OK
Co	**0.182**	**0.091**	**0.273**	0.208	0.0612	
Fe	**69.40**	**68.4**	**70.4**	69.158	0.1240	OK
Mn	**1.52**	**1.25**	**1.85**	1.569	0.0483	OK
Cr	**17.45**	**17.1**	**18**	17.527	0.0642	OK
V	**0.128**	**0.0768**	**0.1792**	0.161	0.0186	
Ti	**0.63**	**0.43**	**0.83**	0.620	0.0316	OK
Al (Bal)	**0.11**			0.00	0.0000	<LOD
LEC				0.50		OK

	Ti 6-2-4-2		IARM 177C		180-503	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0017	<LOD
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0135	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0053	<LOD
Sb				0.000	0.0041	<LOD
Sn	**2.02**	**1.818**	**2.222**	2.030	0.0152	OK
Cd				0.000	0.0037	<LOD
Ag				0.000	0.0039	<LOD
Pd				0.000	0.0046	<LOD
Ru				0.000	0.0017	<LOD
Mo	**1.96**	**1.725**	**2.195**	1.960	0.0116	OK
Nb				0.000	0.0010	<LOD
Zr	**3.99**	**3.59**	**4.39**	3.989	0.0199	OK
Y				0.000	0.0009	<LOD
Se				0.000	0.0011	<LOD
Zn				0.000	0.0034	<LOD
Cu	0.003			0.000	0.0053	<LOD
Ni	0.011			0.007	0.0101	<LOD
Co				0.000	0.0087	<LOD
Fe	0.033			0.017	0.0156	<LOD
Mn	0.0015			0.000	0.0260	<LOD
Cr				0.000	0.0727	<LOD
V	0.02			0.000	0.1791	<LOD
Ti	**85.72**	**83.15**	**88.29**	85.994	0.1860	OK
Al (Bal)	6.02			0.00		<LOD
LEC				6.0		OK

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007			0.010	0.0008	
Pb	0.0073			0.009	0.0009	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0093	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0024	<LOD
Sb				0.000	0.0019	<LOD
Sn	0.014	0.004	0.024	0.014	0.0014	OK
Cd				0.000	0.0021	<LOD
Ag				0.000	0.0014	<LOD
Pd				0.003	0.0025	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024			0.0024	0.0002	
Y				0.000	0.0002	<LOD
Se				0.000	0.0004	<LOD
Zn	**5.75**	**5.463**	**6.038**	5.776	0.0182	OK
Cu	**1.750**	**1.575**	**1.925**	1.755	0.0130	OK
Ni	0.027			0.028	0.0026	
Co				0.000	0.0042	<LOD
Fe	**0.17**	**0.1445**	**0.1955**	0.159	0.0080	OK
Mn	0.031			0.040	0.0085	
Cr	**0.22**	**0.187**	**0.253**	0.220	0.0168	OK
V	0.020			0.050	0.0241	
Ti	**0.092**	**0.012**	**0.172**	0.123	0.0490	OK
Al (Bal)	***91.7***	**88.9102**	**94.4098**	91.81	0.1343	OK
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

	1.25Cr 0.5Mo		IARM35H		195-019	
	Provisional	Low	High	Measured	Err	
Bi				0.002	0.0008	
Pb	0.001			0.000	0.0019	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0187	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb	0.002			0.000	0.0040	<LOD
Sn	0.002			0.004	0.0048	<LOD
Cd				0.000	0.0040	<LOD
Ag				0.000	0.0041	<LOD
Pd				0.000	0.0045	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.47	0.423	0.517	0.490	0.0046	OK
Nb	0.002			0.000	0.0006	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.004	0.0043	<LOD
Cu	0.032	0.017	0.077	0.030	0.0079	OK
Ni	0.071			0.127	0.0264	
Co	0.004			0.000	0.0564	<LOD
Fe	96.96	95.021	98.899	96.962	0.0701	OK
Mn	0.56	0.45	0.67	0.559	0.0239	OK
Cr	1.11	0.89	1.33	1.109	0.0073	OK
V	0.004			0.000	0.0025	<LOD
Ti	0.002			0.000	0.0020	<LOD
Al (Bal)	0.028			0.00	0.0000	<LOD
LEC	0.75			0.750		OK

	Tool steel T-1		IARM 48C		195-152	
	Certified	Low	High	Measured	Err	
Bi				0.010	0.0015	
Pb				0.000	0.0035	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	17.50	16.63	18.38	17.301	0.1120	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.009	0.0044	
Sn	0.012			0.025	0.0044	
Cd				0.004	0.0047	<LOD
Ag				0.000	0.0049	<LOD
Pd				0.000	0.0050	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.17	0.150	0.190	0.162	0.0029	OK
Nb	0.005	0.001	0.010	0.004	0.0007	OK
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0114	<LOD
Zn				0.035	0.0325	<LOD
Cu	0.13			0.110	0.0165	
Ni	0.204			0.179	0.0228	
Co	0.22			0.185	0.0574	
Fe	74.5	73.3825	75.618	74.847	0.1330	OK
Mn	0.39	0.27	0.51	0.425	0.0329	OK
Cr	4.24	3.90	4.58	4.431	0.0433	OK
V	1.27	1.08	1.46	1.256	0.0112	OK
Ti	0.006			0.000	0.0035	<LOD
Al (Bal)	0.017			0.00	0.0000	<LOD
LEC	1.025			1.025		OK

	Custom 455		IARM16B		195-142	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0009	<LOD
Pb				0.000	0.0011	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.065	0.0587	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0059	<LOD
Sn	0.004			0.007	0.0035	
Cd				0.000	0.0046	<LOD
Ag				0.000	0.0039	<LOD
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0008	<LOD
Mo	0.016	0.010	0.022	0.001	0.0009	<LOD
Nb	0.25	0.20	0.30	0.258	0.0033	OK
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0021	<LOD
Zn				0.000	0.0075	<LOD
Cu	2.23	1.90	2.56	2.229	0.0379	OK
Ni	8.28	7.45	9.11	8.254	0.0764	OK
Co	0.027			0.058	0.0646	<LOD
Fe	76.4	72.58	80.22	76.490	0.1159	OK
Mn	0.026			0.108	0.0359	
Cr	11.44	10.52	12.36	11.360	0.0508	OK
V	0.067			0.071	0.0050	
Ti	1.11	0.999	1.221	1.109	0.0103	OK
Al (Bal)	0.062			0.000	0.0000	<LOD
LEC						

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007			0.010	0.0008	
Pb	0.0073			0.009	0.0009	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0093	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0024	<LOD
Sb				0.000	0.0019	<LOD
Sn	0.014	0.007	0.021	0.014	0.0014	OK
Cd				0.000	0.0021	<LOD
Ag				0.000	0.0014	<LOD
Pd				0.003	0.0025	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024	0.0004	0.0044	0.002	0.0002	OK
Y				0.000	0.0002	<LOD
Se				0.000	0.0004	<LOD
Zn	5.75	5.463	6.038	5.766	0.0179	OK
Cu	1.750	1.575	1.925	1.752	0.0129	OK
Ni	0.027			0.029	0.0026	
Co				0.000	0.0423	<LOD
Fe	0.17	0.1445	0.1955	0.158	0.0080	OK
Mn	0.031			0.040	0.0085	
Cr	0.22	0.187	0.253	0.221	0.0041	OK
V	0.020			0.041	0.0025	
Ti	0.092	0.062	0.122	0.092	0.0034	OK
Al (Bal)	91.7	88.9102	94.4098	91.868	0.1192	OK

Certificate of Calibration

Small Spot Locator Sample (30s main filter only)

	Low	High	Measured	Err	
Cu	93	100	97.991	0.0835	OK
Ti			1.935	0.0599	
Al			0.000	0.0000	

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Serial Number: X500875 Model: Niton XL5- Software: 5372 Date of Q.C.: 19-Jun-18
Resolution: 167.5896 149.6424 Escale: 7.408 7.430 Spot Size: 3mm Inspector: VK

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0002	<LOD
Pb			0.000	0.0003	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0024	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0012	<LOD
Sb			0.000	0.0010	<LOD
Sn			0.000	0.0009	<LOD
Cd			0.000	0.0009	<LOD
Ag			0.000	0.0009	<LOD
Pd			0.000	0.0012	<LOD
Ru			0.000	0.0002	<LOD
Mo			0.000	0.0001	<LOD
Nb			0.000	0.0001	<LOD
Zr			0.000	0.0001	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0002	<LOD
Zn			0.004	0.0008	
Cu			0.000	0.0010	<LOD
Ni			0.000	0.0014	<LOD
Co			0.000	0.0021	<LOD
Fe	0	0.02	0.000	0.0040	<LOD
Mn			0.000	0.0073	<LOD
Cr			0.000	0.0136	<LOD
V			0.000	0.0280	<LOD
Ti			0.000	0.0582	<LOD
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.037	0.0132	
Al			0.074	0.0601	<LOD
Mg	99.85	100	99.88	0.0904	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.002	0.0005	
Pb			0.000	0.0022	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0166	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0045	<LOD
Sn			0.000	0.0035	<LOD
Cd			0.000	0.0036	<LOD
Ag			0.000	0.0039	<LOD
Pd			0.000	0.0055	<LOD
Ru			0.000	0.0009	<LOD
Mo			0.000	0.0006	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0005	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0010	<LOD
Zn			0.000	0.0036	<LOD
Cu			0.000	0.0072	<LOD
Ni			0.000	0.0335	<LOD
Co			0.000	0.0582	<LOD
Fe	99.75	100	99.93	0.1024	OK
Mn			0.000	0.0216	<LOD
Cr			0.000	0.0163	<LOD
V			0.000	0.0281	<LOD
Ti			0.000	0.0439	<LOD
S			0.021	0.0027	
P			0.009	0.0032	
Si			0.039	0.0101	
Al			0.000	0.0428	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.0007	<LOD
Pb			0.000	0.0009	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0091	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0032	<LOD
Sb			0.000	0.0026	<LOD
Sn			0.000	0.0023	<LOD
Cd			0.000	0.0022	<LOD
Ag			0.000	0.0026	<LOD
Pd			0.000	0.0034	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0003	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0003	<LOD
Se			0.000	0.0007	<LOD
Zn			0.000	0.0026	<LOD
Cu			0.000	0.0047	<LOD
Ni			0.000	0.0044	<LOD
Co			0.000	0.0062	<LOD
Fe			0.000	0.0101	<LOD
Mn			0.000	0.0200	<LOD
Cr			0.134	0.0708	
V			0.000	0.1140	<LOD
Ti	99.7	100	99.96	0.1608	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0167	<LOD
Al			0.000	0.0799	<LOD
Mg			0.000	0.0000	<LOD

Certificate of Calibration

Ti 6-6-2 — IARM 178B — 195-095

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0009	<LOD
Pb				0.000	0.0011	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0116	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0050	<LOD
Sb				0.000	0.0029	<LOD
Sn	**1.99**	**1.70**	**2.30**	1.954	0.0124	OK
Cd				0.000	0.0034	<LOD
Ag				0.000	0.0027	<LOD
Pd				0.000	0.0042	<LOD
Ru				0.000	0.0008	<LOD
Mo	0.008	0.002	0.014	0.007	0.0006	OK
Nb				0.000	0.0003	<LOD
Zr	0.004	0.001	0.01	0.004	0.0004	OK
Y				0.000	0.0002	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0029	OK
Cu	**0.51**	**0.40**	**0.60**	0.505	0.0144	OK
Ni	0.017	0.005	0.030	0.016	0.0057	OK
Co				0.000	0.0106	<LOD
Fe	**0.56**	**0.42**	**0.64**	0.558	0.0281	OK
Mn	0.003			0.051	0.0193	
Cr	0.015			0.000	0.0525	<LOD
V	**5.51**	**5.21**	**5.81**	5.461	0.1100	OK
Ti	**85.5**	**83.79**	**87.21**	85.931	0.1728	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.00	0.05	0.000	0.0144	<LOD
Al	**5.57**	**5.15**	**6.09**	5.538	0.1386	OK
Mg				0.000	0.0000	<LOD

AA 4032 — ALCOA SS-4032D — 195-093

	Certified	Low	High	Measured	Err	
Bi	0.0000			0.000	0.0003	<LOD
Pb	0.0006			0.001	0.0003	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0109	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0018	<LOD
Sb	0.000			0.000	0.0014	<LOD
Sn	0.0003			0.000	0.0010	<LOD
Cd	0.000			0.000	0.0015	<LOD
Ag	0.0001			0.000	0.0010	<LOD
Pd				0.000	0.0021	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0018			0.004	0.0002	
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	0.102	0.051	0.153	0.099	0.0033	OK
Cu	**0.895**	**0.81**	**0.98**	0.892	0.0125	OK
Ni	**0.90**	**0.77**	**1.04**	0.870	0.0138	OK
Co	0.0003			0.004	0.0046	<LOD
Fe	**0.232**	**0.162**	**0.302**	0.264	0.0107	OK
Mn	0.0307	0.015	0.043	0.036	0.0090	
Cr	0.0499	0.030	0.065	0.058	0.0153	
V	0.0099			0.044	0.0293	<LOD
Ti	0.012			0.058	0.0587	<LOD
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	**12.20**	**11.47**	**12.93**	12.01	0.1248	OK
Al	***84.4***	**81.04**	**87.80**	84.34	0.1717	OK
Mg	**1.10**	**0.350**	**1.850**	1.312	0.2459	OK

AA5083 — ALCAN 5083AF — 195-091

	Certified	Low	High	Measured	Err	
Bi	0.008			0.010	0.0006	
Pb	0.0077			0.010	0.0007	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0034	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0014	<LOD
Sb	0.0012			0.000	0.0013	<LOD
Sn	0.020			0.018	0.0011	
Cd	0.0012			0.000	0.0010	<LOD
Ag				0.000	0.0013	<LOD
Pd				0.000	0.0015	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0035			0.004	0.0021	
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	**0.050**	**0.04**	**0.06**	0.051	0.0021	OK
Cu	**0.078**	**0.06**	**0.09**	0.080	0.0032	OK
Ni	0.03			0.032	0.0028	
Co				0.000	0.0041	<LOD
Fe	**0.34**	**0.27**	**0.41**	0.326	0.0132	OK
Mn	**0.740**	**0.67**	**0.81**	0.738	0.0227	OK
Cr	0.15	0.08	0.21	0.134	0.0180	OK
V	0.02			0.059	0.0336	
Ti	0.027			0.000	0.0750	<LOD
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	**0.17**	**0.09**	**0.26**	0.21	0.0190	OK
Al	**93.4**	**88.73**	**98.07**	93.03	0.2634	OK
Mg	**4.85**	**4.12**	**5.58**	5.33	0.2637	OK

CDA 642 — IARM 81B — 195-097

	Certified	Low	High	Measured	Err	
Bi				0.003	0.0019	<LOD
Pb	0.006			0.012	0.0029	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.040	0.0273	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.009	0.0070	<LOD
Sb	0.003			0.000	0.0071	<LOD
Sn	0.008			0.014	0.0047	
Cd				0.000	0.0051	<LOD
Ag	0.004			0.000	0.0052	<LOD
Pd				0.000	0.0073	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0007	<LOD
Nb				0.000	0.0007	<LOD
Zr				0.002	0.0014	<LOD
Y				0.000	0.0005	<LOD
Se				0.000	0.0025	<LOD
Zn	**0.176**	**0.132**	**0.220**	0.161	0.0185	OK
Cu	**91.2**	**89.38**	**93.02**	91.024	0.1711	OK
Ni	0.003			0.000	0.0109	
Co				0.000	0.0091	<LOD
Fe	**0.047**	**0.022**	**0.072**	0.052	0.0051	
Mn	0.012			0.013	0.0053	
Cr				0.000	0.0180	<LOD
V				0.000	0.0295	<LOD
Ti				0.000	0.0578	
S				0.043	0.0035	
P	0.004			0.013	0.0045	
Si	**1.84**	**1.44**	**2.24**	1.839	0.0378	OK
Al	**6.70**	**5.36**	**8.04**	6.795	0.1594	OK
Mg				0.000	0.0000	<LOD

Thermo Fisher SCIENTIFIC

Certificate of Calibration

CDA 922 32X PB11 F — 195-100

	Certified	Low	High	Measured	Err	
Bi	0.033			0.041	0.0064	
Pb	1.038	0.88	1.19	1.05	0.0215	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.064	0.0311	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0088	
Sb	0.478	0.41	0.55	0.484	0.0102	OK
Sn	3.40	2.89	3.91	3.431	0.0223	OK
Cd				0.000	0.0048	
Ag				0.000	0.0055	<LOD
Pd				0.000	0.0064	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0007	<LOD
Zr				0.000	0.0013	<LOD
Y				0.000	0.0013	<LOD
Se				0.000	0.0025	<LOD
Zn	1.50	1.28	1.73	1.68	0.0249	OK
Cu	90.54	87.82	93.26	90.39	0.1081	OK
Ni	0.904	0.68	1.13	0.89	0.0171	OK
Co	0.097	0.073	0.121	0.097	0.0064	
Fe	0.566	0.42	0.71	0.57	0.0128	OK
Mn	0.201	0.15	0.25	0.20	0.0107	OK
Cr				0.000	0.0251	<LOD
V				0.000	0.0404	<LOD
Ti				0.000	0.0681	<LOD
S	0.0227			0.000	0.0061	<LOD
P	0.885	0.62	1.15	1.08	0.0184	OK
Si	0.099			0.03	0.0247	<LOD
Al				0.000	0.0620	<LOD
Mg	0.004			0.000	0.0000	<LOD

Nitronic 60 IARM 18C — 195-089

	Certified	Low	High	Measured	Err	
Bi				0.002	0.0012	
Pb				0.000	0.0008	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.092	0.0570	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0036	<LOD
Sn	0.004			0.009	0.0034	
Cd				0.000	0.0035	<LOD
Ag				0.000	0.0038	<LOD
Pd				0.000	0.0042	<LOD
Ru				0.000	0.0012	
Mo	0.354	0.27	0.44	0.350	0.0037	OK
Nb	0.090	0.068	0.113	0.089	0.0019	
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0020	<LOD
Zn				0.000	0.0062	<LOD
Cu	0.285	0.21	0.36	0.286	0.0200	OK
Ni	8.05	7.25	8.86	7.845	0.0746	OK
Co	0.060	0.00	0.15	0.000	0.0765	OK
Fe	63.0	61.13	64.91	63.424	0.1329	OK
Mn	7.69	6.92	8.46	7.643	0.0689	OK
Cr	16.19	15.70	16.68	16.134	0.0610	OK
V	0.099			0.130	0.0163	
Ti	0.013			0.036	0.0210	
S	0.0010			0.000	0.0057	<LOD
P	0.027			0.040	0.0050	
Si	3.80	3.04	4.56	3.914	0.0458	OK
Al	0.014			0.000	0.0629	<LOD
Mg				0.000	0.0000	<LOD

RIFM T2/2 — 195-101

	Certified	Low	High	Measured	Err	
Bi				0.003	0.0008	
Pb				0.000	0.0021	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0192	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0046	<LOD
Sn				0.007	0.0047	
Cd				0.000	0.0037	<LOD
Ag				0.000	0.0044	<LOD
Pd				0.000	0.0053	<LOD
Ru				0.000	0.0008	<LOD
Mo				0.012	0.0008	
Nb				0.000	0.0005	<LOD
Zr				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.000	0.0039	<LOD
Cu	0.075			0.069	0.0092	
Ni	0.74			0.060	0.0254	
Co				0.000	0.0587	<LOD
Fe	95.5	93.59	97.41	95.675	0.1034	OK
Mn	0.28	0.22	0.34	0.253	0.0172	OK
Cr	0.065			0.053	0.0073	
V				0.000	0.0308	
Ti	0.037			0.034	0.0360	
S	0.02			0.043	0.0032	
P	0.012			0.016	0.0037	
Si	3.84	3.57	4.11	3.765	0.0445	OK
Al				0.000	0.0481	<LOD
Mg				0.000	0.0000	<LOD

Ti6-2-4-2 IARM 177C — 180-503

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0122	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0046	<LOD
Sb				0.000	0.0037	<LOD
Sn	2.02	1.82	2.22	2.004	0.0149	OK
Cd				0.000	0.0032	<LOD
Ag				0.000	0.0035	<LOD
Pd				0.000	0.0040	<LOD
Ru				0.000	0.0015	<LOD
Mo	1.96	1.67	2.25	1.931	0.0115	OK
Nb				0.000	0.0009	
Zr	3.99	3.59	4.39	3.931	0.0207	OK
Y				0.000	0.0008	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0030	<LOD
Cu				0.000	0.0048	<LOD
Ni				0.007	0.0089	<LOD
Co				0.000	0.0078	<LOD
Fe				0.017	0.0143	<LOD
Mn				0.000	0.0234	<LOD
Cr				0.000	0.0656	<LOD
V				0.000	0.1688	<LOD
Ti	85.72	83.15	88.29	85.912	0.2108	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.00	0.16	0.012	0.0312	OK
Al	6.02	5.52	6.52	6.184	0.1463	OK
Mg				0.000	0.0000	<LOD

ThermoFisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy Light 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

	SS416 Certified	IARM 10c Low	High	195-151 Measured	Err	
Bi				0.005	0.0011	
Pb				0.000	0.0007	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.024	0.0211	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0036	<LOD
Sn	0.009			0.014	0.0035	
Cd				0.000	0.0036	<LOD
Ag				0.000	0.0038	<LOD
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0010	<LOD
Mo	0.08	0.04	0.14	0.086	0.0019	OK
Nb	0.003			0.001	0.0005	
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.007	0.0052	<LOD
Cu	0.155	0.11	0.20	0.163	0.0115	OK
Ni	0.24	0.16	0.31	0.228	0.0187	OK
Co	0.022			0.075	0.0683	
Fe	86.0	81.70	90.30	86.128	0.1112	OK
Mn	0.35	0.25	0.46	0.408	0.0390	OK
Cr	12.25	11.64	12.86	12.053	0.0510	OK
V	0.024			0.060	0.0131	
Ti	0.002			0.040	0.0196	
S	0.29	0.20	0.38	0.346	0.0071	OK
P	0.026			0.027	0.0045	
Si	0.37	0.31	0.43	0.377	0.0174	OK
Al	0.003			0.000	0.0438	<LOD
Mg				0.000	0.0000	<LOD

	Iron Certified	BAS SCRM 660/09 Low	High	195-166 Measured	Err	
Bi				0.009	0.0014	
Pb				0.000	0.0019	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0216	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0046	<LOD
Sn				0.000	0.0050	<LOD
Cd				0.000	0.0038	<LOD
Ag				0.000	0.0043	<LOD
Pd				0.000	0.0061	<LOD
Ru				0.000	0.0008	<LOD
Mo				0.000	0.0005	<LOD
Nb				0.003	0.0006	
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.007	0.0038	
Cu				0.000	0.0088	<LOD
Ni				0.000	0.0338	<LOD
Co				0.000	0.0530	<LOD
Fe	94.18	90.41	97.95	94.337	0.1017	OK
Mn	0.406	0.37	0.45	0.379	0.0188	OK
Cr				0.007	0.0182	<LOD
V				0.000	0.0239	<LOD
Ti				0.031	0.0181	
S	0.105	0.053	0.158	0.123	0.0046	OK
P	0.153	0.077	0.230	0.123	0.0063	OK
Si	1.70	1.19	2.21	1.501	0.0303	OK
Al				0.000	0.0583	<LOD
Mg				0.000	0.0000	<LOD

	LAS Certified	BS15a Low	High	195-167 Measured	Err	
Bi				0.005	0.0013	
Pb				0.000	0.0035	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0203	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0054	<LOD
Sn				0.006	0.0046	<LOD
Cd				0.000	0.0050	<LOD
Ag				0.000	0.0051	<LOD
Pd				0.000	0.0059	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.008	0.0011	
Nb				0.043	0.0018	
Zr				0.023	0.0016	
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.006	0.0055	<LOD
Cu				0.028	0.0096	
Ni				0.074	0.0320	
Co				0.000	0.0678	<LOD
Fe	*98.4*	95.45	100.0	97.806	0.1146	OK
Mn	1.12	1.01	1.23	1.078	0.0328	OK
Cr				0.045	0.0088	
V				0.020	0.0117	
Ti				0.034	0.0434	<LOD
S				0.022	0.0029	
P				0.027	0.0042	
Si	0.058	0.03	0.1	0.061	0.0113	OK
Al				0.000	0.0594	<LOD
Mg				0.000	0.0000	<LOD

	Mar-M 247 Provisional	IARM 333a Low	High	195-173 Measured		
Bi				0.000	0.0014	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	*0.01*			0.000	0.0296	
W	*9.7*	8.73	10.67	9.443	0.2342	OK
Ta	*3.15*	2.84	3.47	3.120	0.0968	OK
Hf	*1.4*	1.260	1.540	1.387	0.0428	OK
Te				0.000	0.0000	<LOD
Sb				0.006	0.0048	<LOD
Sn				0.010	0.0047	
Cd				0.005	0.0057	<LOD
Ag				0.000	0.0053	<LOD
Pd				0.000	0.0052	<LOD
Ru				0.002	0.0016	<LOD
Mo	*0.49*	0.44	0.54	0.498	0.0057	OK
Nb	*0.005*			0.003	0.0008	
Zr	*0.009*			0.001	0.0008	
Y				0.000	0.0000	<LOD
Se				0.000	0.0136	<LOD
Zn				0.000		OK
Cu	*0.01*			0.000		OK
Ni	*61.1*	54.99	67.21	61.012	0.2327	OK
Co	*9.4*	8.46	10.34	9.400	0.0669	OK
Fe	*0.036*	0.016	0.056	0.040	0.0088	OK
Mn	*0.005*			0.036	0.0400	<LOD
Cr	*8.32*	7.49	9.15	8.414	0.0629	OK
V				0.000	0.0482	<LOD
Ti	*0.73*	0.621	0.840	0.725	0.0453	OK
S				0.030	0.0084	
P	*0.004*			0.099	0.0096	
Si	*0.08*			0.000	0.0774	
Al	*5.53*	4.98	6.08	5.783	0.1559	OK
Mg				0.000	0.0000	<LOD

Thermo Fisher SCIENTIFIC

Certificate of Calibration

	CMSX-4	IARM 332a		195-174		
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0020	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	*2.9*	*2.465*	*3.335*	2.891	0.0625	OK
W	*6.5*	*5.525*	*7.475*	6.356	0.2495	OK
Ta	*6.51*	*5.534*	*7.487*	7.050	0.1067	OK
Hf	*0.098*			0.055	0.0394	
Te				0.000	0.0000	<LOD
Sb				0.007	0.0063	<LOD
Sn				0.011	0.0048	
Cd				0.004	0.0048	<LOD
Ag				0.000	0.0055	<LOD
Pd				0.000	0.0054	<LOD
Ru				0.002	0.0016	<LOD
Mo	*0.61*	0.488	0.732	0.602	0.0009	OK
Nb				0.005	0.0009	
Zr				0.000	0.0007	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0136	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	*61*	*59.17*	*62.83*	60.337	0.2307	OK
Co	*9.4*	*8.46*	*10.34*	9.438	0.0661	OK
Fe	*0.023*			0.029	0.0084	
Mn				0.035	0.0440	<LOD
Cr	*6.31*	5.36	7.26	6.259	0.0570	OK
V				0.023	0.0388	<LOD
Ti	*0.99*	0.84	1.14	1.012	0.0515	OK
S				0.030	0.0092	
P				0.109	0.0119	
Si				0.000	0.0794	
Al	*5.8*	4.93	6.67	5.821	0.1609	OK
Mg				0.000	0.0000	<LOD

	Cu-Cd	MBH 36X CCD2		195-156		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0021	<LOD
Pb				0.000	0.0027	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.052	0.0293	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0103	<LOD
Sb				0.016	0.0084	
Sn	0.2	0.16	0.24	0.200	0.0071	OK
Cd	1.18	1.003	1.357	1.178	0.0128	OK
Ag	*0.0012*			0.000	0.0057	<LOD
Pd				0.000	0.0081	<LOD
Ru				0.000	0.0013	<LOD
Mo				0.000	0.0010	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.004	0.0013	
Y				0.000	0.0005	<LOD
Se				0.000	0.0037	<LOD
Zn	*0.0019*			0.000	0.0193	<LOD
Cu	*98.6*	98	99.2	98.477	0.1037	OK
Ni				0.000	0.0095	<LOD
Co				0.000	0.0093	<LOD
Fe				0.000	0.0095	<LOD
Mn				0.000	0.0135	<LOD
Cr				0.000	0.0238	<LOD
V				0.000	0.0389	<LOD
Ti				0.000	0.0604	<LOD
S				0.053	0.0035	
P				0.015	0.0044	
Si				0.035	0.0136	
Al				0.071	0.0574	<LOD
Mg				0.000	0.0000	<LOD

	AA7075	ALC 7075 AF		180-505		
	Cert	Low	High	Measured	Err	
Bi	0.007			0.010	0.0008	
Pb	0.0073			0.009	0.0008	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0092	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0024	<LOD
Sb				0.000	0.0019	<LOD
Sn	0.014	0.004	0.024	0.014	0.0014	
Cd				0.000	0.0021	<LOD
Ag				0.000	0.0014	<LOD
Pd				0.003	0.0024	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024			0.003	0.0002	
Y				0.000	0.0002	<LOD
Se				0.000	0.0004	<LOD
Zn	5.75	5.463	6.038	5.716	0.0555	OK
Cu	1.750	1.575	1.925	1.736	0.0201	OK
Ni	0.027			0.028	0.0026	
Co				0.000	0.0041	OK
Fe	0.17	0.1275	0.2125	0.156	0.0081	OK
Mn	0.031			0.040	0.0084	
Cr	0.22	0.187	0.253	0.217	0.0168	OK
V	0.020			0.050	0.0239	
Ti	0.092	0.012	0.172	0.130	0.0486	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.095	0.285	0.188	0.0186	OK
Al	89	86.33	91.67	89.269	0.2460	OK
Mg	2.66	2.128	3.192	2.435	0.3053	OK

	CDA510	IARM 77b		195-177		
	Certified	Low	High	Measured	Err	
Bi				0.005	0.0028	
Pb	0.016	0.008	0.024	0.022	0.0040	OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0000	<LOD
W				0.040	0.0273	<LOD
Ta				0.000	0.1019	<LOD
Hf				0.000	0.0092	<LOD
Te				0.007	0.0072	<LOD
Sb				0.000	0.0061	<LOD
Sn	4.66	4.520	4.800	4.678	0.0263	OK
Cd				0.000	0.0049	<LOD
Ag				0.000	0.0055	<LOD
Pd				0.000	0.0063	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.002	0.0012	<LOD
Y				0.000	0.0006	<LOD
Se				0.000	0.0019	<LOD
Zn				0.000	0.0221	<LOD
Cu	95.2	94.248	96.152	95.067	0.1019	OK
Ni				0.008	0.0092	<LOD
Co				0.000	0.0094	<LOD
Fe				0.000	0.0048	<LOD
Mn				0.000	0.0166	<LOD
Cr				0.000	0.0219	<LOD
V				0.000	0.0335	<LOD
Ti				0.000	0.0699	<LOD
S				0.039	0.0028	
P	0.148	0.118	0.178	0.136	0.0075	OK
Si				0.000	0.0159	<LOD
Al				0.000	0.0591	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Certificate of Calibration

Serial Number: X500875 Model: Niton XL5- Software: 5372 Date of Q.C.: 13-Jun-18

Resolution: 173.022 148.947 Escale: 7.409 7.430 Spot Size: 8mm Inspector: VK

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.002	0.0004	
Pb			0.000	0.0025	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0091	<LOD
Ta			0.000	0.0668	OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0031	<LOD
Sn			0.000	0.0030	<LOD
Cd			0.000	0.0025	<LOD
Ag			0.000	0.0029	<LOD
Pd			0.000	0.0032	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0007	<LOD
Zn			0.000	0.0035	<LOD
Cu			0.005	0.0042	<LOD
Ni			0.000	0.0274	<LOD
Co			0.000	0.0421	<LOD
Fe	99.85	100.000	99.996	0.0797	OK
Mn			0.000	0.0136	<LOD
Cr			0.000	0.0155	<LOD
V			0.000	0.0232	<LOD
Ti			0.000	0.0513	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.000	0.0055	<LOD
Pb			0.000	0.0000	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.260	0.0925	
Ta	99.5	100	99.691	0.1112	OK
Hf			0.000	0.0559	<LOD
Te			0.000	0.0076	<LOD
Sb			0.000	0.0074	<LOD
Sn			0.000	0.0068	<LOD
Cd			0.000	0.0049	<LOD
Ag			0.000	0.0070	<LOD
Pd			0.000	0.0058	<LOD
Ru			0.000	0.0012	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0010	<LOD
Zr			0.000	0.0011	<LOD
Y			0.000	0.0008	<LOD
Se			0.000	0.0229	<LOD
Zn			0.000	0.0000	OK
Cu			0.000	0.0000	OK
Ni			0.000	0.0113	<LOD
Co			0.000	0.0292	<LOD
Fe			0.000	0.0255	<LOD
Mn			0.000	0.0225	<LOD
Cr			0.000	0.0341	<LOD
V			0.000	0.0552	<LOD
Ti			0.071	0.0902	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.000	0.0039	<LOD
Pb			0.000	0.0045	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0260	<LOD
Ta			0.000	0.0000	OK
Hf			0.000		OK
Te			0.000	0.0197	<LOD
Sb			0.000	0.0255	<LOD
Sn	99	100.000	99.981	0.6007	OK
Cd			0.000	0.0122	<LOD
Ag			0.000	0.0087	<LOD
Pd			0.000	0.0074	<LOD
Ru			0.000	0.0015	<LOD
Mo			0.000	0.0012	<LOD
Nb			0.000	0.0011	<LOD
Zr			0.000	0.0012	<LOD
Y			0.000	0.0010	<LOD
Se			0.000	0.0027	<LOD
Zn			0.012	0.0080	<LOD
Cu			0.000	0.0135	<LOD
Ni			0.000	0.0219	<LOD
Co			0.021	0.0257	<LOD
Fe			0.000	0.0396	<LOD
Mn			0.000	0.0681	<LOD
Cr			0.000	0.0848	<LOD
V			0.000	0.2240	<LOD
Ti			0.000	0.5413	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.002	<LOD
Pb			0.000	0.002	<LOD
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.029	0.032	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.006	<LOD
Sb			0.000	0.005	<LOD
Sn			0.000	0.005	<LOD
Cd			0.000	0.004	<LOD
Ag			0.000	0.005	<LOD
Pd			0.000	0.005	<LOD
Ru			0.000	0.001	<LOD
Mo			0.000	0.001	<LOD
Nb			0.000	0.001	<LOD
Zr			0.002	0.001	<LOD
Y			0.000	0.001	<LOD
Se			0.000	0.004	<LOD
Zn			0.000	0.019	<LOD
Cu	99.85	100	99.980	0.097	OK
Ni			0.000	0.010	<LOD
Co			0.000	0.009	<LOD
Fe			0.000	0.010	<LOD
Mn			0.000	0.019	<LOD
Cr			0.000	0.022	<LOD
V			0.000	0.045	<LOD
Ti			0.030	0.066	<LOD
Al (Bal)			0.000	0.000	<LOD
LEC					

Thermo Fisher
SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 8mm QC Sheet
Document:140-00195
Revision: G
Release Date: 10 June 2016

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.000	0.0017	<LOD
Pb			0.000	0.0025	<LOD
Au			0.000	0.0017	<LOD
Re			0.000		OK
W			0.000	0.5282	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0051	<LOD
Sn			0.000	0.0058	<LOD
Cd			0.000	0.0037	<LOD
Ag			0.000	0.0050	<LOD
Pd			0.000	0.0057	<LOD
Ru			0.000	0.0010	<LOD
Mo			0.000	0.0006	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.000	0.0011	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0110	<LOD
Zn			0.000	0.0364	<LOD
Cu			0.000	0.0412	<LOD
Ni	**99.85**	**100.000**	100.000	0.5604	OK
Co			0.000	0.0110	<LOD
Fe			0.000	0.0102	<LOD
Mn			0.000	0.0137	<LOD
Cr			0.000	0.0202	<LOD
V			0.000	0.0362	<LOD
Ti			0.000	0.0577	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.001	<LOD
Pb			0.000	0.001	<LOD
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.000	0.003	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.002	<LOD
Sb			0.000	0.001	<LOD
Sn			0.000	0.001	<LOD
Cd			0.000	0.001	<LOD
Ag			0.000	0.001	<LOD
Pd			0.000	0.002	<LOD
Ru			0.000	0.000	<LOD
Mo			0.000	0.000	<LOD
Nb			0.000	0.000	<LOD
Zr			0.000	0.000	<LOD
Y			0.000	0.000	<LOD
Se			0.000	0.000	<LOD
Zn			0.000	0.001	<LOD
Cu			0.000	0.002	<LOD
Ni			0.000	0.003	<LOD
Co			0.000	0.003	<LOD
Fe			0.000	0.009	<LOD
Mn			0.000	0.013	<LOD
Cr			0.060	0.054	<LOD
V			0.000	0.050	<LOD
Ti	**99.85**	**100**	99.980	0.075	OK
Al (Bal)			0.000	0.000	<LOD
LEC					

20Cb3 **IARM 25C** 180-509

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.000	0.0012	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.080			0.104	0.0961	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0034	<LOD
Sn	0.01	0.002	0.020	0.008	0.0028	OK
Cd				0.000	0.0026	<LOD
Ag				0.000	0.0029	<LOD
Pd				0.000	0.0033	<LOD
Ru				0.000	0.0013	<LOD
Mo	**2.26**	**2.030**	**2.480**	2.194	0.0088	OK
Nb	**0.58**	**0.480**	**0.680**	0.570	0.0040	OK
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0032	<LOD
Zn				0.000	0.0103	<LOD
Cu	**3.51**	**3.260**	**3.760**	3.520	0.0350	OK
Ni	**33.30**	**31.640**	**35.640**	33.023	0.1172	OK
Co	0.091	0.020	0.200	0.172	0.0379	OK
Fe	**38.80**	**36.800**	**40.800**	38.480	0.0722	OK
Mn	**0.90**	**0.400**	**1.400**	0.921	0.0325	OK
Cr	**19.97**	**19.570**	**20.570**	20.293	0.0534	OK
V	0.095	0.035	0.155	0.127	0.0148	OK
Ti	0.003			0.023	0.0201	<LOD
Al (Bal)	0.019			0.000	0.00	<LOD
LEC				0.500		

Stellite 6B **IARM 95B** 180-502

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0005	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0126	
W	**3.42**	**3.120**	**3.720**	3.432	0.0504	OK
Ta				0.000	0.0261	<LOD
Hf				0.058	0.0357	
Te				0.000	0.0000	<LOD
Sb				0.003	0.0037	<LOD
Sn				0.004	0.0025	
Cd				0.000	0.0023	<LOD
Ag				0.000	0.0026	<LOD
Pd				0.000	0.0029	<LOD
Ru				0.000	0.0009	<LOD
Mo	**0.83**	**0.700**	**0.960**	0.833	0.0045	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.002			0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0034	<LOD
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	**2.25**	**1.913**	**2.588**	2.258	0.0369	OK
Co	**60.90**	**59.682**	**61.814**	60.008	0.1070	OK
Fe	**1.10**	**0.990**	**1.210**	1.104	0.0236	OK
Mn	**0.99**	**0.891**	**1.089**	0.993	0.0291	OK
Cr	**28.90**	**28.467**	**29.334**	28.998	0.0606	OK
V	0.002			0.035	0.0136	
Ti	0.004			0.037	0.0296	<LOD
Al (Bal)	0.07			0.000	0.00	<LOD
LEC		2.250	2.250	2.250		

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	0.01			0.053	0.0099	
Pb	5.03	4.680	5.440	5.019	0.0419	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.074	0.0281	
Ta				0.000		OK
Hf				0.000		OK
Te				0.009	0.0081	<LOD
Sb	0.143	0.122	0.164	0.133	0.0069	OK
Sn	4.37	3.460	5.380	4.345	0.0245	OK
Cd				0.000	0.0050	<LOD
Ag	0.02			0.000	0.0053	<LOD
Pd				0.000	0.0071	<LOD
Ru				0.000	0.0013	<LOD
Mo				0.000	0.0007	<LOD
Nb				0.000	0.0003	<LOD
Zr				0.002	0.0016	<LOD
Y				0.000	0.0025	<LOD
Se				0.000	0.0033	<LOD
Zn	5.38	4.790	6.080	5.391	0.0344	OK
Cu	84.6	82.600	86.600	84.473	0.0968	OK
Ni	0.27	0.100	0.400	0.271	0.0109	OK
Co				0.008	0.0112	<LOD
Fe	0.24	0.210	0.270	0.242	0.0096	OK
Mn	0.002			0.009	0.0115	<LOD
Cr				0.000	0.0266	<LOD
V				0.026	0.0398	<LOD
Ti				0.000	0.0897	<LOD
Al (Bal)	0.002			0.000	0.00	<LOD
LEC						

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.001	0.0005	
Pb	0.0009			0.000	0.0022	
Au				0.000	0.0000	
Re				0.000		OK
W	0.004			0.000	0.0103	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0041	<LOD
Sn	0.002			0.000	0.0034	<LOD
Cd				0.000	0.0031	<LOD
Ag				0.000	0.0029	<LOD
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0010	<LOD
Mo	0.47	0.430	0.530	0.482	0.0037	OK
Nb	0.002			0.000	0.0004	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0034	<LOD
Cu	0.033	0.018	0.048	0.035	0.0055	OK
Ni	0.071			0.104	0.0210	
Co	0.004			0.000	0.0431	<LOD
Fe	96.96	95.900	98.000	96.991	0.0704	OK
Mn	0.56	0.350	0.750	0.551	0.0188	OK
Cr	1.11	0.999	1.221	1.091	0.0143	OK
V	0.004			0.000	0.0214	<LOD
Ti	0.0016			0.000	0.0362	<LOD
Al (Bal)	0.028			0.000	0.00	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb				0.000	0.0023	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.62	0.320	0.920	0.613	0.1681	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0050	<LOD
Sn	0.002			0.000	0.0043	<LOD
Cd				0.000	0.0043	<LOD
Ag				0.000	0.0046	<LOD
Pd				0.000	0.0051	<LOD
Ru				0.000	0.0030	<LOD
Mo	8.30	7.720	8.890	8.313	0.0353	OK
Nb	0.09	0.030	0.150	0.074	0.0023	OK
Zr	0.004			0.000	0.0013	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0061	<LOD
Zn				0.000	0.0210	<LOD
Cu				0.082	0.0280	
Ni	48.80	46.800	50.760	48.052	0.1994	OK
Co	1.11	0.930	1.350	1.193	0.0424	OK
Fe	18.30	17.390	19.220	18.477	0.0713	OK
Mn	0.47	0.200	0.900	0.460	0.0386	OK
Cr	21.60	20.740	22.470	22.191	0.0759	OK
V	0.03			0.052	0.0199	
Ti	0.02			0.031	0.0557	<LOD
Al (Bal)	0.12			0.00	0.00	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0013	
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	6.30	5.800	6.870	6.617	0.0718	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0039	<LOD
Sn	0.01			0.006	0.0040	<LOD
Cd				0.000	0.0033	<LOD
Ag				0.000	0.0037	<LOD
Pd				0.000	0.0040	<LOD
Ru				0.000	0.0021	<LOD
Mo	4.85	4.610	5.150	4.842	0.0165	OK
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0057	<LOD
Zn				0.000	0.0216	<LOD
Cu	0.13	0.104	0.156	0.131	0.0110	OK
Ni	0.35	0.280	0.420	0.308	0.0181	OK
Co	0.31	0.217	0.403	0.303	0.0470	OK
Fe	80.59	78.590	82.590	80.183	0.0992	OK
Mn	0.29	0.240	0.340	0.300	0.0249	OK
Cr	3.98	3.590	4.420	4.081	0.0328	OK
V	2.03	1.570	2.460	1.994	0.0333	OK
Ti				0.000	0.0455	<LOD
Al (Bal)	0.02			0.00	0.00	<LOD
LEC				1.24		

Certificate of Calibration

SS321 | IARM 6D | 180-512

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.000	0.0006	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09			0.141	0.0410	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0024	<LOD
Sn	0.013	0.003	0.023	0.021	0.0023	OK
Cd				0.000	0.0027	<LOD
Ag				0.000	0.0024	<LOD
Pd				0.000	0.0030	<LOD
Ru				0.000	0.0006	<LOD
Mo	**0.358**	**0.290**	**0.440**	0.359	0.0026	OK
Nb	**0.039**	**0.010**	**0.060**	0.038	0.0009	OK
Zr	***0.002***			0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0049	<LOD
Cu	**0.302**	**0.150**	**0.500**	0.312	0.0143	OK
Ni	**9.42**	**9.000**	**9.800**	9.273	0.0545	OK
Co	**0.182**	**0.109**	**0.255**	0.214	0.0415	OK
Fe	**69.40**	**68.400**	**70.400**	69.058	0.0844	OK
Mn	**1.52**	**1.250**	**1.850**	1.566	0.0344	OK
Cr	**17.45**	**17.100**	**18.000**	17.714	0.0443	OK
V	**0.128**	**0.077**	**0.179**	0.163	0.0131	OK
Ti	**0.63**	**0.378**	**0.882**	0.638	0.0229	OK
Al (Bal)	0.11			0.00	0.00	<LOD
LEC				0.50		OK

Ti 6-2-4-2 | IARM 177C | 180-503

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb				0.000	0.0014	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0086	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0040	<LOD
Sb				0.000	0.0032	<LOD
Sn	**2.02**	**1.919**	**2.121**	2.029	0.0116	OK
Cd				0.000	0.0028	<LOD
Ag				0.000	0.0028	<LOD
Pd				0.000	0.0033	<LOD
Ru				0.000	0.0013	<LOD
Mo	**1.96**	**1.764**	**2.156**	1.960	0.0090	OK
Nb				0.000	0.0011	<LOD
Zr	**3.99**	**3.751**	**4.229**	3.990	0.0155	OK
Y				0.000	0.0007	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0028	<LOD
Cu	0.003			0.000	0.0036	<LOD
Ni	0.011			0.007	0.0052	<LOD
Co				0.000	0.0073	<LOD
Fe	0.033	0.023	0.053	0.000	0.0189	<LOD
Mn	0.0015			0.000	0.0218	<LOD
Cr				0.000	0.0642	<LOD
V	0.02			0.000	0.0997	<LOD
Ti	**85.72**	**84.006**	**87.434**	86.004	0.1174	OK
Al (Bal)	6.02			0.00	0.00	<LOD
LEC				6.0		OK

AA7075 | ALC 7075 AF | 180-505

	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.007	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0054	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0017	<LOD
Sb				0.000	0.0009	<LOD
Sn	0.014	0.007	0.021	0.015	0.0008	OK
Cd				0.000	0.0008	<LOD
Ag				0.000	0.0008	<LOD
Pd				0.000	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0024	0.001	0.003	0.0025	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	**5.75**	**5.578**	**5.923**	5.766	0.0114	OK
Cu	**1.750**	**1.663**	**1.838**	1.754	0.0082	OK
Ni	0.027	0.007	0.047	0.025	0.0016	OK
Co				0.000	0.0026	<LOD
Fe	**0.17**	**0.136**	**0.204**	0.165	0.0052	OK
Mn	0.031	0.016	0.046	0.038	0.0056	OK
Cr	**0.22**	**0.187**	**0.253**	0.219	0.0111	OK
V	0.020			0.072	0.0167	
Ti	**0.092**	**0.012**	**0.172**	0.136	0.0349	OK
Al (Bal)	***91.7***	**89.827**	**93.493**	91.80	0.09	OK
LEC						

ThermoFisher SCIENTIFIC

Certificate of Calibration

15s Main Filter and 30s Low Filter

	1.25Cr 0.5Mo		IARM35H		195-019	
	Provisional	Low	High	Measured	Err	
Bi				0.001	0.0005	
Pb	0.001			0.000	0.0022	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0104	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0041	<LOD
Sn	0.002			0.000	0.0034	<LOD
Cd				0.000	0.0031	<LOD
Ag				0.000	0.0029	<LOD
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0010	<LOD
Mo	0.47	0.432	0.508	0.484	0.0036	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0034	<LOD
Cu	0.032	0.012	0.052	0.035	0.0055	OK
Ni	0.071			0.105	0.0211	
Co	0.004			0.000	0.0432	<LOD
Fe	96.96	95.990	97.930	96.969	0.0533	OK
Mn	0.56	0.476	0.644	0.552	0.0189	OK
Cr	1.11	0.999	1.221	1.109	0.0054	OK
V	0.004			0.000	0.0016	<LOD
Ti	0.002			0.002	0.0019	<LOD
Al (Bal)	0.028			0.00	0.00	<LOD
LEC	0.75			0.750		OK

	Tool steel T-1		IARM 48C		195-152	
	Certified	Low	High	Measured	Err	
Bi				0.006	0.0009	
Pb				0.000	0.0021	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	17.50	16.625	18.375	17.264	0.0782	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.009	0.0030	
Sn	0.012			0.026	0.0029	
Cd				0.003	0.0030	<LOD
Ag				0.000	0.0031	<LOD
Pd				0.000	0.0031	<LOD
Ru				0.000	0.0007	<LOD
Mo	0.17	0.150	0.190	0.161	0.0020	OK
Nb	0.005	0.001	0.010	0.003	0.0005	OK
Zr				0.001	0.0004	
Y				0.000	0.0000	<LOD
Se				0.000	0.0078	<LOD
Zn				0.028	0.0286	<LOD
Cu	0.13	0.090	0.170	0.130	0.0116	OK
Ni	0.204	0.143	0.265	0.175	0.0165	OK
Co	0.22	0.120	0.320	0.191	0.0401	OK
Fe	74.5	73.383	75.618	74.862	0.0938	OK
Mn	0.39	0.304	0.476	0.409	0.0230	OK
Cr	4.24	3.901	4.579	4.474	0.0308	OK
V	1.27	1.143	1.397	1.254	0.0079	OK
Ti	0.006			0.000	0.0025	<LOD
Al (Bal)	0.017			0.00	0.00	<LOD
LEC	1.025			1.025		OK

	Custom 455		IARM16B		195-142	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.000	0.0011	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.059	0.0399	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0025	<LOD
Sn	0.004			0.008	0.0023	
Cd				0.002	0.0028	<LOD
Ag				0.000	0.0025	<LOD
Pd				0.000	0.0031	<LOD
Ru				0.000	0.0006	<LOD
Mo	0.016	0.010	0.022	0.014	0.0006	OK
Nb	0.25	0.225	0.275	0.256	0.0023	OK
Zr				0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0053	<LOD
Cu	2.23	2.119	2.342	2.197	0.0264	OK
Ni	8.28	7.866	8.694	8.222	0.0532	OK
Co	0.027			0.104	0.0407	
Fe	76.4	72.580	80.220	76.413	0.0363	OK
Mn	0.026			0.072	0.0254	
Cr	11.44	10.868	12.012	11.492	0.0363	OK
V	0.067			0.063	0.0042	
Ti	1.11	1.055	1.166	1.105	0.0084	OK
Al (Bal)	0.062			0.000	0.00	<LOD

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0009	OK
Pb	0.0073	0.001	0.020	0.007	0.0009	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0094	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0028	<LOD
Sb				0.000	0.0017	<LOD
Sn	0.014	0.007	0.021	0.016	0.0015	OK
Cd				0.002	0.0014	
Ag				0.000	0.0014	<LOD
Pd				0.003	0.0023	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024	0.000	0.004	0.002	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn	5.75	5.578	5.923	5.836	0.0197	OK
Cu	1.750	1.663	1.838	1.752	0.0144	OK
Ni	0.027	0.007	0.047	0.025	0.0028	OK
Co				0.000	0.0300	<LOD
Fe	0.17	0.136	0.204	0.166	0.0092	OK
Mn	0.031	0.016	0.046	0.038	0.0098	OK
Cr	0.22	0.198	0.242	0.222	0.0029	OK
V	0.020			0.030	0.0015	
Ti	0.092	0.072	0.112	0.097	0.0024	OK
Al (Bal)	91.7	89.827	93.493	91.799	0.01	OK

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

ThermoFisher
SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy Light 8mm QC Sheet
Document: 140-00195
Revision: G
Release Date:10 June 2016

Serial Number: X500875 Model: Niton XL5- Software: 5372 Date of Q.C.: 19-Jun-18
Resolution: 170.341 156.71 Escale: 7.453 7.430 Spot Size: 8mm Inspector: VK

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0001	<LOD
Pb			0.000	0.0008	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0032	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0005	<LOD
Sb			0.000	0.0011	<LOD
Sn			0.000	0.0012	<LOD
Cd			0.000	0.0010	<LOD
Ag			0.000	0.0010	<LOD
Pd			0.000	0.0013	<LOD
Ru			0.000	0.0002	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0003	<LOD
Zn			0.004	0.0010	
Cu			0.000	0.0016	<LOD
Ni			0.000	0.0068	<LOD
Co			0.000	0.0115	<LOD
Fe	0	0.02	0.000	0.0213	OK
Mn			0.000	0.0073	<LOD
Cr			0.000	0.0100	<LOD
V			0.000	0.0203	<LOD
Ti			0.000	0.0390	<LOD
S			0.000	0.0004	<LOD
P			0.000	0.0031	<LOD
Si			0.000	0.0069	<LOD
Al			0.000	0.0318	<LOD
Mg	99.85	100	100.00	0.0422	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.002	0.0004	
Pb			0.000	0.0025	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0091	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0000	<LOD
Sb			0.000	0.0031	<LOD
Sn			0.000	0.0030	<LOD
Cd			0.000	0.0025	<LOD
Ag			0.000	0.0029	<LOD
Pd			0.000	0.0032	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0004	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0007	<LOD
Zn			0.000	0.0035	<LOD
Cu			0.005	0.0042	<LOD
Ni			0.000	0.0269	<LOD
Co			0.000	0.0421	<LOD
Fe	99.85	100	99.99	0.0859	OK
Mn			0.000	0.0136	<LOD
Cr			0.000	0.0155	<LOD
V			0.000	0.0232	<LOD
Ti			0.000	0.0513	<LOD
S			0.003	0.0017	
P			0.000	0.0123	<LOD
Si			0.000	0.0068	<LOD
Al			0.000	0.0283	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.000	0.0005	<LOD
Pb			0.000	0.0005	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0035	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0019	<LOD
Sb			0.000	0.0014	<LOD
Sn			0.000	0.0013	<LOD
Cd			0.000	0.0014	<LOD
Ag			0.000	0.0014	<LOD
Pd			0.000	0.0017	<LOD
Ru			0.000	0.0003	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0003	<LOD
Zn			0.000	0.0013	<LOD
Cu			0.000	0.0018	<LOD
Ni			0.000	0.0026	<LOD
Co			0.000	0.0033	<LOD
Fe			0.000	0.0086	<LOD
Mn			0.000	0.0130	<LOD
Cr			0.060	0.0536	<LOD
V			0.000	0.0499	<LOD
Ti	99.8	100	99.98	0.1075	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0151	<LOD
Al			0.000	0.0750	<LOD
Mg			0.000	0.0000	<LOD

Certificate of Calibration

	Ti 6-6-2 Certified	IARM 178B Low	High	195-095 Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.000	0.0006	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0055	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0027	<LOD
Sb				0.000	0.0023	<LOD
Sn	1.99	1.750	2.229	1.968	0.01	OK
Cd				0.000	0.0019	<LOD
Ag				0.000	0.0014	<LOD
Pd				0.000	0.0022	<LOD
Ru				0.000	0.0004	<LOD
Mo	0.008	0.002	0.014	0.007	0.0003	OK
Nb				0.000	0.0002	<LOD
Zr	0.004	0.001	0.010	0.004	0.0003	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn				0.000	0.0018	<LOD
Cu	0.51	0.420	0.600	0.508	0.0084	OK
Ni	0.017	0.007	0.027	0.017	0.0032	OK
Co				0.000	0.0061	<LOD
Fe	0.56	0.420	0.640	0.557	0.0167	OK
Mn	0.003			0.000	0.0153	<LOD
Cr	0.015			0.000	0.0319	<LOD
V	5.51	5.210	5.810	5.484	0.0662	OK
Ti	85.5	83.790	87.210	85.963	0.1428	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.000	0.050	0.000	0.0140	OK
Al	5.57	5.124	6.016	5.492	0.1391	OK
Mg				0.000	0.0000	<LOD

	AA 4032 Certified	ALCOA SS-4032D Low	High	195-093 Measured	Err	
Bi	0.0000			0.000	0.0002	<LOD
Pb	0.0006			0.001	0.0002	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0048	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0012	<LOD
Sb	0.000			0.000	0.0008	<LOD
Sn	0.0003			0.000	0.0006	<LOD
Cd	0.000			0.000	0.0007	<LOD
Ag	0.0001			0.000	0.0005	<LOD
Pd				0.000	0.0009	<LOD
Ru				0.000	0.0001	<LOD
Mo				0.000	0.0001	
Nb				0.000	0.0001	<LOD
Zr	0.0018			0.004	0.0001	
Y				0.000	0.0000	<LOD
Se				0.000	0.0002	<LOD
Zn	0.102	0.082	0.122	0.100	0.0019	OK
Cu	0.895	0.850	0.940	0.891	0.0077	OK
Ni	0.90	0.810	0.990	0.885	0.0083	OK
Co	0.0003			0.002	0.0028	<LOD
Fe	0.232	0.186	0.278	0.269	0.0065	OK
Mn	0.0307	0.015	0.043	0.039	0.0058	OK
Cr	0.0499	0.030	0.065	0.060	0.0099	OK
V	0.0099			0.056	0.0192	
Ti	0.012			0.105	0.0395	
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	12.20	11.712	12.688	12.15	0.0805	OK
Al	84.4	82.732	86.108	84.28	0.1099	OK
Mg	1.10	0.420	1.780	1.176	0.1582	OK

	AA5083 Certified	ALCAN 5083AF Low	High	195-091 Measured	Err	
Bi	0.008			0.008	0.0004	
Pb	0.0077			0.007	0.0004	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0021	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0008	<LOD
Sb	0.0012			0.000	0.0006	<LOD
Sn	0.020	0.010	0.030	0.019	0.0006	OK
Cd	0.0012			0.000	0.0006	<LOD
Ag				0.000	0.0005	<LOD
Pd				0.000	0.0007	<LOD
Ru				0.000	0.0001	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0035	0.002	0.005	0.003	0.0001	OK
Y				0.000	0.0000	<LOD
Se				0.000	0.0001	<LOD
Zn	0.050	0.040	0.060	0.050	0.001	OK
Cu	0.078	0.062	0.094	0.079	0.002	OK
Ni	0.03	0.010	0.050	0.030	0.0016	OK
Co				0.003	0.0026	<LOD
Fe	0.34	0.272	0.408	0.322	0.0079	OK
Mn	0.740	0.666	0.814	0.744	0.0135	OK
Cr	0.15	0.11	0.20	0.126	0.0113	OK
V	0.02			0.027	0.0201	<LOD
Ti	0.027			0.000	0.0578	<LOD
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	0.17	0.102	0.240	0.183	0.0120	OK
Al	93.4	91.532	95.268	93.355	0.1697	OK
Mg	4.85	4.365	5.335	5.041	0.1661	OK

	CDA 642 Certified	IARM 81B Low	High	195-097 Measured	Err	
Bi				0.000	0.0018	<LOD
Pb	0.006			0.016	0.0030	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.030	0.0322	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0078	<LOD
Sb	0.003			0.000	0.0054	<LOD
Sn	0.008			0.007	0.0043	
Cd				0.000	0.0041	<LOD
Ag	0.004			0.000	0.0046	<LOD
Pd				0.000	0.0066	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.002	0.0012	
Y				0.000	0.0004	<LOD
Se				0.000	0.0032	<LOD
Zn	0.176	0.141	0.211	0.156	0.0179	OK
Cu	91.2	89.376	93.024	91.233	0.1166	OK
Ni	0.003			0.000	0.0088	<LOD
Co				0.000	0.0088	<LOD
Fe	0.047	0.027	0.067	0.055	0.0051	OK
Mn	0.012			0.010	0.0052	
Cr				0.000	0.0249	<LOD
V				0.000	0.0393	<LOD
Ti				0.000	0.0652	<LOD
S				0.047	0.0024	
P	0.004			0.000	0.0124	<LOD
Si	1.84	1.440	2.240	1.814	0.0229	OK
Al	6.70	6.030	7.370	6.646	0.0947	OK
Mg				0.000	0.0000	<LOD

	CDA 922 Certified	32X PB11 F Low	High	195-100 Measured	Err	
Bi	0.033			0.046	0.0083	

	Nitronic 60 Certified	IARM 18C Low	High	195-089 Measured	Err	
Bi				0.000	0.0005	<LOD

	Certified	Low	High	Measured	Err	
Pb	1.038	0.934	1.142	1.033	0.03	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.054	0.0466	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0112	<LOD
Sb	0.478	0.430	0.526	0.473	0.01	OK
Sn	3.40	3.060	3.740	3.441	0.03	OK
Cd				0.000	0.0060	<LOD
Ag				0.000	0.0066	<LOD
Pd				0.000	0.0068	<LOD
Ru				0.000	0.0014	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.000	0.0014	<LOD
Y				0.000	0.0016	<LOD
Se				0.000	0.0045	<LOD
Zn	1.50	1.350	1.650	1.539	0.03	OK
Cu	90.54	88.729	92.351	90.553	0.12	OK
Ni	0.904	0.723	1.085	0.874	0.02	OK
Co	0.097	0.078	0.116	0.097	0.01	OK
Fe	0.566	0.453	0.679	0.556	0.02	OK
Mn	0.201	0.161	0.241	0.191	0.01	OK
Cr				0.000	0.0368	<LOD
V				0.000	0.0477	<LOD
Ti				0.064	0.0792	<LOD
S	0.0227			0.000	0.0037	<LOD
P	0.885	0.664	1.106	1.077	0.01	
Si	0.099			0.034	0.01	
Al				0.000	0.0396	<LOD
Mg	0.004			0.000	0.0000	<LOD

	Certified	Low	High	Measured	Err	
Pb				0.000	0.0005	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.091	0.0374	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0024	<LOD
Sn	0.004			0.011	0.0022	
Cd				0.000	0.0028	<LOD
Ag				0.000	0.0023	<LOD
Pd				0.000	0.0026	<LOD
Ru				0.000	0.0007	<LOD
Mo	0.354	0.283	0.425	0.350	0.0025	OK
Nb	0.090	0.072	0.108	0.089	0.0013	
Zr				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0043	<LOD
Cu	0.285	0.228	0.342	0.288	0.0134	OK
Ni	8.05	7.648	8.453	7.871	0.0504	OK
Co	0.060	0.000	0.150	0.000	0.0422	OK
Fe	63.0	61.760	64.280	63.265	0.0859	OK
Mn	7.69	7.306	8.075	7.655	0.0470	OK
Cr	16.19	15.785	16.595	16.171	0.0422	OK
V	0.099			0.127	0.0116	
Ti	0.013			0.028	0.0159	
S	0.0010			0.005	0.0035	<LOD
P	0.027			0.159	0.0101	
Si	3.80	3.420	4.180	3.878	0.0285	OK
Al	0.014			0.000	0.0359	<LOD
Mg				0.000	0.0000	<LOD

RIFM T2/2 — 195-101

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0005	<LOD
Pb				0.000	0.0023	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0110	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0035	<LOD
Sn				0.008	0.0027	
Cd				0.000	0.0032	<LOD
Ag				0.000	0.0028	<LOD
Pd				0.000	0.0031	<LOD
Ru				0.000	0.0007	<LOD
Mo				0.012	0.0007	
Nb				0.000	0.0004	<LOD
Zr				0.000	0.0003	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0032	<LOD
Cu	0.075			0.068	0.0065	
Ni	0.74			0.054	0.0205	
Co				0.000	0.0545	<LOD
Fe	95.5	94.259	96.742	95.691	0.0749	OK
Mn	0.28	0.238	0.322	0.263	0.0139	OK
Cr	0.065	0.035	0.095	0.060	0.0060	OK
V				0.000	0.0217	<LOD
Ti	0.037			0.047	0.0164	
S	0.02			0.037	0.0021	
P	0.012			0.000	0.0105	<LOD
Si	3.84	3.648	4.032	3.760	0.0264	OK
Al				0.000	0.0274	<LOD
Mg				0.000	0.0000	<LOD

Ti6-2-4-2 — IARM 177C — 180-503

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.000	0.0013	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0077	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0035	<LOD
Sb				0.000	0.0028	<LOD
Sn	2.02	1.919	2.121	2.016	0.0120	OK
Cd				0.000	0.0024	<LOD
Ag				0.000	0.0025	<LOD
Pd				0.000	0.0029	<LOD
Ru				0.000	0.0012	<LOD
Mo	1.96	1.764	2.352	1.944	0.0095	OK
Nb				0.000	0.0009	<LOD
Zr	3.99	3.751	4.229	3.958	0.0175	OK
Y				0.000	0.0006	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0025	<LOD
Cu				0.000	0.0032	<LOD
Ni				0.007	0.0046	
Co				0.000	0.0065	<LOD
Fe				0.029	0.0169	
Mn				0.000	0.0195	<LOD
Cr				0.000	0.0575	<LOD
V				0.000	0.0936	<LOD
Ti	85.72	84.006	87.434	85.977	0.1615	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.000	0.160	0.069	0.0232	OK
Al	6.02	5.520	6.520	6.019	0.1436	OK
Mg				0.000	0.0000	<LOD

SS416 — IARM 10c — 195-151

	Certified	Low	High	Measured	Err	
Bi				0.001	0.0005	
Pb				0.000	0.0012	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.017	0.0117	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0025	<LOD
Sn	0.009			0.016	0.0023	
Cd				0.000	0.0030	<LOD

Iron — BAS SCRM 660/09 — 195-166

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.000	0.0029	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0115	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0044	<LOD
Sn				0.005	0.0038	<LOD
Cd				0.004	0.0038	<LOD

Ag				0.000	0.0024	<LOD				0.000	0.0036	<LOD
Pd				0.000	0.0027	<LOD				0.000	0.0041	<LOD
Ru				0.000	0.0007	<LOD				0.000	0.0007	<LOD
Mo	0.08	0.040	0.120	0.087	0.0013	OK				0.001	0.0005	
Nb	0.003			0.000	0.0003	<LOD				0.002	0.0006	
Zr				0.000	0.0004	<LOD				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Se				0.000	0.0009	<LOD				0.000	0.0011	<LOD
Zn				0.004	0.0025					0.000	0.0032	<LOD
Cu	0.155	0.110	0.200	0.158	0.0076	OK				0.000	0.0073	<LOD
Ni	0.24	0.160	0.310	0.238	0.0118	OK				0.000	0.0287	<LOD
Co	0.022			0.045	0.0425					0.000	0.0574	<LOD
Fe	86.0	81.700	90.300	86.086	0.0726	OK	94.18	91.355	97.005	94.362	0.1029	OK
Mn	0.35	0.250	0.460	0.403	0.0277	OK	0.406	0.365	0.447	0.393	0.0190	OK
Cr	12.25	11.638	12.863	12.153	0.0367	OK				0.000	0.0221	<LOD
V	0.024			0.050	0.0097					0.000	0.0250	<LOD
Ti	0.002			0.043	0.0154					0.000	0.0635	<LOD
S	0.29	0.220	0.360	0.334	0.0044	OK	0.105	0.079	0.131	0.115	0.0029	OK
P	0.026			0.000	0.0108	<LOD	0.153	0.122	0.184	0.140	0.0037	OK
Si	0.37	0.310	0.430	0.359	0.0106	OK	1.70	1.274	2.124	1.485	0.0189	OK
Al	0.003			0.000	0.0261	<LOD				0.000	0.0335	<LOD
Mg				0.000	0.0000	<LOD				0.000	0.0000	<LOD

	LAS Certified	BS15a Low	High	195-167 Measured	Err		Mar-M 247 Provisional	IARM 333a Low	High	195-173 Measured	Err	
Bi				0.000	0.0007	<LOD				0.000	0.0010	<LOD
Pb				0.000	0.0024	<LOD				0.000		OK
Au				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Re				0.000		OK	0.01			0.000	0.0236	
W				0.000	0.0098	<LOD	9.7	8.730	10.670	9.691	0.1820	OK
Ta				0.000		OK	3.15	2.835	3.465	3.116	0.0771	OK
Hf				0.000		OK	1.4	1.260	1.540	1.396	0.0344	OK
Te				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Sb				0.000	0.0032	<LOD				0.007	0.0044	<LOD
Sn				0.000	0.0039	<LOD				0.010	0.0035	
Cd				0.000	0.0030	<LOD				0.004	0.0037	<LOD
Ag				0.000	0.0038	<LOD				0.000	0.0038	<LOD
Pd				0.000	0.0032	<LOD				0.000	0.0039	<LOD
Ru				0.000	0.0008	<LOD				0.001	0.0012	<LOD
Mo				0.007	0.0006		0.49	0.466	0.515	0.498	0.0045	OK
Nb				0.043	0.0012		0.005			0.003	0.0006	
Zr				0.020	0.0009		0.009			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD				0.000	0.0105	<LOD
Zn				0.000	0.0040	<LOD				0.000		OK
Cu				0.024	0.0053		0.01			0.000		OK
Ni				0.107	0.0205		61.1	58.045	64.155	61.054	0.1734	OK
Co				0.000	0.0429	<LOD	9.4	8.930	9.870	9.390	0.0520	OK
Fe	98.4	95.448	100.000	97.920	0.0680	OK	0.036	0.016	0.056	0.039	0.0071	OK
Mn	1.12	1.008	1.232	1.086	0.0208	OK	0.005			0.032	0.0378	<LOD
Cr				0.044	0.0057		8.32	7.904	8.736	8.429	0.0503	OK
V				0.000	0.0078	<LOD				0.024	0.0277	<LOD
Ti				0.035	0.0259	<LOD	0.73	0.621	0.840	0.712	0.0383	OK
S				0.015	0.0020					0.051	0.0051	
P				0.000	0.0131	<LOD	0.004			0.000	0.0150	<LOD
Si	0.058	0.030	0.100	0.071	0.0071	OK	0.08			0.000	0.0466	
Al				0.086	0.0260		5.53	5.254	5.807	5.571	0.0947	OK
Mg				0.000	0.0000	<LOD				0.000	0.0000	<LOD

Certificate of Calibration

CMSX-4 IARM 332a 195-174

	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0015	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	2.9	2.610	3.190	2.880	0.0497	OK
W	6.5	5.850	7.150	6.438	0.1961	OK
Ta	6.51	5.859	7.161	6.967	0.0855	OK
Hf	0.098			0.066	0.0278	
Te				0.000	0.0000	<LOD
Sb				0.006	0.0039	
Sn				0.007	0.0036	
Cd				0.003	0.0046	<LOD
Ag				0.000	0.0040	<LOD
Pd				0.000	0.0040	<LOD
Ru				0.000	0.0013	<LOD
Mo	0.61	0.549	0.671	0.602	0.0051	
Nb				0.005	0.0007	
Zr				0.000	0.0002	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0106	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	61	59.780	62.220	60.567	0.1725	OK
Co	9.4	8.930	9.588	9.425	0.0517	OK
Fe	0.023	0.003	0.043	0.029	0.0068	OK
Mn				0.020	0.0272	<LOD
Cr	6.31	5.679	6.941	6.240	0.0454	OK
V				0.029	0.0181	
Ti	0.99	0.891	1.089	0.974	0.0433	OK
S				0.046	0.0057	
P				0.067	0.0147	
Si				0.000	0.0483	
Al	5.8	5.220	6.380	5.669	0.0986	OK
Mg				0.000	0.0000	<LOD

Cu-Cd MBH 36X CCD2 195-156

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0020	<LOD
Pb				0.000	0.0027	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.038	0.0261	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0083	<LOD
Sb				0.009	0.0096	<LOD
Sn	0.2	0.180	0.220	0.194	0.0066	OK
Cd	1.18	1.062	1.298	1.179	0.0122	OK
Ag	0.0012			0.000	0.0051	<LOD
Pd				0.000	0.0067	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0007	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.000	0.0014	<LOD
Y				0.000	0.0004	<LOD
Se				0.000	0.0017	<LOD
Zn	0.0019			0.000	0.0189	<LOD
Cu	98.6	98.000	99.200	98.474	0.0980	
Ni				0.000	0.0089	<LOD
Co				0.000	0.0095	<LOD
Fe				0.000	0.0123	<LOD
Mn				0.009	0.0053	
Cr				0.000	0.0215	<LOD
V				0.000	0.0406	<LOD
Ti				0.000	0.0697	<LOD
S				0.062	0.0023	
P				0.000	0.0103	<LOD
Si				0.012	0.0082	<LOD
Al				0.040	0.0371	<LOD
Mg				0.000	0.0000	<LOD

AA7075 ALC 7075 AF 180-505

	Cert	Low	High	Measured	Err	
Bi	0.007			0.007	0.0005	
Pb	0.0073			0.008	0.0005	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0054	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0017	<LOD
Sb				0.000	0.0009	<LOD
Sn	0.014	0.004	0.024	0.016	0.0008	OK
Cd				0.000	0.0008	<LOD
Ag				0.000	0.0008	<LOD
Pd				0.000	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0024	0.001	0.003	0.003	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	5.75	5.578	5.923	5.778	0.0349	OK
Cu	1.750	1.663	1.838	1.761	0.0127	OK
Ni	0.027	0.007	0.047	0.025	0.0016	OK
Co				0.000	0.0026	<LOD
Fe	0.17	0.136	0.204	0.161	0.0053	OK
Mn	0.031	0.016	0.046	0.038	0.0056	OK
Cr	0.22	0.187	0.253	0.219	0.0111	OK
V	0.020			0.072	0.0166	
Ti	0.092	0.012	0.172	0.154	0.0346	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.114	0.266	0.190	0.0123	OK
Al	89	87.220	90.780	89.229	0.1577	OK
Mg	2.66	2.261	3.059	2.350	0.1947	OK

CDA510 IARM 77B 195-177

	Certified	Low	High	Measured	Err	
Bi				0.005	0.0012	
Pb	0.016	0.008	0.024	0.022	0.0020	
Au				0.000	0.0000	<LOD
Re				0.000		<LOD
W				0.055	0.0158	
Ta				0.000		<LOD
Hf				0.000		<LOD
Te				0.000	0.0016	<LOD
Sb				0.000	0.0046	<LOD
Sn	4.66	4.520	4.800	4.658	0.0079	OK
Cd				0.000	0.0038	<LOD
Ag				0.000	0.0043	<LOD
Pd				0.000	0.0050	<LOD
Ru				0.000	0.0010	<LOD
Mo				0.000	0.0044	<LOD
Nb				0.000	0.0006	<LOD
Zr				0.000	0.0072	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0040	<LOD
Cu	95.2	94.248	96.152	95.070	0.0078	
Ni				0.000	0.0205	<LOD
Co				0.000	0.0417	<LOD
Fe				0.000	0.0757	<LOD
Mn				0.000	0.0191	<LOD
Cr				0.000	0.0268	<LOD
V				0.000	0.0825	<LOD
Ti				0.056	0.1029	<LOD
S				0.051	0.0021	
P	0.148	0.118	0.178	0.121	0.0024	OK
Si				0.000	0.0412	<LOD
Al				0.000	0.0810	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Thermo Fisher SCIENTIFIC

The world leader in serving science

Thermo Scientific Portable XRF Analyzers
X-Ray Tube Radiation Survey Certificate

Instrument Model:	XL5
Instrument S/N:	500946

Detector Model:	RadEye
Detector S/N:	0240
Calibration Date:	12/5/2017

Sample (Beam Stop)	Steel
Maximum scatter net dose rate (µrem/hr) (100.0 µrem = 0.1 mrem = 1.0 µSv)	
5 cm	10 cm
480	279

- All recorded measurements are net above background. An entry of "ND" for non-detectable means that the measurement results was at or indistinguishable from background.

Conducted by: Steve Seng

Survey 8/15/2018

Thermo Scientific Portable Analytical Instruments
2 Radcliff Road Tewksbury MA 01876 USA
140-00200_B

+1 978-670-7460
+1 978-670-7430 fax

800-875-1578 (toll free)
www.thermoscientific.com/pai

ThermoFisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy Light 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

Serial Number: X500946 Model: Niton XL5- Software: 5372 Date of Q.C.: 21-Aug-18
Resolution: 161.7009 147.8162 Escale: 7.497 7.494 Spot Size: 3mm Inspector: VK

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0002	<LOD
Pb			0.001	0.0004	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0020	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0012	<LOD
Sb			0.000	0.0009	<LOD
Sn			0.000	0.0008	<LOD
Cd			0.000	0.0009	<LOD
Ag			0.000	0.0008	<LOD
Pd			0.000	0.0011	<LOD
Ru			0.000	0.0002	<LOD
Mo			0.000	0.0001	<LOD
Nb			0.000	0.0001	<LOD
Zr			0.000	0.0001	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0001	<LOD
Zn			0.003	0.0007	
Cu			0.000	0.0008	<LOD
Ni			0.000	0.0013	<LOD
Co			0.000	0.0017	<LOD
Fe	0	0.02	0.000	0.0031	<LOD
Mn			0.000	0.0060	<LOD
Cr			0.000	0.0106	<LOD
V			0.000	0.0228	<LOD
Ti			0.000	0.0467	<LOD
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.017	0.0137	<LOD
Al			0.062	0.0518	<LOD
Mg	99.85	100	99.92	0.0757	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.002	0.0007	
Pb			0.011	0.0047	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0173	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0045	<LOD
Sn			0.000	0.0040	<LOD
Cd			0.000	0.0036	<LOD
Ag			0.000	0.0044	<LOD
Pd			0.000	0.0053	<LOD
Ru			0.000	0.0009	<LOD
Mo			0.000	0.0008	<LOD
Nb			0.000	0.0007	<LOD
Zr			0.000	0.0005	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0011	<LOD
Zn			0.000	0.0037	<LOD
Cu			0.000	0.0064	<LOD
Ni			0.000	0.0295	<LOD
Co			0.000	0.0660	<LOD
Fe	99.75	100	99.99	0.1040	OK
Mn			0.000	0.0132	<LOD
Cr			0.000	0.0175	<LOD
V			0.000	0.0306	<LOD
Ti			0.000	0.0449	<LOD
S			0.000	0.0030	<LOD
P			0.000	0.0029	<LOD
Si			0.000	0.0117	<LOD
Al			0.000	0.0381	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.001	0.0009	<LOD
Pb			0.003	0.0010	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0105	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0041	<LOD
Sb			0.000	0.0033	<LOD
Sn			0.000	0.0035	<LOD
Cd			0.000	0.0025	<LOD
Ag			0.000	0.0039	<LOD
Pd			0.000	0.0035	<LOD
Ru			0.000	0.0007	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0002	<LOD
Se			0.000	0.0007	<LOD
Zn			0.003	0.0024	<LOD
Cu			0.004	0.0046	<LOD
Ni			0.000	0.0047	<LOD
Co			0.000	0.0063	<LOD
Fe			0.000	0.0112	<LOD
Mn			0.000	0.0178	<LOD
Cr			0.000	0.0881	<LOD
V			0.000	0.1076	<LOD
Ti	99.7	100	99.96	0.1606	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0119	<LOD
Al			0.117	0.0738	
Mg			0.000	0.0000	<LOD

Certificate of Calibration

Ti 6-6-2 **IARM 178B** 195-095

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0009	<LOD
Pb				0.000	0.0011	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0113	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0041	<LOD
Sb				0.000	0.0030	<LOD
Sn	**1.99**	**1.70**	**2.30**	1.978	0.0124	OK
Cd				0.000	0.0037	<LOD
Ag				0.011	0.0029	
Pd				0.000	0.0049	<LOD
Ru				0.001	0.0006	<LOD
Mo	0.008	0.002	0.014	0.007	0.0006	OK
Nb				0.001	0.0005	<LOD
Zr	0.004	0.001	0.01	0.004	0.0005	OK
Y				0.000	0.0002	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0029	OK
Cu	**0.51**	**0.40**	**0.60**	0.506	0.0144	OK
Ni	0.017	0.005	0.030	0.017	0.0062	OK
Co				0.000	0.0107	<LOD
Fe	**0.56**	**0.42**	**0.64**	0.555	0.0270	OK
Mn	0.003			0.029	0.0182	
Cr	0.015			0.000	0.0520	<LOD
V	**5.51**	**5.21**	**5.81**	5.462	0.1125	OK
Ti	**85.5**	**83.79**	**87.21**	86.023	0.1683	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.00	0.05	0.014	0.0120	<LOD
Al	**5.57**	**5.15**	**6.09**	5.386	0.1292	OK
Mg				0.000	0.0000	<LOD

AA 4032 **ALCOA SS-4032D** 195-093

	Certified	Low	High	Measured	Err	
Bi	0.0000			0.001	0.0003	
Pb	0.0006			0.001	0.0005	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.011	0.0117	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0018	<LOD
Sb	0.000			0.000	0.0014	<LOD
Sn	0.0003			0.000	0.0012	<LOD
Cd	0.000			0.000	0.0013	<LOD
Ag	0.0001			0.000	0.0012	<LOD
Pd				0.000	0.0016	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0018			0.005	0.0003	
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	0.102	0.051	0.153	0.108	0.0036	OK
Cu	**0.895**	**0.81**	**0.98**	0.950	0.0127	OK
Ni	**0.90**	**0.77**	**1.04**	0.891	0.0149	OK
Co	0.0003			0.000	0.0040	<LOD
Fe	**0.232**	**0.162**	**0.302**	0.251	0.0113	OK
Mn	0.0307	0.015	0.043	0.034	0.0091	
Cr	0.0499	0.030	0.065	0.025	0.0152	
V	0.0099			0.000	0.0307	<LOD
Ti	0.012			0.000	0.0613	<LOD
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	**12.20**	**11.47**	**12.93**	12.26	0.1216	OK
Al	***84.4***	**81.04**	**87.80**	84.25	0.1552	OK
Mg	**1.10**	**0.350**	**1.850**	1.217	0.1918	OK

AA5083 **ALCAN 5083AF** 195-091

	Certified	Low	High	Measured	Err	
Bi	0.008			0.008	0.0008	
Pb	0.0077			0.010	0.0009	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0044	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0019	<LOD
Sb	0.0012			0.000	0.0016	<LOD
Sn	0.020			0.020	0.0014	
Cd	0.0012			0.000	0.0019	<LOD
Ag				0.000	0.0016	<LOD
Pd				0.000	0.0018	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0035			0.004	0.0027	
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	**0.050**	**0.04**	**0.06**	0.051	0.0027	OK
Cu	**0.078**	**0.06**	**0.09**	0.074	0.0039	OK
Ni	0.03			0.031	0.0036	
Co				0.007	0.0050	<LOD
Fe	**0.34**	**0.27**	**0.41**	0.283	0.0160	OK
Mn	**0.740**	**0.67**	**0.81**	0.739	0.0278	OK
Cr	0.15	0.08	0.21	0.140	0.0214	OK
V	0.02			0.000	0.0426	<LOD
Ti	0.027			0.000	0.0736	<LOD
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	**0.17**	**0.09**	**0.26**	0.20	0.0192	OK
Al	**93.4**	**88.73**	**98.07**	93.17	0.2392	OK
Mg	**4.85**	**4.12**	**5.58**	5.26	0.2325	OK

CDA 642 **IARM 81B** 195-097

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0020	<LOD
Pb	0.006			0.009	0.0030	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0401	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0072	<LOD
Sb	0.003			0.000	0.0052	<LOD
Sn	0.008			0.013	0.0050	
Cd				0.000	0.0050	<LOD
Ag	0.004			0.023	0.0057	
Pd				0.000	0.0071	<LOD
Ru				0.000	0.0014	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0014	<LOD
Y				0.000	0.0006	<LOD
Se				0.000	0.0047	<LOD
Zn	**0.176**	**0.132**	**0.220**	0.164	0.0191	OK
Cu	**91.2**	**89.38**	**93.02**	91.212	0.1764	OK
Ni	0.003			0.007	0.0088	
Co				0.000	0.0088	<LOD
Fe	**0.047**	**0.022**	**0.072**	0.053	0.0050	
Mn	0.012			0.008	0.0057	<LOD
Cr				0.000	0.0214	<LOD
V				0.000	0.0334	<LOD
Ti				0.000	0.0628	
S				0.051	0.0039	
P	0.004			0.000	0.0046	<LOD
Si	**1.84**	**1.44**	**2.24**	1.824	0.0408	OK
Al	**6.70**	**5.36**	**8.04**	6.642	0.1618	OK
Mg				0.000	0.0000	<LOD

Certificate of Calibration

	CDA 922	32X PB11 F		195-100		
	Certified	Low	High	Measured	Err	
Bi	0.033			0.054	0.0072	
Pb	1.038	0.88	1.19	1.04	0.0221	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.052	0.0346	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0080	
Sb	0.478	0.41	0.55	0.479	0.0111	OK
Sn	3.40	2.89	3.91	3.460	0.0238	OK
Cd				0.000	0.0059	
Ag				0.022	0.0062	
Pd				0.000	0.0070	<LOD
Ru				0.000	0.0016	<LOD
Mo				0.000	0.0010	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.002	0.0013	<LOD
Y				0.003	0.0023	<LOD
Se				0.000	0.0027	<LOD
Zn	1.50	1.28	1.73	1.50	0.0261	OK
Cu	90.54	87.82	93.26	90.65	0.1077	OK
Ni	0.904	0.68	1.13	0.91	0.0182	OK
Co	0.097	0.073	0.121	0.097	0.0065	
Fe	0.566	0.42	0.71	0.57	0.0129	OK
Mn	0.201	0.15	0.25	0.20	0.0109	OK
Cr				0.010	0.0208	<LOD
V				0.000	0.0440	<LOD
Ti				0.037	0.0606	<LOD
S	0.0227			0.000	0.0071	<LOD
P	0.885	0.62	1.15	0.92	0.0178	OK
Si	0.099			0.03	0.0179	
Al				0.000	0.0581	<LOD
Mg	0.004			0.000	0.0000	<LOD

	Nitronic 60	IARM 18C		195-089		
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0013	
Pb				0.003	0.0016	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.098	0.0585	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0060	<LOD
Sn	0.004			0.008	0.0036	
Cd				0.000	0.0040	<LOD
Ag				0.032	0.0041	
Pd				0.000	0.0043	<LOD
Ru				0.000	0.0011	
Mo	0.354	0.27	0.44	0.350	0.0039	OK
Nb	0.090	0.068	0.113	0.090	0.0020	
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0022	<LOD
Zn				0.000	0.0070	<LOD
Cu	0.285	0.21	0.36	0.275	0.0197	OK
Ni	8.05	7.25	8.86	8.011	0.0774	OK
Co	0.060	0.00	0.15	0.078	0.0618	OK
Fe	63.0	61.13	64.91	63.208	0.1280	OK
Mn	7.69	6.92	8.46	7.649	0.0697	OK
Cr	16.19	15.70	16.68	16.177	0.0636	OK
V	0.099			0.133	0.0158	
Ti	0.013			0.037	0.0211	
S	0.0010			0.006	0.0067	<LOD
P	0.027			0.028	0.0043	
Si	3.80	3.04	4.56	3.819	0.0483	OK
Al	0.014			0.000	0.0555	<LOD
Mg				0.000	0.0000	<LOD

		RIFM T2/2		195-101		
	Certified	Low	High	Measured	Err	
Bi				0.001	0.0005	
Pb				0.005	0.0040	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0178	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0042	<LOD
Sn				0.007	0.0048	<LOD
Cd				0.000	0.0037	<LOD
Ag				0.000	0.0056	<LOD
Pd				0.000	0.0050	<LOD
Ru				0.000	0.0010	<LOD
Mo				0.012	0.0010	
Nb				0.001	0.0006	
Zr				0.000	0.0006	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0011	<LOD
Zn				0.000	0.0043	<LOD
Cu	0.075			0.077	0.0092	
Ni	0.74			0.053	0.0223	
Co				0.066	0.0705	<LOD
Fe	95.5	93.59	97.41	95.568	0.1029	OK
Mn	0.28	0.22	0.34	0.265	0.0160	OK
Cr	0.065			0.062	0.0075	
V				0.010	0.0229	
Ti	0.037			0.025	0.0197	
S	0.02			0.048	0.0038	
P	0.012			0.011	0.0034	
Si	3.84	3.57	4.11	3.830	0.0479	OK
Al				0.000	0.0422	<LOD
Mg				0.000	0.0000	<LOD

	Ti6-2-4-2	IARM 177C		180-503		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0016	<LOD
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0127	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0048	<LOD
Sb				0.000	0.0038	<LOD
Sn	2.02	1.82	2.22	1.989	0.0147	OK
Cd				0.000	0.0035	<LOD
Ag				0.007	0.0045	
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0016	<LOD
Mo	1.96	1.67	2.25	1.935	0.0115	OK
Nb				0.000	0.0010	
Zr	3.99	3.59	4.39	3.940	0.0201	OK
Y				0.000	0.0008	<LOD
Se				0.000	0.0010	<LOD
Zn				0.000	0.0030	<LOD
Cu				0.000	0.0045	<LOD
Ni				0.007	0.0066	<LOD
Co				0.000	0.0082	<LOD
Fe				0.019	0.0133	<LOD
Mn				0.000	0.0212	<LOD
Cr				0.000	0.0685	<LOD
V				0.111	0.1150	<LOD
Ti	85.72	83.15	88.29	85.920	0.1744	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.00	0.16	0.075	0.0180	OK
Al	6.02	5.52	6.52	6.069	0.1371	OK
Mg				0.000	0.0000	<LOD

Certificate of Calibration

	SS416 Certified	IARM 10c Low	High	195-151 Measured	Err	
Bi				0.004	0.0012	
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.026	0.0195	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.007	0.0045	
Sn	0.009			0.014	0.0037	
Cd				0.000	0.0040	<LOD
Ag				0.031	0.0042	
Pd				0.000	0.0052	<LOD
Ru				0.001	0.0009	<LOD
Mo	0.08	0.04	0.14	0.089	0.0020	OK
Nb	0.003			0.002	0.0006	
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0042	<LOD
Cu	0.155	0.11	0.20	0.171	0.0115	OK
Ni	0.24	0.16	0.31	0.232	0.0179	OK
Co	0.022			0.142	0.0616	
Fe	86.0	81.70	90.30	85.921	0.1221	OK
Mn	0.35	0.25	0.46	0.406	0.0394	OK
Cr	12.25	11.64	12.86	12.156	0.0562	OK
V	0.024			0.052	0.0125	
Ti	0.002			0.021	0.0434	
S	0.29	0.20	0.38	0.372	0.0084	OK
P	0.026			0.022	0.0037	
Si	0.37	0.31	0.43	0.379	0.0183	OK
Al	0.003			0.000	0.0484	<LOD
Mg				0.000	0.0000	<LOD

	Iron Certified	BAS SCRM 660/09 Low	High	195-166 Measured	Err	
Bi				0.010	0.0012	
Pb				0.009	0.0045	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0170	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0050	<LOD
Sn				0.000	0.0049	<LOD
Cd				0.000	0.0039	<LOD
Ag				0.008	0.0044	
Pd				0.000	0.0057	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.001	0.0007	<LOD
Nb				0.004	0.0006	
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.000	0.0035	<LOD
Cu				0.010	0.0082	<LOD
Ni				0.000	0.0264	<LOD
Co				0.000	0.0771	<LOD
Fe	94.18	90.41	97.95	94.239	0.1127	OK
Mn	0.406	0.37	0.45	0.397	0.0176	OK
Cr				0.008	0.0171	<LOD
V				0.011	0.0208	<LOD
Ti				0.024	0.0385	<LOD
S	0.105	0.053	0.158	0.131	0.0053	OK
P	0.153	0.077	0.230	0.111	0.0058	OK
Si	1.70	1.19	2.21	1.578	0.0330	OK
Al				0.000	0.0487	<LOD
Mg				0.000	0.0000	<LOD

	LAS Certified	BS15a Low	High	195-167 Measured	Err	
Bi				0.003	0.0013	
Pb				0.009	0.0033	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0164	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0041	<LOD
Sn				0.000	0.0038	<LOD
Cd				0.000	0.0035	<LOD
Ag				0.000	0.0043	<LOD
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.007	0.0009	
Nb				0.047	0.0016	
Zr				0.016	0.0011	
Y				0.000	0.0000	<LOD
Se				0.000	0.0012	<LOD
Zn				0.000	0.0039	<LOD
Cu				0.037	0.0075	
Ni				0.059	0.0263	
Co				0.000	0.0537	<LOD
Fe	*98.4*	95.45	100.0	98.258	0.0997	OK
Mn	1.12	1.01	1.23	1.130	0.0250	OK
Cr				0.056	0.0069	
V				0.025	0.0273	<LOD
Ti				0.000	0.0517	<LOD
S				0.032	0.0034	
P				0.015	0.0035	
Si	0.058	0.03	0.1	0.078	0.0120	OK
Al				0.061	0.0409	<LOD
Mg				0.000	0.0000	<LOD

	Mar-M 247 Provisional	IARM 333a Low	High	195-173 Measured		
Bi				0.000	0.0015	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	*0.01*			0.000	0.0303	
W	*9.7*	8.73	10.67	9.513	0.2315	OK
Ta	*3.15*	2.84	3.47	2.872	0.0920	OK
Hf	*1.4*	1.260	1.540	1.381	0.0434	OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0053	<LOD
Sn				0.006	0.0063	
Cd				0.005	0.0044	<LOD
Ag				0.032	0.0054	
Pd				0.000	0.0053	<LOD
Ru				0.000	0.0014	<LOD
Mo	*0.49*	0.44	0.54	0.494	0.0058	OK
Nb	*0.005*			0.003	0.0010	
Zr	*0.009*			0.004	0.0009	
Y				0.000	0.0000	<LOD
Se				0.000	0.0136	<LOD
Zn				0.000		OK
Cu	*0.01*			0.000		OK
Ni	*61.1*	54.99	67.21	61.775	0.2308	OK
Co	*9.4*	8.46	10.34	9.199	0.0647	OK
Fe	*0.036*	0.016	0.056	0.038	0.0079	OK
Mn	*0.005*			0.040	0.0302	<LOD
Cr	*8.32*	7.49	9.15	8.263	0.0614	OK
V				0.022	0.0342	<LOD
Ti	*0.73*	0.621	0.840	0.713	0.0448	OK
S				0.065	0.0091	
P	*0.004*			0.078	0.0083	
Si	*0.08*			0.000	0.0775	
Al	*5.53*	4.98	6.08	5.521	0.1453	OK
Mg				0.000	0.0000	<LOD

Certificate of Calibration

Niton XL5 Alloy Light 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

	CMSX-4	IARM 332a		195-174		
	Provisional	Low	High	Measured	Err	
Bi				0.002	0.0018	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	2.9	2.465	3.335	2.832	0.0628	OK
W	6.5	5.525	7.475	6.430	0.2521	OK
Ta	6.51	5.534	7.487	6.886	0.1031	OK
Hf	0.098			0.066	0.0364	
Te				0.000	0.0000	<LOD
Sb				0.000	0.0059	<LOD
Sn				0.006	0.0054	<LOD
Cd				0.000	0.0044	<LOD
Ag				0.043	0.0059	
Pd				0.000	0.0055	<LOD
Ru				0.000	0.0015	<LOD
Mo	0.61	0.488	0.732	0.587	0.0010	OK
Nb				0.005	0.0010	
Zr				0.001	0.0007	
Y				0.000	0.0000	<LOD
Se				0.000	0.0139	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	61	59.17	62.83	61.107	0.2340	OK
Co	9.4	8.46	10.34	9.252	0.0651	OK
Fe	0.023			0.016	0.0074	
Mn				0.023	0.0363	<LOD
Cr	6.31	5.36	7.26	6.088	0.0572	OK
V				0.000	0.0548	<LOD
Ti	0.99	0.84	1.14	0.972	0.0514	OK
S				0.069	0.0102	
P				0.075	0.0106	
Si				0.000	0.0816	
Al	5.8	4.93	6.67	5.571	0.1507	OK
Mg				0.000	0.0000	<LOD

	Cu-Cd	MBH 36X CCD2		195-156		
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0023	<LOD
Pb				0.000	0.0025	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.032	0.0335	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0080	<LOD
Sb				0.013	0.0108	<LOD
Sn	0.2	0.16	0.24	0.193	0.0074	OK
Cd	1.18	1.003	1.357	1.179	0.0136	OK
Ag	0.0012			0.007	0.0061	<LOD
Pd				0.000	0.0066	<LOD
Ru				0.002	0.0016	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0017	<LOD
Y				0.001	0.0005	<LOD
Se				0.000	0.0041	<LOD
Zn	0.0019			0.000	0.0222	<LOD
Cu	98.6	98	99.2	98.532	0.1174	OK
Ni				0.000	0.0094	<LOD
Co				0.000	0.0109	<LOD
Fe				0.000	0.0121	<LOD
Mn				0.006	0.0122	<LOD
Cr				0.009	0.0184	<LOD
V				0.000	0.0408	<LOD
Ti				0.000	0.0763	<LOD
S				0.064	0.0039	
P				0.000	0.0045	<LOD
Si				0.017	0.0130	<LOD
Al				0.000	0.0622	<LOD
Mg				0.000	0.0000	<LOD

	AA7075		ALC 7075 AF		180-505	
	Cert	Low	High	Measured	Err	
Bi	0.007			0.008	0.0010	
Pb	0.0073			0.009	0.0010	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0107	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0026	<LOD
Sb				0.000	0.0026	<LOD
Sn	0.014	0.004	0.024	0.016	0.0018	
Cd				0.000	0.0020	<LOD
Ag				0.009	0.0018	
Pd				0.000	0.0024	<LOD
Ru				0.000	0.0005	<LOD
Mo				0.000	0.0003	<LOD
Nb				0.000	0.0003	<LOD
Zr	0.0024			0.003	0.0003	
Y				0.000	0.0002	<LOD
Se				0.000	0.0006	<LOD
Zn	5.75	5.463	6.038	5.712	0.0482	OK
Cu	1.750	1.575	1.925	1.662	0.0204	OK
Ni	0.027			0.023	0.0033	
Co				0.000	0.0046	OK
Fe	0.17	0.1275	0.2125	0.137	0.0099	OK
Mn	0.031			0.032	0.0101	
Cr	0.22	0.187	0.253	0.233	0.0205	OK
V	0.020			0.062	0.0364	
Ti	0.092	0.012	0.172	0.122	0.0569	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.095	0.285	0.233	0.0203	OK
Al	89	86.33	91.67	89.137	0.2079	OK
Mg	2.66	2.128	3.192	2.628	0.2426	OK

	CDA510	IARM 77b		195-177		
	Certified	Low	High	Measured	Err	
Bi				0.006	0.0028	
Pb	0.016	0.008	0.024	0.018	0.0039	OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0000	<LOD
W				0.076	0.0303	
Ta				0.000	0.1226	<LOD
Hf				0.000	0.0087	<LOD
Te				0.000	0.0073	<LOD
Sb				0.000	0.0061	<LOD
Sn	4.66	4.520	4.800	4.621	0.0290	OK
Cd				0.000	0.0059	<LOD
Ag				0.000	0.0065	<LOD
Pd				0.000	0.0060	<LOD
Ru				0.000	0.0017	<LOD
Mo				0.000	0.0009	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.000	0.0016	<LOD
Y				0.000	0.0005	<LOD
Se				0.000	0.0020	<LOD
Zn				0.020	0.0201	<LOD
Cu	95.2	94.248	96.152	95.035	0.1226	OK
Ni				0.000	0.0087	<LOD
Co				0.000	0.0094	<LOD
Fe				0.006	0.0116	<LOD
Mn				0.000	0.0153	<LOD
Cr				0.000	0.0236	<LOD
V				0.000	0.0374	<LOD
Ti				0.000	0.1021	<LOD
S				0.108	0.0028	
P	0.148	0.118	0.178	0.128	0.0071	OK
Si				0.000	0.0140	<LOD
Al				0.000	0.0601	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Certificate of Calibration

Serial Number: X500946 Model: Niton XL5- Software: 5372 Date of Q.C.: 21-Aug-18
Resolution: 170.341 156.71 Escale: 7.453 7.494 Spot Size: 8mm Inspector: VK

20 second main + 60s light filter analysis times

Pure Mg

	Low	High	Measured	Err	OK
Bi			0.000	0.0004	<LOD
Pb			0.001	0.0010	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0035	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0005	<LOD
Sb			0.000	0.0012	<LOD
Sn			0.000	0.0011	<LOD
Cd			0.000	0.0011	<LOD
Ag			0.000	0.0012	<LOD
Pd			0.011	0.0013	
Ru			0.000	0.0002	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0003	<LOD
Zn			0.004	0.0009	
Cu			0.000	0.0013	<LOD
Ni			0.000	0.0061	<LOD
Co			0.000	0.0137	<LOD
Fe	0	0.02	0.000	0.0211	OK
Mn			0.000	0.0060	<LOD
Cr			0.000	0.0066	<LOD
V			0.000	0.0166	<LOD
Ti			0.000	0.0345	<LOD
S			0.000	0.0007	<LOD
P			0.000	0.0004	<LOD
Si			0.011	0.0075	<LOD
Al			0.064	0.0301	
Mg	99.85	100	99.91	0.0369	OK

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0014	<LOD
Pb			0.000	0.0026	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.0093	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0000	<LOD
Sb			0.000	0.0032	<LOD
Sn			0.000	0.0028	<LOD
Cd			0.000	0.0028	<LOD
Ag			0.000	0.0034	<LOD
Pd			0.000	0.0033	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0008	<LOD
Zn			0.004	0.0028	<LOD
Cu			0.000	0.0040	<LOD
Ni			0.000	0.0242	<LOD
Co			0.000	0.0459	<LOD
Fe	99.85	100	99.99	0.0760	OK
Mn			0.000	0.0112	<LOD
Cr			0.007	0.0122	<LOD
V			0.000	0.0197	<LOD
Ti			0.000	0.0375	<LOD
S			0.002	0.0020	<LOD
P			0.000	0.0017	<LOD
Si			0.000	0.0053	<LOD
Al			0.000	0.0272	<LOD
Mg			0.000	0.0000	<LOD

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.001	0.0007	<LOD
Pb			0.001	0.0006	
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.005	0.0041	<LOD
Ta			0.000	0.0000	<LOD
Hf			0.000	0.0000	<LOD
Te			0.000	0.0020	<LOD
Sb			0.000	0.0016	<LOD
Sn			0.000	0.0012	<LOD
Cd			0.000	0.0012	<LOD
Ag			0.000	0.0020	<LOD
Pd			0.000	0.0017	<LOD
Ru			0.000	0.0004	<LOD
Mo			0.000	0.0002	<LOD
Nb			0.000	0.0002	<LOD
Zr			0.000	0.0002	<LOD
Y			0.000	0.0001	<LOD
Se			0.000	0.0003	<LOD
Zn			0.000	0.0009	<LOD
Cu			0.002	0.0015	<LOD
Ni			0.000	0.0025	<LOD
Co			0.000	0.0034	<LOD
Fe			0.000	0.0055	<LOD
Mn			0.013	0.0114	<LOD
Cr			0.000	0.0466	<LOD
V			0.000	0.0544	<LOD
Ti	99.8	100	99.99	0.1021	OK
S			0.000	0.0000	<LOD
P			0.000	0.0000	<LOD
Si			0.000	0.0128	<LOD
Al			0.000	0.0690	<LOD
Mg			0.000	0.0000	<LOD

Certificate of Calibration

Ti 6-6-2 — IARM 178B — 195-095

	Certified	Low	High	Measured	Err	
Bi				0.001	0.0007	
Pb				0.000	0.0006	<LOD
Au				0.000	0.0010	<LOD
Re				0.000		OK
W				0.005	0.0014	
Ta				0.000		OK
Hf				0.000		OK
Te				0.002	0.0022	<LOD
Sb				0.002	0.0020	<LOD
Sn	1.99	1.750	2.229	1.982	0.01	OK
Cd				0.002	0.0018	<LOD
Ag				0.011	0.0016	
Pd				0.003	0.0022	<LOD
Ru				0.001	0.0004	<LOD
Mo	0.008	0.002	0.014	0.007	0.0003	OK
Nb				0.001	0.0005	
Zr	0.004	0.001	0.010	0.004	0.0003	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn				0.002	0.0020	<LOD
Cu	0.51	0.420	0.600	0.507	0.0082	OK
Ni	0.017	0.007	0.027	0.017	0.0033	OK
Co				0.000	0.0073	<LOD
Fe	0.56	0.420	0.640	0.557	0.0158	OK
Mn	0.003			0.020	0.0145	<LOD
Cr	0.015			0.000	0.0314	<LOD
V	5.51	5.210	5.810	5.479	0.0661	OK
Ti	85.5	83.790	87.210	85.939	0.1317	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.025	0.000	0.050	0.004	0.0154	OK
Al	5.57	5.124	6.016	5.464	0.1245	OK
Mg				0.000	0.0000	<LOD

AA 4032 — ALCOA SS-4032D — 195-093

	Certified	Low	High	Measured	Err	
Bi	0.0000			0.000	0.0003	<LOD
Pb	0.0006			0.001	0.0003	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.021	0.0141	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0012	<LOD
Sb	0.000			0.000	0.0009	<LOD
Sn	0.0003			0.001	0.0008	<LOD
Cd	0.000			0.000	0.0009	<LOD
Ag	0.0001			0.001	0.0008	<LOD
Pd				0.000	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	
Nb				0.000	0.0001	<LOD
Zr	0.0018			0.004	0.0002	
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	0.102	0.082	0.122	0.105	0.0025	OK
Cu	0.895	0.850	0.940	0.919	0.0084	OK
Ni	0.90	0.810	0.990	0.818	0.0095	OK
Co	0.0003			0.000	0.0033	<LOD
Fe	0.232	0.186	0.278	0.240	0.0081	OK
Mn	0.0307	0.015	0.043	0.034	0.0070	OK
Cr	0.0499	0.030	0.065	0.052	0.0120	OK
V	0.0099			0.000	0.0289	<LOD
Ti	0.012			0.049	0.0483	<LOD
S				0.000	0.0000	<LOD
P	0.0008			0.000	0.0000	<LOD
Si	12.20	11.712	12.688	12.36	0.0741	OK
Al	84.4	82.732	86.108	84.27	0.0959	OK
Mg	1.10	0.420	1.780	1.122	0.1100	OK

AA5083 — ALCAN 5083AF — 195-091

	Certified	Low	High	Measured	Err	
Bi	0.008			0.007	0.0005	
Pb	0.0077			0.006	0.0005	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.003	0.0026	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0011	<LOD
Sb	0.0012			0.000	0.0012	<LOD
Sn	0.020	0.010	0.030	0.020	0.0008	OK
Cd	0.0012			0.001	0.0009	<LOD
Ag				0.000	0.0010	<LOD
Pd				0.000	0.0010	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0035	0.002	0.005	0.003	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	0.050	0.040	0.060	0.050	0.002	OK
Cu	0.078	0.062	0.094	0.079	0.002	OK
Ni	0.03	0.010	0.050	0.026	0.0020	OK
Co				0.000	0.0033	<LOD
Fe	0.34	0.272	0.408	0.286	0.0095	OK
Mn	0.740	0.666	0.814	0.739	0.0168	OK
Cr	0.15	0.11	0.20	0.126	0.0134	OK
V	0.02			0.000	0.0276	<LOD
Ti	0.027			0.000	0.0686	<LOD
S				0.000	0.0000	<LOD
P	0.0014			0.000	0.0000	<LOD
Si	0.17	0.102	0.240	0.221	0.0124	OK
Al	93.4	91.532	95.268	93.402	0.1583	OK
Mg	4.85	4.365	5.335	5.030	0.1455	OK

CDA 642 — IARM 81B — 195-097

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0019	<LOD
Pb	0.006			0.013	0.0030	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0353	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.007	0.0062	<LOD
Sb	0.003			0.007	0.0051	<LOD
Sn	0.008			0.011	0.0043	
Cd				0.006	0.0053	<LOD
Ag	0.004			0.017	0.0052	
Pd				0.005	0.0048	<LOD
Ru				0.000	0.0011	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.001	0.0010	<LOD
Zr				0.000	0.0015	<LOD
Y				0.001	0.0004	
Se				0.000	0.0045	<LOD
Zn	0.176	0.141	0.211	0.188	0.0180	OK
Cu	91.2	89.376	93.024	91.127	0.1142	OK
Ni	0.003			0.009	0.0094	<LOD
Co				0.000	0.0087	<LOD
Fe	0.047	0.027	0.067	0.049	0.0048	OK
Mn	0.012			0.011	0.0054	
Cr				0.009	0.0176	<LOD
V				0.000	0.0309	<LOD
Ti				0.000	0.0625	<LOD
S				0.047	0.0022	
P	0.004			0.007	0.0024	
Si	1.84	1.440	2.240	1.831	0.0240	OK
Al	6.70	6.030	7.370	6.667	0.0954	OK
Mg				0.000	0.0000	<LOD

CDA 922 — 32X PB11 F — 195-100

	Certified	Low	High	Measured	Err	
Bi	0.033			0.040	0.0066	

Nitronic 60 — IARM 18C — 195-089

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD

Pb	1.038	0.934	1.142	1.040	0.02	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.083	0.0324	
Ta				0.000		OK
Hf				0.000		OK
Te				0.012	0.0072	
Sb	0.478	0.430	0.526	0.479	0.01	OK
Sn	3.40	3.060	3.740	3.360	0.02	OK
Cd				0.006	0.0052	<LOD
Ag				0.022	0.0057	
Pd				0.005	0.0048	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.000	0.0008	<LOD
Zr				0.000	0.0012	<LOD
Y				0.005	0.0033	<LOD
Se				0.000	0.0024	<LOD
Zn	1.50	1.350	1.650	1.501	0.02	OK
Cu	90.54	88.729	92.351	90.679	0.10	OK
Ni	0.904	0.723	1.085	0.906	0.02	OK
Co	0.097	0.078	0.116	0.097	0.01	OK
Fe	0.566	0.453	0.679	0.567	0.01	OK
Mn	0.201	0.161	0.241	0.201	0.01	OK
Cr				0.009	0.0214	<LOD
V				0.016	0.0281	<LOD
Ti				0.000	0.0731	<LOD
S	0.0227			0.000	0.0041	<LOD
P	0.885	0.664	1.106	0.988	0.01	
Si	0.099			0.000	0.01	<LOD
Al				0.000	0.0396	<LOD
Mg	0.004			0.000	0.0000	<LOD

Pb				0.000	0.0013	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.05			0.101	0.0372	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0032	<LOD
Sn	0.004			0.010	0.0023	
Cd				0.000	0.0027	<LOD
Ag				0.025	0.0026	
Pd				0.000	0.0026	<LOD
Ru				0.000	0.0007	<LOD
Mo	0.354	0.283	0.425	0.350	0.0025	OK
Nb	0.090	0.072	0.108	0.089	0.0013	
Zr				0.001	0.0004	
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0049	<LOD
Cu	0.285	0.228	0.342	0.280	0.0131	OK
Ni	8.05	7.648	8.453	8.000	0.0510	OK
Co	0.060	0.000	0.150	0.000	0.0424	OK
Fe	63.0	61.760	64.280	63.245	0.0846	OK
Mn	7.69	7.306	8.075	7.639	0.0464	OK
Cr	16.19	15.785	16.595	16.163	0.0425	OK
V	0.099			0.125	0.0110	
Ti	0.013			0.074	0.0161	
S	0.0010			0.000	0.0044	<LOD
P	0.027			0.044	0.0027	
Si	3.80	3.420	4.180	3.813	0.0288	OK
Al	0.014			0.087	0.0317	
Mg				0.000	0.0000	<LOD

		RIFM T2/2		195-101		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0014	<LOD
Pb				0.018	0.0053	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0131	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0031	<LOD
Sn				0.005	0.0028	
Cd				0.000	0.0028	<LOD
Ag				0.006	0.0033	
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0006	<LOD
Mo				0.011	0.0007	
Nb				0.001	0.0005	<LOD
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0007	<LOD
Zn				0.003	0.0030	<LOD
Cu	0.075			0.080	0.0065	
Ni	0.74			0.074	0.0173	
Co				0.049	0.0462	<LOD
Fe	95.5	94.259	96.742	95.548	0.0668	OK
Mn	0.28	0.238	0.322	0.269	0.0126	OK
Cr	0.065	0.035	0.095	0.061	0.0059	OK
V				0.000	0.0196	<LOD
Ti	0.037			0.033	0.0168	
S	0.02			0.039	0.0021	
P	0.012			0.017	0.0020	
Si	3.84	3.648	4.032	3.840	0.0274	OK
Al				0.000	0.0247	<LOD
Mg				0.000	0.0000	<LOD

	Ti6-2-4-2	IARM 177C		180-503		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb				0.000	0.0013	<LOD
Au				0.000	0.0008	<LOD
Re				0.000		OK
W				0.000	0.0044	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0038	<LOD
Sb				0.000	0.0029	<LOD
Sn	2.02	1.919	2.121	1.999	0.0117	OK
Cd				0.000	0.0025	<LOD
Ag				0.005	0.0028	
Pd				0.000	0.0028	<LOD
Ru				0.000	0.0012	<LOD
Mo	1.96	1.764	2.352	1.942	0.0093	OK
Nb				0.001	0.0009	<LOD
Zr	3.99	3.751	4.229	3.954	0.0167	OK
Y				0.000	0.0006	<LOD
Se				0.000	0.0007	<LOD
Zn				0.000	0.0019	<LOD
Cu				0.000	0.0031	<LOD
Ni				0.009	0.0048	
Co				0.000	0.0064	<LOD
Fe				0.019	0.0108	
Mn				0.000	0.0176	<LOD
Cr				0.000	0.0453	<LOD
V				0.084	0.1122	<LOD
Ti	85.72	84.006	87.434	85.905	0.1607	OK
S				0.000	0.0000	<LOD
P				0.000	0.0000	<LOD
Si	0.086	0.000	0.160	0.104	0.0175	OK
Al	6.02	5.520	6.520	6.035	0.1313	OK
Mg				0.000	0.0000	<LOD

	SS416	IARM 10c		195-151		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0002	<LOD
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.016	0.0111	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0037	<LOD
Sn	0.009			0.014	0.0024	
Cd				0.002	0.0027	<LOD

	Iron	BAS SCRM 660/09		195-166		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0006	<LOD
Pb				0.019	0.0102	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0082	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0035	<LOD
Sn				0.000	0.0039	<LOD
Cd				0.000	0.0034	<LOD

Certificate of Calibration

Ag				0.028	0.0028	
Pd				0.000	0.0038	<LOD
Ru				0.001	0.0007	<LOD
Mo	0.08	0.040	0.120	0.088	0.0014	OK
Nb	0.003			0.001	0.0005	
Zr				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.006	0.0024	
Cu	0.155	0.110	0.200	0.161	0.0076	OK
Ni	0.24	0.160	0.310	0.239	0.0121	OK
Co	0.022			0.048	0.0430	
Fe	86.0	81.700	90.300	85.888	0.0716	OK
Mn	0.35	0.250	0.460	0.408	0.0276	OK
Cr	12.25	11.638	12.863	12.151	0.0375	OK
V	0.024			0.053	0.0093	
Ti	0.002			0.062	0.0158	
S	0.29	0.220	0.360	0.355	0.0047	OK
P	0.026			0.032	0.0023	
Si	0.37	0.310	0.430	0.384	0.0105	OK
Al	0.003			0.039	0.0245	
Mg				0.000	0.0000	<LOD

Ag				0.006	0.0034	
Pd				0.003	0.0040	<LOD
Ru				0.001	0.0007	<LOD
Mo				0.001	0.0007	<LOD
Nb				0.003	0.0005	
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.004	0.0025	
Cu				0.007	0.0040	
Ni				0.000	0.0252	<LOD
Co				0.000	0.0474	<LOD
Fe	94.18	91.355	97.005	94.174	0.0696	OK
Mn	0.406	0.365	0.447	0.390	0.0142	OK
Cr				0.006	0.0051	<LOD
V				0.000	0.0238	<LOD
Ti				0.024	0.0166	<LOD
S	0.105	0.079	0.131	0.119	0.0030	OK
P	0.153	0.122	0.184	0.153	0.0035	OK
Si	1.70	1.274	2.124	1.556	0.0188	OK
Al				0.029	0.0251	<LOD
Mg				0.000	0.0000	<LOD

	LAS	BS15a		195-167		
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.013	0.0055	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0097	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0031	<LOD
Sn				0.000	0.0028	<LOD
Cd				0.000	0.0027	<LOD
Ag				0.000	0.0033	<LOD
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0006	<LOD
Mo				0.007	0.0007	
Nb				0.045	0.0012	
Zr				0.017	0.0009	
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0025	<LOD
Cu				0.037	0.0053	
Ni				0.077	0.0210	
Co				0.000	0.0431	<LOD
Fe	98.4	95.448	100.000	98.175	0.0686	OK
Mn	1.12	1.008	1.232	1.128	0.0201	OK
Cr				0.047	0.0056	
V				0.013	0.0236	<LOD
Ti				0.029	0.0233	<LOD
S				0.030	0.0019	
P				0.031	0.0022	
Si	0.058	0.030	0.100	0.080	0.0066	OK
Al				0.072	0.0243	
Mg				0.000	0.0000	<LOD

	Mar-M 247	IARM 333a		195-173		
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0016	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	0.01			0.000	0.0247	
W	9.7	8.730	10.670	9.624	0.1806	OK
Ta	3.15	2.835	3.465	2.889	0.0746	OK
Hf	1.4	1.260	1.540	1.386	0.0357	OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0049	<LOD
Sn				0.010	0.0035	
Cd				0.004	0.0044	<LOD
Ag				0.037	0.0042	
Pd				0.000	0.0038	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.49	0.466	0.515	0.494	0.0045	OK
Nb	0.005			0.003	0.0007	
Zr	0.009			0.003	0.0007	
Y				0.000	0.0000	<LOD
Se				0.000	0.0106	<LOD
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	61.1	58.045	64.155	61.556	0.1721	OK
Co	9.4	8.930	9.870	9.264	0.0514	OK
Fe	0.036	0.016	0.056	0.033	0.0064	OK
Mn	0.005			0.017	0.0281	<LOD
Cr	8.32	7.904	8.736	8.284	0.0495	OK
V				0.025	0.0240	<LOD
Ti	0.73	0.621	0.840	0.720	0.0383	OK
S				0.056	0.0052	
P	0.004			0.091	0.0052	
Si	0.08			0.000	0.0451	
Al	5.53	5.254	5.807	5.514	0.0870	OK
Mg				0.000	0.0000	<LOD

Thermo Fisher SCIENTIFIC

Certificate of Calibration

CMSX-4 | IARM 332a | 195-174

	Provisional	Low	High	Measured	Err	
Bi				0.003	0.0021	<LOD
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re	2.9	2.610	3.190	2.855	0.0499	OK
W	6.5	5.850	7.150	6.373	0.1956	OK
Ta	6.51	5.859	7.161	6.606	0.0825	OK
Hf	0.098			0.099	0.0293	
Te				0.000	0.0000	<LOD
Sb				0.000	0.0044	<LOD
Sn				0.007	0.0037	
Cd				0.000	0.0047	<LOD
Ag				0.038	0.0045	
Pd				0.000	0.0039	<LOD
Ru				0.000	0.0012	<LOD
Mo	0.61	0.549	0.671	0.594	0.0051	
Nb				0.005	0.0008	
Zr				0.005	0.0005	
Y				0.000	0.0000	<LOD
Se				0.000	0.0108	<LOD
Zn				0.000		OK
Cu				0.000		OK
Ni	61	59.780	62.220	61.160	0.1728	OK
Co	9.4	8.930	9.588	9.299	0.0511	OK
Fe	0.023	0.003	0.043	0.027	0.0061	OK
Mn				0.017	0.0166	<LOD
Cr	6.31	5.679	6.941	6.153	0.0450	OK
V				0.020	0.0270	<LOD
Ti	0.99	0.891	1.089	0.976	0.0432	OK
S				0.038	0.0059	
P				0.093	0.0069	
Si				0.000	0.0482	
Al	5.8	5.220	6.380	5.659	0.0923	OK
Mg				0.000	0.0000	<LOD

Cu-Cd | MBH 36X CCD2 | 195-156

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0022	<LOD
Pb				0.004	0.0025	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.033	0.0342	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0105	<LOD
Sb				0.010	0.0096	<LOD
Sn	0.2	0.180	0.220	0.191	0.0068	OK
Cd	1.18	1.062	1.298	1.178	0.0125	OK
Ag	0.0012			0.008	0.0070	<LOD
Pd				0.000	0.0084	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.000	0.0013	<LOD
Y				0.001	0.0006	
Se				0.000	0.0039	<LOD
Zn	0.0019			0.020	0.0189	<LOD
Cu	98.6	98.000	99.200	98.395	0.1008	
Ni				0.000	0.0116	<LOD
Co				0.000	0.0104	<LOD
Fe				0.000	0.0139	<LOD
Mn				0.000	0.0166	<LOD
Cr				0.000	0.0282	<LOD
V				0.000	0.0371	<LOD
Ti				0.000	0.0695	<LOD
S				0.059	0.0023	
P				0.008	0.0024	
Si				0.016	0.0100	
Al				0.126	0.0333	
Mg				0.000	0.0000	<LOD

AA7075 | ALC 7075 AF | 180-505

	Cert	Low	High	Measured	Err	
Bi	0.007			0.006	0.0007	
Pb	0.0073			0.007	0.0007	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.191	0.1364	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.002	0.0019	<LOD
Sb				0.002	0.0018	<LOD
Sn	0.014	0.004	0.024	0.016	0.0011	OK
Cd				0.002	0.0011	<LOD
Ag				0.007	0.0012	
Pd				0.000	0.0020	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024	0.001	0.003	0.002	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn	5.75	5.578	5.923	5.727	0.0286	OK
Cu	1.750	1.663	1.838	1.743	0.0132	OK
Ni	0.027	0.007	0.047	0.021	0.0021	OK
Co				0.000	0.0034	<LOD
Fe	0.17	0.136	0.204	0.146	0.0068	OK
Mn	0.031	0.016	0.046	0.037	0.0072	OK
Cr	0.22	0.187	0.253	0.233	0.0144	OK
V	0.020			0.053	0.0208	
Ti	0.092	0.012	0.172	0.167	0.0434	OK
S				0.000	0.0000	<LOD
P	0.001			0.000	0.0000	<LOD
Si	0.19	0.114	0.266	0.230	0.0122	OK
Al	89	87.220	90.780	88.830	0.1277	OK
Mg	2.66	2.261	3.059	2.580	0.1453	OK

CDA510 | IARM 77B | 195-177

	Certified	Low	High	Measured	Err	
Bi				0.006	0.0009	
Pb	0.016	0.008	0.024	0.022	0.0036	
Au				0.000	0.0000	<LOD
Re				0.000		<LOD
W				0.077	0.0162	
Ta				0.000		<LOD
Hf				0.000		<LOD
Te				0.000	0.0016	<LOD
Sb				0.000	0.0041	<LOD
Sn	4.66	4.520	4.800	4.549	0.0075	OK
Cd				0.000	0.0037	<LOD
Ag				0.000	0.0056	<LOD
Pd				0.000	0.0048	<LOD
Ru				0.000	0.0012	<LOD
Mo				0.000	0.0045	<LOD
Nb				0.000	0.0007	<LOD
Zr				0.000	0.0071	<LOD
Y				0.001	0.0003	
Se				0.000	0.0010	<LOD
Zn				0.088	0.0043	
Cu	95.2	94.248	96.152	94.981	0.0077	
Ni				0.000	0.0155	<LOD
Co				0.000	0.0450	<LOD
Fe				0.005	0.0702	<LOD
Mn				0.000	0.0175	<LOD
Cr				0.000	0.0180	<LOD
V				0.000	0.0557	<LOD
Ti				0.000	0.0675	<LOD
S				0.093	0.0025	
P	0.148	0.118	0.178	0.123	0.0023	OK
Si				0.000	0.0381	<LOD
Al				0.075	0.0741	<LOD
Mg				0.000	0.0000	<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

ThermoFisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 8mm QC Sheet
Document:140-00195
Revision: G
Release Date: 10 June 2016

Serial Number: X500946 | Model: Niton XL5- | Software: 5372 | Date of Q.C.: 21-Aug-18
Resolution: 161.701 147.816 | Escale: 7.497 7.494 | Spot Size: 8mm | Inspector: VK

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0014	<LOD
Pb			0.000	0.0026	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0093	<LOD
Ta			0.000	0.0650	OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0032	<LOD
Sn			0.000	0.0028	<LOD
Cd			0.000	0.0028	<LOD
Ag			0.000	0.0034	<LOD
Pd			0.000	0.0033	<LOD
Ru			0.000	0.0006	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0004	<LOD
Zr			0.000	0.0004	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0008	<LOD
Zn			0.004	0.0028	<LOD
Cu			0.000	0.0040	<LOD
Ni			0.000	0.0242	<LOD
Co			0.000	0.0459	<LOD
Fe	99.85	100.000	99.996	0.0706	OK
Mn			0.000	0.0112	<LOD
Cr			0.007	0.0122	<LOD
V			0.000	0.0197	<LOD
Ti			0.000	0.0375	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.000	0.0045	<LOD
Pb			0.000	0.0000	<LOD
Au			0.000	0.0000	<LOD
Re			0.000	0.0000	<LOD
W			0.000	0.1094	<LOD
Ta	99.5	100	99.915	0.1429	OK
Hf			0.144	0.0728	
Te			0.000	0.0103	<LOD
Sb			0.000	0.0066	<LOD
Sn			0.000	0.0068	<LOD
Cd			0.000	0.0067	<LOD
Ag			0.000	0.0084	<LOD
Pd			0.000	0.0060	<LOD
Ru			0.000	0.0016	<LOD
Mo			0.003	0.0015	
Nb			0.000	0.0010	<LOD
Zr			0.000	0.0013	<LOD
Y			0.000	0.0011	<LOD
Se			0.000	0.0246	<LOD
Zn			0.000	0.0000	OK
Cu			0.000	0.0000	OK
Ni			0.000	0.0142	<LOD
Co			0.000	0.0326	<LOD
Fe			0.011	0.0180	<LOD
Mn			0.000	0.0239	<LOD
Cr			0.000	0.0312	<LOD
V			0.000	0.0557	<LOD
Ti			0.000	0.1213	<LOD
Al (Bal)			0.000	0.0000	OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.000	0.0045	<LOD
Pb			0.007	0.0048	
Au			0.000	0.0071	<LOD
Re			0.000		OK
W			0.000	0.0083	<LOD
Ta			0.000	0.0000	OK
Hf			0.000		OK
Te			0.000	0.0262	<LOD
Sb			0.046	0.0217	
Sn	99	100.000	99.841	0.5088	OK
Cd			0.000	0.0140	<LOD
Ag			0.012	0.0095	<LOD
Pd			0.000	0.0076	<LOD
Ru			0.000	0.0017	<LOD
Mo			0.000	0.0014	<LOD
Nb			0.000	0.0014	<LOD
Zr			0.000	0.0014	<LOD
Y			0.000	0.0011	<LOD
Se			0.000	0.0032	<LOD
Zn			0.000	0.0092	<LOD
Cu			0.000	0.0130	<LOD
Ni			0.000	0.0176	<LOD
Co			0.000	0.0235	<LOD
Fe			0.000	0.0479	<LOD
Mn			0.060	0.0607	<LOD
Cr			0.000	0.0950	<LOD
V			0.000	0.1846	<LOD
Ti			0.343	0.4538	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.002	<LOD
Pb			0.007	0.003	
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.000	0.035	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.009	<LOD
Sb			0.000	0.006	<LOD
Sn			0.000	0.006	<LOD
Cd			0.000	0.005	<LOD
Ag			0.000	0.007	<LOD
Pd			0.000	0.006	<LOD
Ru			0.000	0.001	<LOD
Mo			0.000	0.001	<LOD
Nb			0.002	0.001	
Zr			0.003	0.002	
Y			0.000	0.001	<LOD
Se			0.000	0.005	<LOD
Zn			0.000	0.019	<LOD
Cu	99.85	100	99.989	0.094	OK
Ni			0.000	0.010	<LOD
Co			0.000	0.009	<LOD
Fe			0.006	0.009	<LOD
Mn			0.000	0.014	<LOD
Cr			0.009	0.020	<LOD
V			0.000	0.033	<LOD
Ti			0.000	0.070	<LOD
Al (Bal)			0.000	0.000	<LOD
LEC					

Certificate of Calibration

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.005	0.0027	
Pb			0.000	0.0033	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.7688	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0048	<LOD
Sn			0.000	0.0056	<LOD
Cd			0.000	0.0048	<LOD
Ag			0.000	0.0057	<LOD
Pd			0.000	0.0048	<LOD
Ru			0.000	0.0010	<LOD
Mo			0.001	0.0009	<LOD
Nb			0.000	0.0006	<LOD
Zr			0.001	0.0005	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0173	<LOD
Zn			0.000	0.0527	<LOD
Cu			0.000	0.0299	<LOD
Ni	**99.85**	**100.000**	99.995	0.7754	OK
Co			0.000	0.0107	<LOD
Fe			0.000	0.0129	<LOD
Mn			0.000	0.0140	<LOD
Cr			0.000	0.0177	<LOD
V			0.000	0.0295	<LOD
Ti			0.000	0.0663	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.001	0.001	<LOD
Pb			0.001	0.001	
Au			0.000	0.000	<LOD
Re			0.000		OK
W			0.005	0.004	<LOD
Ta			0.000	0.000	OK
Hf			0.000		OK
Te			0.000	0.002	<LOD
Sb			0.000	0.002	<LOD
Sn			0.000	0.001	<LOD
Cd			0.000	0.001	<LOD
Ag			0.000	0.002	<LOD
Pd			0.000	0.002	<LOD
Ru			0.000	0.000	<LOD
Mo			0.000	0.000	<LOD
Nb			0.000	0.000	<LOD
Zr			0.000	0.000	<LOD
Y			0.000	0.000	<LOD
Se			0.000	0.000	<LOD
Zn			0.000	0.001	<LOD
Cu			0.002	0.001	<LOD
Ni			0.000	0.003	<LOD
Co			0.000	0.003	<LOD
Fe			0.000	0.006	<LOD
Mn			0.013	0.011	<LOD
Cr			0.000	0.047	<LOD
V			0.000	0.054	<LOD
Ti	**99.85**	**100**	99.988	0.074	OK
Al (Bal)			0.000	0.000	<LOD
LEC					

20Cb3 — **IARM 25C** — 180-509

	Certified	Low	High	Measured	Err	
Bi				0.001	0.0011	<LOD
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.080			0.275	0.0966	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0037	<LOD
Sn	0.01	0.002	0.020	0.011	0.0029	OK
Cd				0.000	0.0027	<LOD
Ag				0.035	0.0034	
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0014	<LOD
Mo	**2.26**	**2.030**	**2.480**	2.197	0.0091	OK
Nb	**0.58**	**0.480**	**0.680**	0.570	0.0041	OK
Zr				0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0033	<LOD
Zn				0.000	0.0107	<LOD
Cu	**3.51**	**3.260**	**3.760**	3.499	0.0345	OK
Ni	**33.30**	**31.640**	**35.640**	33.038	0.1177	OK
Co	0.091	0.020	0.200	0.165	0.0382	OK
Fe	**38.80**	**36.800**	**40.800**	38.312	0.0724	OK
Mn	**0.90**	**0.400**	**1.400**	0.945	0.0325	OK
Cr	**19.97**	**19.570**	**20.570**	20.237	0.0543	OK
V	0.095	0.035	0.155	0.139	0.0143	OK
Ti	0.003			0.050	0.0204	
Al (Bal)	0.019			0.000	0.00	<LOD
LEC				0.500		

Stellite 6B — **IARM 95B** — 180-502

	Certified	Low	High	Measured	Err	
Bi				0.005	0.0012	
Pb				0.000		OK
Au				0.000	0.0000	<LOD
Re				0.000	0.0124	
W	**3.42**	**3.120**	**3.720**	3.432	0.0498	OK
Ta				0.000	0.0278	<LOD
Hf				0.092	0.0390	
Te				0.000	0.0000	<LOD
Sb				0.005	0.0028	
Sn				0.012	0.0025	
Cd				0.001	0.0032	<LOD
Ag				0.042	0.0030	
Pd				0.000	0.0044	<LOD
Ru				0.000	0.0009	<LOD
Mo	**0.83**	**0.700**	**0.960**	0.833	0.0045	OK
Nb	0.002			0.001	0.0006	
Zr	0.002			0.001	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0035	<LOD
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	**2.25**	**1.913**	**2.588**	2.258	0.0367	OK
Co	**60.90**	**59.682**	**61.814**	59.844	0.1034	OK
Fe	**1.10**	**0.990**	**1.210**	1.104	0.0223	OK
Mn	**0.99**	**0.891**	**1.089**	0.993	0.0288	OK
Cr	**28.90**	**28.467**	**29.334**	29.000	0.0596	OK
V	0.002			0.041	0.0121	
Ti	0.004			0.075	0.0183	
Al (Bal)	0.07			0.000	0.00	<LOD
LEC		2.250	2.250	2.250		

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	0.01			0.051	0.0105	
Pb	5.03	4.680	5.440	4.852	0.0413	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.125	0.0311	
Ta				0.000		OK
Hf				0.000		OK
Te				0.010	0.0087	<LOD
Sb	0.143	0.122	0.164	0.142	0.0073	OK
Sn	4.37	3.460	5.380	4.467	0.0246	OK
Cd				0.006	0.0063	<LOD
Ag	0.02			0.047	0.0061	
Pd				0.007	0.0059	<LOD
Ru				0.000	0.0015	<LOD
Mo				0.000	0.0008	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.003	0.0017	
Y				0.022	0.0147	<LOD
Se				0.000	0.0036	<LOD
Zn	5.38	4.790	6.080	5.036	0.0334	OK
Cu	84.6	82.600	86.600	84.666	0.0878	OK
Ni	0.27	0.100	0.400	0.265	0.0106	OK
Co				0.000	0.0117	<LOD
Fe	0.24	0.210	0.270	0.248	0.0093	OK
Mn	0.002			0.011	0.0135	<LOD
Cr				0.010	0.0173	<LOD
V				0.000	0.0399	<LOD
Ti				0.066	0.0658	<LOD
Al (Bal)	0.002			0.000	0.00	<LOD
LEC						

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb	0.0009			0.011	0.0041	
Au				0.000	0.0014	
Re				0.000		OK
W	0.004			0.000	0.0069	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.004	0.0043	<LOD
Sn	0.002			0.008	0.0029	
Cd				0.000	0.0036	<LOD
Ag				0.012	0.0034	
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0009	<LOD
Mo	0.47	0.430	0.530	0.493	0.0039	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.001			0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0025	<LOD
Cu	0.033	0.018	0.048	0.034	0.0054	OK
Ni	0.071			0.086	0.0211	
Co	0.004			0.000	0.0474	<LOD
Fe	96.96	95.900	98.000	96.933	0.0780	OK
Mn	0.56	0.350	0.750	0.576	0.0182	OK
Cr	1.11	0.999	1.221	1.105	0.0148	OK
V	0.004			0.000	0.0225	<LOD
Ti	0.0016			0.016	0.0422	<LOD
Al (Bal)	0.028			0.000	0.00	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0017	<LOD
Pb				0.000	0.0023	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.62	0.320	0.920	0.571	0.1575	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0050	<LOD
Sn	0.002			0.000	0.0043	<LOD
Cd				0.000	0.0042	<LOD
Ag				0.028	0.0050	
Pd				0.000	0.0048	<LOD
Ru				0.000	0.0030	<LOD
Mo	8.30	7.720	8.890	8.319	0.0339	OK
Nb	0.09	0.030	0.150	0.073	0.0022	OK
Zr	0.004			0.001	0.0009	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0059	<LOD
Zn				0.031	0.0220	<LOD
Cu				0.093	0.0260	
Ni	48.80	46.800	50.760	48.299	0.1862	OK
Co	1.11	0.930	1.350	1.197	0.0396	OK
Fe	18.30	17.390	19.220	18.330	0.0661	OK
Mn	0.47	0.200	0.900	0.471	0.0361	OK
Cr	21.60	20.740	22.470	22.017	0.0716	OK
V	0.03			0.049	0.0175	
Ti	0.02			0.050	0.0510	<LOD
Al (Bal)	0.12			0.00	0.00	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0012	<LOD
Pb				0.000	0.0026	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	6.30	5.800	6.870	6.554	0.0717	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0041	<LOD
Sn	0.01			0.000	0.0051	<LOD
Cd				0.000	0.0035	<LOD
Ag				0.022	0.0043	
Pd				0.000	0.0040	<LOD
Ru				0.000	0.0022	<LOD
Mo	4.85	4.610	5.150	4.844	0.0176	OK
Nb				0.000	0.0011	<LOD
Zr				0.000	0.0007	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0058	<LOD
Zn				0.018	0.0189	<LOD
Cu	0.13	0.104	0.156	0.131	0.0112	OK
Ni	0.35	0.280	0.420	0.314	0.0183	OK
Co	0.31	0.217	0.403	0.264	0.0473	OK
Fe	80.59	78.590	82.590	80.195	0.1006	OK
Mn	0.29	0.240	0.340	0.315	0.0242	OK
Cr	3.98	3.590	4.420	4.093	0.0335	OK
V	2.03	1.570	2.460	2.008	0.0343	OK
Ti				0.026	0.0508	<LOD
Al (Bal)	0.02			0.00	0.00	<LOD
LEC				1.24		

Certificate of Calibration

SS321 — **IARM 6D** — 180-512

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0007	<LOD
Pb				0.000	0.0014	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09			0.181	0.0415	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.005	0.0041	<LOD
Sn	0.013	0.003	0.023	0.022	0.0024	OK
Cd				0.003	0.0030	<LOD
Ag				0.038	0.0028	
Pd				0.003	0.0032	<LOD
Ru				0.000	0.0008	<LOD
Mo	**0.358**	**0.290**	**0.440**	0.360	0.0027	OK
Nb	**0.039**	**0.010**	**0.060**	0.039	0.0009	OK
Zr	***0.002***			0.001	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0015	<LOD
Zn				0.000	0.0048	<LOD
Cu	**0.302**	**0.150**	**0.500**	0.309	0.0142	OK
Ni	**9.42**	**9.000**	**9.800**	9.294	0.0555	OK
Co	**0.182**	**0.109**	**0.255**	0.201	0.0423	OK
Fe	**69.40**	**68.400**	**70.400**	68.945	0.0854	OK
Mn	**1.52**	**1.250**	**1.850**	1.601	0.0339	OK
Cr	**17.45**	**17.100**	**18.000**	17.705	0.0453	OK
V	**0.128**	**0.077**	**0.179**	0.161	0.0128	OK
Ti	**0.63**	**0.378**	**0.882**	0.650	0.0232	OK
Al (Bal)	0.11			0.00	0.00	<LOD
LEC				0.50		OK

Ti 6-2-4-2 — **IARM 177C** — 180-503

	Certified	Low	High	Measured	Err	
Bi				0.000	0.0014	<LOD
Pb				0.000	0.0014	<LOD
Au				0.000	0.0009	<LOD
Re				0.000		OK
W				0.000	0.0049	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0043	<LOD
Sb				0.000	0.0033	<LOD
Sn	**2.02**	**1.919**	**2.121**	2.020	0.0116	OK
Cd				0.000	0.0029	<LOD
Ag				0.006	0.0032	
Pd				0.000	0.0032	<LOD
Ru				0.000	0.0014	<LOD
Mo	**1.96**	**1.764**	**2.156**	1.960	0.0091	OK
Nb				0.001	0.0010	<LOD
Zr	**3.99**	**3.751**	**4.229**	3.990	0.0153	OK
Y				0.000	0.0007	<LOD
Se				0.000	0.0008	<LOD
Zn				0.000	0.0022	<LOD
Cu	0.003			0.000	0.0035	<LOD
Ni	0.011			0.009	0.0053	
Co				0.000	0.0071	<LOD
Fe	0.033	0.023	0.053	0.019	0.0120	
Mn	0.0015			0.000	0.0196	<LOD
Cr				0.000	0.0505	<LOD
V	0.02			0.085	0.1192	<LOD
Ti	**85.72**	**84.006**	**87.434**	85.968	0.1262	OK
Al (Bal)	6.02			0.00	0.00	<LOD
LEC				6.0		OK

AA7075 — **ALC 7075 AF** — 180-505

	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.008	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.230	0.1486	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0012	<LOD
Sb				0.000	0.0009	<LOD
Sn	0.014	0.007	0.021	0.012	0.0008	OK
Cd				0.000	0.0008	<LOD
Ag				0.003	0.0008	
Pd				0.000	0.0009	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	
Zr	0.0024	0.001	0.003	0.0026	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	**5.75**	**5.578**	**5.923**	5.741	0.0105	OK
Cu	**1.750**	**1.663**	**1.838**	1.750	0.0076	OK
Ni	0.027	0.007	0.047	0.024	0.0015	OK
Co				0.000	0.0021	<LOD
Fe	**0.17**	**0.136**	**0.204**	0.177	0.0047	OK
Mn	0.031	0.016	0.046	0.033	0.0050	OK
Cr	**0.22**	**0.187**	**0.253**	0.223	0.0101	OK
V	0.020			0.025	0.0224	<LOD
Ti	**0.092**	**0.012**	**0.172**	0.138	0.0314	OK
Al (Bal)	***91.7***	**89.827**	**93.493**	91.66	0.07	OK
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

	1.25Cr 0.5Mo		IARM35H		195-019	
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0013	<LOD
Pb	0.001			0.011	0.0041	
Au				0.000	0.0014	<LOD
Re				0.000		OK
W	0.004			0.000	0.0070	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.004	0.0043	<LOD
Sn	0.002			0.008	0.0029	
Cd				0.000	0.0036	<LOD
Ag				0.012	0.0035	
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0009	<LOD
Mo	0.47	0.432	0.508	0.495	0.0038	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.001			0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0025	<LOD
Cu	0.032	0.012	0.052	0.035	0.0054	OK
Ni	0.071			0.086	0.0212	
Co	0.004			0.000	0.0474	<LOD
Fe	96.96	95.990	97.930	96.931	0.0564	OK
Mn	0.56	0.476	0.644	0.577	0.0182	OK
Cr	1.11	0.999	1.221	1.109	0.0055	OK
V	0.004			0.000	0.0018	<LOD
Ti	0.002			0.000	0.0019	<LOD
Al (Bal)	0.028			0.00	0.00	<LOD
LEC	0.75			0.750		OK

	Tool steel T-1		IARM 48C		195-152	
	Certified	Low	High	Measured	Err	
Bi				0.006	0.0008	
Pb				0.000	0.0030	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	17.50	16.625	18.375	17.348	0.0789	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.012	0.0033	
Sn	0.012			0.030	0.0031	
Cd				0.005	0.0027	
Ag				0.072	0.0037	
Pd				0.007	0.0039	
Ru				0.001	0.0010	<LOD
Mo	0.17	0.150	0.190	0.163	0.0021	OK
Nb	0.005	0.001	0.010	0.004	0.0005	OK
Zr				0.001	0.0004	
Y				0.000	0.0000	<LOD
Se				0.000	0.0082	<LOD
Zn				0.026	0.0280	<LOD
Cu	0.13	0.090	0.170	0.125	0.0122	OK
Ni	0.204	0.143	0.265	0.156	0.0165	OK
Co	0.22	0.120	0.320	0.226	0.0407	OK
Fe	74.5	73.383	75.618	74.696	0.0947	OK
Mn	0.39	0.304	0.476	0.429	0.0226	OK
Cr	4.24	3.901	4.579	4.433	0.0314	OK
V	1.27	1.143	1.397	1.259	0.0084	OK
Ti	0.006			0.000	0.0025	<LOD
Al (Bal)	0.017			0.00	0.00	<LOD
LEC	1.025			1.025		OK

	Custom 455		IARM16B		195-142	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0005	<LOD
Pb				0.006	0.0022	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.109	0.0411	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.008	0.0035	
Sn	0.004			0.011	0.0025	
Cd				0.004	0.0023	
Ag				0.039	0.0029	
Pd				0.004	0.0028	
Ru				0.002	0.0011	
Mo	0.016	0.010	0.022	0.015	0.0007	OK
Nb	0.25	0.225	0.275	0.257	0.0024	OK
Zr				0.000	0.0004	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0054	<LOD
Cu	2.23	2.119	2.342	2.220	0.0266	OK
Ni	8.28	7.866	8.694	8.266	0.0545	OK
Co	0.027			0.101	0.0416	
Fe	76.4	72.580	80.220	76.257	0.0374	OK
Mn	0.026			0.078	0.0254	
Cr	11.44	10.868	12.012	11.495	0.0374	OK
V	0.067			0.014	0.0107	<LOD
Ti	1.11	1.055	1.166	1.106	0.0085	OK
Al (Bal)	0.062			0.000	0.00	<LOD

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.008	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.230	0.1486	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0012	<LOD
Sb				0.000	0.0009	<LOD
Sn	0.014	0.007	0.021	0.012	0.0008	OK
Cd				0.000	0.0008	<LOD
Ag				0.003	0.0008	
Pd				0.000	0.0009	<LOD
Ru				0.000	0.0002	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	
Zr	0.0024	0.000	0.004	0.003	0.0001	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0003	<LOD
Zn	5.75	5.578	5.923	5.741	0.0103	OK
Cu	1.750	1.663	1.838	1.750	0.0076	OK
Ni	0.027	0.007	0.047	0.024	0.0015	OK
Co				0.000	0.0492	<LOD
Fe	0.17	0.136	0.204	0.177	0.0047	OK
Mn	0.031	0.016	0.046	0.033	0.0050	OK
Cr	0.22	0.198	0.242	0.220	0.0024	OK
V	0.020			0.049	0.0016	
Ti	0.092	0.072	0.112	0.092	0.0021	OK
Al (Bal)	91.7	89.827	93.493	91.674	0.01	OK

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Thermo Fisher SCIENTIFIC

Certificate of Calibration

Niton XL5 Alloy 3mm QC Sheet
Document: 140-00195
Revision: G
Release Date: 10 June 2016

Serial Number: X500946 | Model: Niton XL5 | Software: 5372 | Date of Q.C.: 21-Aug-18

Resolution: 161.7009 147.8162 | Escale: 7.497 7.494 | Spot Size: 3mm | Inspector: VK

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.002	0.0007	
Pb			0.011	0.0047	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0173	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0045	<LOD
Sn			0.000	0.0040	<LOD
Cd			0.000	0.0036	<LOD
Ag			0.000	0.0044	<LOD
Pd			0.000	0.0053	<LOD
Ru			0.000	0.0009	<LOD
Mo			0.000	0.0008	<LOD
Nb			0.000	0.0007	<LOD
Zr			0.000	0.0005	<LOD
Y			0.000	0.0000	<LOD
Se			0.000	0.0011	<LOD
Zn			0.000	0.0037	<LOD
Cu			0.000	0.0064	<LOD
Ni			0.000	0.0295	<LOD
Co			0.000	0.0660	<LOD
Fe	99.75	100	99.993	0.0960	OK
Mn			0.000	0.0132	<LOD
Cr			0.000	0.0175	<LOD
V			0.000	0.0306	<LOD
Ti			0.000	0.0449	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Ta

	Low	High	Measured	Err	OK
Bi			0.002	0.0053	<LOD
Pb			0.000		OK
Au			0.000	0.0000	<LOD
Re			0.000	0.0236	<LOD
W			0.000	0.1333	<LOD
Ta	99.4	100	99.949	0.2417	OK
Hf			0.000	0.1120	<LOD
Te			0.000	0.0121	<LOD
Sb			0.000	0.0094	<LOD
Sn			0.000	0.0114	<LOD
Cd			0.000	0.0103	<LOD
Ag			0.000	0.0111	<LOD
Pd			0.000	0.0109	<LOD
Ru			0.002	0.0020	<LOD
Mo			0.000	0.0018	<LOD
Nb			0.000	0.0013	<LOD
Zr			0.000	0.0017	<LOD
Y			0.000	0.0009	<LOD
Se			0.000	0.0315	<LOD
Zn			0.000		OK
Cu			0.000		OK
Ni			0.000	0.0161	<LOD
Co			0.000	0.0377	<LOD
Fe			0.000	0.0257	<LOD
Mn			0.000	0.0281	<LOD
Cr			0.039	0.0399	<LOD
V			0.000	0.0770	<LOD
Ti			0.107	0.1196	<LOD
Al (Bal)			0.000		OK
LEC					

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.007	0.0038	
Pb			0.006	0.0047	<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0314	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0220	<LOD
Sb			0.000	0.0205	<LOD
Sn	99	100	99.989	0.4654	OK
Cd			0.000	0.0123	<LOD
Ag			0.000	0.0111	<LOD
Pd			0.000	0.0082	<LOD
Ru			0.000	0.0018	<LOD
Mo			0.000	0.0014	<LOD
Nb			0.000	0.0011	<LOD
Zr			0.000	0.0015	<LOD
Y			0.000	0.0011	<LOD
Se			0.000	0.0027	<LOD
Zn			0.000	0.0083	<LOD
Cu			0.000	0.0136	<LOD
Ni			0.000	0.0206	<LOD
Co			0.000	0.0224	<LOD
Fe			0.000	0.0333	<LOD
Mn			0.000	0.0506	<LOD
Cr			0.000	0.0775	<LOD
V			0.000	0.1445	<LOD
Ti			0.000	0.4260	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Cu

	Low	High	Measured	Err	OK
Bi			0.000	0.0022	<LOD
Pb			0.005	0.0024	
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0344	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0069	<LOD
Sb			0.000	0.0056	<LOD
Sn			0.000	0.0051	<LOD
Cd			0.000	0.0048	<LOD
Ag			0.000	0.0075	<LOD
Pd			0.000	0.0059	<LOD
Ru			0.000	0.0012	<LOD
Mo			0.000	0.0009	<LOD
Nb			0.000	0.0010	<LOD
Zr			0.002	0.0014	<LOD
Y			0.000	0.0005	<LOD
Se			0.000	0.0053	<LOD
Zn			0.000	0.0198	<LOD
Cu	99.8	100	99.997	0.0985	OK
Ni			0.000	0.0099	<LOD
Co			0.000	0.0090	<LOD
Fe			0.000	0.0146	<LOD
Mn			0.000	0.0143	<LOD
Cr			0.000	0.0222	<LOD
V			0.000	0.0355	<LOD
Ti			0.000	0.0739	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Certificate of Calibration

Pure Ni

	Low	High	Measured	Err	OK
Bi			0.007	0.0032	
Pb			0.000		<LOD
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.7598	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0057	<LOD
Sn			0.000	0.0050	<LOD
Cd			0.000	0.0048	<LOD
Ag			0.000	0.0060	<LOD
Pd			0.000	0.0060	<LOD
Ru			0.000	0.0012	<LOD
Mo			0.000	0.0007	<LOD
Nb			0.002	0.0008	
Zr			0.001	0.0006	
Y			0.000	0.0000	<LOD
Se			0.000	0.0185	<LOD
Zn			0.000	0.0663	<LOD
Cu			0.000	0.0311	<LOD
Ni	99.7	100	99.980	0.7668	OK
Co			0.000	0.0104	<LOD
Fe			0.000	0.0116	<LOD
Mn			0.011	0.0133	<LOD
Cr			0.000	0.0183	<LOD
V			0.000	0.0295	<LOD
Ti			0.026	0.0460	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC					

Pure Ti

	Low	High	Measured	Err	OK
Bi			0.001	0.0009	<LOD
Pb			0.003		
Au			0.000	0.0000	<LOD
Re			0.000		OK
W			0.000	0.0105	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0041	<LOD
Sb			0.000	0.0033	<LOD
Sn			0.000	0.0035	<LOD
Cd			0.000	0.0026	<LOD
Ag			0.000	0.0039	<LOD
Pd			0.000	0.0035	<LOD
Ru			0.000	0.0007	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.000	0.0005	<LOD
Zr			0.000	0.0003	<LOD
Y			0.000	0.0002	<LOD
Se			0.000	0.0007	<LOD
Zn			0.003	0.0024	<LOD
Cu			0.004	0.0046	<LOD
Ni			0.000	0.0047	<LOD
Co			0.000	0.0063	<LOD
Fe			0.000	0.0112	<LOD
Mn			0.000	0.0178	<LOD
Cr			0.000	0.0882	<LOD
V			0.000	0.1076	<LOD
Ti	99.75	100	99.996	0.1436	OK
Al (Bal)			0.000	0.0000	<LOD
LEC					

	20Cb3		IARM 25C		180-509	
	Certified	Low	High	Measured	Err	
Bi				0.003	0.0019	<LOD
Pb				0.003	0.0021	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.08			0.263	0.1374	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.000	0.0053	
Sn	0.01	0.002	0.020	0.007	0.0042	
Cd				0.000	0.0040	
Ag				0.036	0.0048	
Pd				0.000	0.0049	<LOD
Ru				0.000	0.0020	<LOD
Mo	2.26	2.03	2.48	2.195	0.0127	OK
Nb	0.58	0.48	0.68	0.577	0.0059	OK
Zr				0.000	0.0008	
Y				0.000	0.0000	
Se				0.000	0.0047	
Zn				0.000	0.0154	
Cu	3.51	3.26	3.76	3.504	0.0472	OK
Ni	33.30	31.64	35.64	33.219	0.1660	OK
Co	0.091			0.157	0.0522	
Fe	38.80	36.8	40.8	38.224	0.0991	OK
Mn	0.90	0.40	1.40	0.939	0.0445	OK
Cr	19.97	19.57	20.57	20.155	0.0742	OK
V	0.095	0.035	0.155	0.119	0.0185	
Ti	0.003			0.032	0.0248	
Al (Bal)	0.019			0.000		<LOD
LEC				0.500		

	Stellite 6B		IARM 95B			180-502
	Certified	Low	High	Measured	Err	
Bi				0.003	0.0017	
Pb				0.000		OK
Au				0.000	0.0000	
Re				0.000	0.0152	
W	3.42	3.12	3.72	3.431	0.0741	OK
Ta				0.000	0.0325	<LOD
Hf				0.000	0.0553	<LOD
Te				0.000	0.0000	
Sb				0.006	0.0048	
Sn				0.009	0.0040	
Cd				0.000	0.0050	
Ag				0.048	0.0046	
Pd				0.000	0.0050	<LOD
Ru				0.000	0.0014	<LOD
Mo	0.83	0.70	0.96	0.833	0.0067	OK
Nb	0.002			0.001	0.0008	
Zr	0.002			0.001	0.0008	
Y				0.000	0.0000	
Se				0.000	0.0059	
Zn				0.000		OK
Cu	0.01			0.000		OK
Ni	2.25	1.80	2.70	2.257	0.0542	OK
Co	60.90	59.68	62.12	60.009	0.1478	
Fe	1.10	0.94	1.27	1.104	0.0321	OK
Mn	0.99	0.84	1.14	0.993	0.0419	OK
Cr	28.90	28.32	29.48	28.993	0.0861	OK
V	0.002			0.043	0.0164	
Ti	0.004			0.027	0.0230	
Al (Bal)	0.07			0.000		<LOD
LEC				2.250		

Certificate of Calibration

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	*0.01*			0.044	0.0111	
Pb	**5.03**	**4.68**	**5.44**	5.024	0.0438	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.065	0.0388	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0095	
Sb	0.143	0.114	0.172	0.135	0.0081	OK
Sn	**4.37**	**3.46**	**5.38**	4.401	0.0273	OK
Cd				0.000	0.0069	<LOD
Ag	*0.02*			0.049	0.0067	
Pd				0.000	0.0074	<LOD
Ru				0.000	0.0015	<LOD
Mo				0.000	0.0011	<LOD
Nb				0.000	0.0010	<LOD
Zr				0.000	0.0022	<LOD
Y				0.020	0.0145	<LOD
Se				0.000	0.0044	<LOD
Zn	**5.38**	**4.79**	**6.08**	5.387	0.0365	OK
Cu	**84.6**	**82.60**	**86.60**	84.357	0.0947	OK
Ni	**0.27**	**0.10**	**0.40**	0.263	0.0114	OK
Co				0.007	0.0086	<LOD
Fe	**0.24**	**0.21**	**0.27**	0.247	0.0097	OK
Mn	0.002			0.000	0.0232	<LOD
Cr				0.014	0.0134	<LOD
V				0.000	0.0411	<LOD
Ti				0.048	0.0730	<LOD
Al (Bal)	0.002			0.000	0.0000	<LOD
LEC				#DIV/0!		

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0007	
Pb	0.0009			0.012	0.0039	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.004			0.000	0.0172	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.007	0.0059	<LOD
Sn	0.002			0.000	0.0048	<LOD
Cd				0.000	0.0040	<LOD
Ag				0.016	0.0047	
Pd				0.005	0.0060	<LOD
Ru				0.000	0.0012	<LOD
Mo	**0.47**	**0.43**	**0.53**	0.492	0.0051	OK
Nb	0.002			0.001	0.0008	<LOD
Zr	0.001			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0013	<LOD
Zn				0.000	0.0049	<LOD
Cu	0.033	0.013	0.053	0.036	0.0080	OK
Ni	0.071			0.065	0.0228	
Co	0.004			0.095	0.0661	<LOD
Fe	**96.96**	**95.9**	**98**	96.942	0.0933	OK
Mn	**0.56**	**0.35**	**0.75**	0.572	0.0234	OK
Cr	**1.11**	**0.89**	**1.33**	1.087	0.0187	OK
V	0.004			0.009	0.0184	<LOD
Ti	0.0016			0.043	0.0427	<LOD
Al (Bal)	0.028			0.000	0.0000	<LOD
LEC				0.750		

	Hast X		IARM 69C		180-511	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0023	<LOD
Pb				0.000	0.0027	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**0.62**	**0.32**	**0.92**	0.662	0.1966	OK
Ta	0.003			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0062	<LOD
Sn	0.002			0.000	0.0054	<LOD
Cd				0.000	0.0054	<LOD
Ag				0.028	0.0062	
Pd				0.000	0.0065	<LOD
Ru				0.000	0.0037	<LOD
Mo	**8.30**	**7.72**	**8.89**	8.273	0.0400	OK
Nb	**0.09**	**0.03**	**0.15**	0.073	0.0027	OK
Zr	0.004			0.002	0.0013	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0074	<LOD
Zn				0.000	0.0241	<LOD
Cu				0.000	0.0388	<LOD
Ni	**48.80**	**46.80**	**50.76**	48.589	0.2293	OK
Co	**1.11**	**0.93**	**1.35**	1.193	0.0476	OK
Fe	**18.30**	**17.39**	**19.22**	18.228	0.0794	OK
Mn	**0.47**	**0.20**	**0.90**	0.468	0.0435	OK
Cr	**21.60**	**20.74**	**22.47**	21.924	0.0860	OK
V	0.03			0.063	0.0200	
Ti	0.02			0.000	0.0530	<LOD
Al (Bal)	0.12			0.00	0.0000	<LOD
LEC				0.50		

	Tool steel M2		BS 32C		180-492	
	Certified	Low	High	Measured	Err	
Bi				0.002	0.0018	<LOD
Pb				0.000	0.0031	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**6.30**	**5.8**	**6.87**	6.575	0.0916	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.000	0.0054	<LOD
Sn	0.01			0.000	0.0066	<LOD
Cd				0.000	0.0047	<LOD
Ag				0.030	0.0056	
Pd				0.000	0.0057	<LOD
Ru				0.000	0.0028	<LOD
Mo	**4.85**	**4.61**	**5.15**	4.869	0.0210	OK
Nb				0.000	0.0014	<LOD
Zr				0.000	0.0009	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0075	<LOD
Zn				0.027	0.0217	<LOD
Cu	**0.13**	**0.091**	**0.169**	0.130	0.0141	OK
Ni	**0.35**	**0.245**	**0.455**	0.312	0.0237	OK
Co	**0.31**	**0.217**	**0.403**	0.271	0.0597	OK
Fe	**80.59**	**78.59**	**82.59**	80.363	0.1233	OK
Mn	**0.29**	**0.23**	**0.35**	0.301	0.0305	OK
Cr	**3.98**	**3.59**	**4.42**	4.077	0.0419	OK
V	**2.03**	**1.57**	**2.46**	1.818	0.0430	OK
Ti				0.029	0.0425	<LOD
Al (Bal)	0.02			0.00	0.0000	<LOD
LEC				1.24		

Certificate of Calibration

	SS321		IARM 6D		180-512	
	Certified	Low	High	Measured	Err	
Bi				0.005	0.0014	
Pb				0.002	0.0018	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.09	0.030	0.190	0.214	0.0645	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.007	0.0041	
Sn	0.013			0.016	0.0038	
Cd				0.005	0.0038	<LOD
Ag				0.039	0.0042	
Pd				0.000	0.0053	<LOD
Ru				0.000	0.0011	<LOD
Mo	**0.358**	**0.29**	**0.44**	0.362	0.0041	OK
Nb	**0.039**	**0.01**	**0.06**	0.039	0.0014	OK
Zr	***0.002***			0.001	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0024	<LOD
Zn				0.000	0.0074	<LOD
Cu	**0.302**	**0.15**	**0.5**	0.303	0.0212	OK
Ni	**9.42**	**9**	**9.8**	9.408	0.0836	OK
Co	**0.182**	**0.091**	**0.273**	0.247	0.0623	
Fe	**69.40**	**68.4**	**70.4**	68.944	0.1266	OK
Mn	**1.52**	**1.25**	**1.85**	1.628	0.0488	OK
Cr	**17.45**	**17.1**	**18**	17.525	0.0663	OK
V	**0.128**	**0.0768**	**0.1792**	0.150	0.0183	
Ti	**0.63**	**0.43**	**0.83**	0.631	0.0323	OK
Al (Bal)	**0.11**			0.00	0.0000	<LOD
LEC				0.50		OK

	Ti 6-2-4-2		IARM 177C		180-503	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0018	<LOD
Pb				0.000	0.0018	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0141	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0054	<LOD
Sb				0.000	0.0043	<LOD
Sn	**2.02**	**1.818**	**2.222**	2.019	0.0152	OK
Cd				0.000	0.0039	<LOD
Ag				0.008	0.0051	<LOD
Pd				0.000	0.0047	<LOD
Ru				0.000	0.0018	<LOD
Mo	**1.96**	**1.725**	**2.195**	1.960	0.0117	OK
Nb				0.000	0.0011	<LOD
Zr	**3.99**	**3.59**	**4.39**	3.990	0.0197	OK
Y				0.000	0.0009	<LOD
Se				0.000	0.0011	<LOD
Zn				0.000	0.0034	<LOD
Cu	0.003			0.000	0.0051	<LOD
Ni	0.011			0.007	0.0074	<LOD
Co				0.000	0.0091	<LOD
Fe	0.033			0.019	0.0147	<LOD
Mn	0.0015			0.000	0.0235	<LOD
Cr				0.000	0.0759	<LOD
V	0.02			0.113	0.1217	<LOD
Ti	**85.72**	**83.15**	**88.29**	85.960	0.1423	OK
Al (Bal)	6.02			0.00		<LOD
LEC				6.0		OK

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007			0.009	0.0008	
Pb	0.0073			0.008	0.0008	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0082	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0019	<LOD
Sb				0.000	0.0015	<LOD
Sn	0.014	0.004	0.024	0.011	0.0013	OK
Cd				0.000	0.0014	<LOD
Ag				0.003	0.0013	
Pd				0.000	0.0017	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024			0.0024	0.0002	
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn	**5.75**	**5.463**	**6.038**	5.762	0.0172	OK
Cu	**1.750**	**1.575**	**1.925**	1.758	0.0122	OK
Ni	0.027			0.025	0.0025	
Co				0.000	0.0033	<LOD
Fe	**0.17**	**0.1445**	**0.1955**	0.163	0.0073	OK
Mn	0.031			0.037	0.0077	
Cr	**0.22**	**0.187**	**0.253**	0.224	0.0152	OK
V	0.020			0.024	0.0262	<LOD
Ti	**0.092**	**0.012**	**0.172**	0.092	0.0435	OK
Al (Bal)	***91.7***	**88.9102**	**94.4098**	91.89	0.1138	OK
LEC						

Certificate of Calibration

15s Main Filter and 30s Low Filter

	1.25Cr 0.5Mo		IARM35H		195-019	
	Provisional	Low	High	Measured	Err	
Bi				0.002	0.0007	
Pb	*0.001*			0.012	0.0040	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	*0.004*			0.000	0.0173	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb	*0.002*			0.007	0.0059	<LOD
Sn	*0.002*			0.000	0.0048	<LOD
Cd				0.000	0.0040	<LOD
Ag				0.016	0.0047	
Pd				0.005	0.0060	<LOD
Ru				0.000	0.0012	<LOD
Mo	***0.47***	**0.423**	**0.517**	0.493	0.0050	OK
Nb	*0.002*			0.001	0.0008	<LOD
Zr	*0.001*			0.000	0.0005	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0049	<LOD
Cu	*0.032*	0.017	0.077	0.036	0.0080	OK
Ni	*0.071*			0.065	0.0229	
Co	*0.004*			0.095	0.0661	<LOD
Fe	***96.96***	**95.021**	**98.899**	96.924	0.0770	OK
Mn	***0.56***	**0.45**	**0.67**	0.573	0.0235	OK
Cr	***1.11***	**0.89**	**1.33**	1.109	0.0081	OK
V	*0.004*			0.000	0.0024	<LOD
Ti	*0.002*			0.000	0.0021	<LOD
Al (Bal)	*0.028*			0.00	0.0000	<LOD
LEC	**0.75**			0.750		OK

	Tool steel T-1		IARM 48C		195-152	
	Certified	Low	High	Measured	Err	
Bi				0.008	0.0017	
Pb				0.000	0.0039	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	**17.50**	**16.63**	**18.38**	17.358	0.1160	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	
Sb				0.012	0.0049	
Sn	0.012			0.025	0.0048	
Cd				0.006	0.0046	<LOD
Ag				0.080	0.0055	
Pd				0.000	0.0069	<LOD
Ru				0.002	0.0018	<LOD
Mo	0.17	0.150	0.190	0.164	0.0031	OK
Nb	0.005	0.001	0.010	0.004	0.0008	OK
Zr				0.001	0.0007	
Y				0.000	0.0000	<LOD
Se				0.000	0.0120	<LOD
Zn				0.000	0.0322	<LOD
Cu	0.13			0.124	0.0168	
Ni	0.204			0.136	0.0240	
Co	0.22			0.258	0.0591	
Fe	***74.5***	**73.3825**	**75.618**	74.734	0.1372	OK
Mn	**0.39**	**0.27**	**0.51**	0.425	0.0327	OK
Cr	**4.24**	**3.90**	**4.58**	4.412	0.0453	OK
V	**1.27**	**1.08**	**1.46**	1.264	0.0126	OK
Ti	0.006			0.000	0.0031	<LOD
Al (Bal)	0.017			0.00	0.0000	<LOD
LEC	**1.025**			1.025		OK

	Custom 455		IARM16B		195-142	
	Certified	Low	High	Measured	Err	
Bi				0.003	0.0012	
Pb				0.000	0.0016	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.084	0.0607	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.006	0.0040	<LOD
Sn	0.004			0.007	0.0037	
Cd				0.000	0.0038	<LOD
Ag				0.040	0.0043	
Pd				0.000	0.0056	<LOD
Ru				0.001	0.0010	<LOD
Mo	0.016	0.010	0.022	0.001	0.0010	<LOD
Nb	**0.25**	**0.20**	**0.30**	0.257	0.0036	OK
Zr				0.001	0.0008	<LOD
Y				0.000	0.0000	<LOD
Se				0.000	0.0022	<LOD
Zn				0.000	0.0081	<LOD
Cu	**2.23**	**1.90**	**2.56**	2.230	0.0379	OK
Ni	**8.28**	**7.45**	**9.11**	8.297	0.0790	OK
Co	0.027			0.154	0.0592	
Fe	***76.4***	**72.58**	**80.22**	76.339	0.1161	OK
Mn	0.026			0.109	0.0362	
Cr	**11.44**	**10.52**	**12.36**	11.372	0.0529	OK
V	0.067			0.012	0.0070	
Ti	**1.11**	**0.999**	**1.221**	1.109	0.0109	OK
Al (Bal)	0.062			0.000	0.0000	<LOD
LEC						

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007			0.009	0.0008	
Pb	0.0073			0.008	0.0008	
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0082	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0019	<LOD
Sb				0.000	0.0015	<LOD
Sn	0.014	0.007	0.021	0.011	0.0013	OK
Cd				0.000	0.0014	<LOD
Ag				0.003	0.0013	
Pd				0.000	0.0017	<LOD
Ru				0.000	0.0004	<LOD
Mo				0.000	0.0002	<LOD
Nb				0.000	0.0002	<LOD
Zr	0.0024	0.0004	0.0044	0.002	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0004	<LOD
Zn	**5.75**	**5.463**	**6.038**	5.762	0.0170	OK
Cu	**1.750**	**1.575**	**1.925**	1.758	0.0121	OK
Ni	0.027			0.025	0.0025	
Co				0.000	0.0355	<LOD
Fe	**0.17**	**0.1445**	**0.1955**	0.163	0.0073	OK
Mn	0.031			0.037	0.0077	
Cr	**0.22**	**0.187**	**0.253**	0.220	0.0040	OK
V	0.020			0.036	0.0025	
Ti	**0.092**	**0.062**	**0.122**	0.092	0.0034	OK
Al (Bal)	***91.7***	**88.9102**	**94.4098**	91.870	0.0994	OK

ThermoFisher SCIENTIFIC

Certificate of Calibration

Small Spot Locator Sample (30s main filter only)

	Low	High	Measured	Err	
Cu	93	100	98.726	0.0778	OK
Ti			1.136	0.0497	
Al			0.000	0.0000	

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
Certificates of Analysis (CoA) are available on request
Signed:

Stephen Elbeery
Director, Quality

Serial Number: X500946 Model: Niton XL5 Software: 5372 Date of Q.C.: Thu Aug 23, 2018 - 10:3
Resolution: 162.458 148.108 Escale: 7.49675 7.49387 Inspector: VK

180 second analysis time, 60 seconds per filter, all 3 filters switched on, all results in ppm

SiO2 blank 180-615

Elem	Certified	Low	High	Measured	2-sigma		
Ba	0	0	20	0.0	13.9	OK	<LOD
Cs	0	0	20	8.5	6.5	OK	<LOD
Te	0	0	20	0.0	5.5	OK	<LOD
Sb	0	0	20	5.3	2.2	OK	
Sn	0	0	20	0.0	2.9	OK	<LOD
Cd	0	0	20	0.0	1.4	OK	<LOD
Pd	0	0	20	0.8	0.7	OK	<LOD
Ag	0	0	20	0.0	1.2	OK	<LOD
Mo	0	0	10	0.0	0.5	OK	<LOD
Th	0	0	10	0.0	0.6	OK	<LOD
Zr	0	0	10	0.0	0.5	OK	<LOD
Sr	0	0	10	0.0	0.2	OK	<LOD
U	0	0	10	0.0	0.9	OK	<LOD
Rb	0	0	10	0.0	0.3	OK	<LOD
As	0	0	10	0.0	0.3	OK	<LOD
Se	0	0	10	0.0	0.2	OK	<LOD
Au	0	0	10	0.0	1.3	OK	<LOD
Hg	0	0	30	0.0	1.5	OK	<LOD
Pb	0	0	10	0.0	0.5	OK	<LOD
W	0	0	10	0.0	2.8	OK	<LOD
Zn	0	0	10	0.0	1.0	OK	<LOD
Cu	0	0	10	0.0	1.4	OK	<LOD
Ni	0	0	20	0.0	3.1	OK	<LOD
Co	0	0	20	0.0	2.8	OK	<LOD
Fe	0	0	20	0.0	5.8	OK	<LOD
Mn	0	0	20	0.0	7.4	OK	<LOD
Cr	0	0	20	0.0	2.0	OK	<LOD
V	0	0	20	0.0	1.4	OK	<LOD
Ti	0	0	20	15.6	4.2	OK	
Sc	0	0	20	0.0	1.1	OK	<LOD
Ca	0	0	100	0.0	3.4	OK	<LOD
K	0	0	50	0.0	10.3	OK	<LOD
S	0	0	60	0.0	29.4	OK	<LOD

NIST 2710 180-427

Elem	Certified	Low	High	Measured	2-sigma		
Ba	707	530.3	883.8	723.5	19.4	OK	
Cs	107	96.3	117.7	107.0	13.5	OK	
Te				0.0	9.2		
Sb	38.4	19.2	57.6	26.6	4.6	OK	
Sn				18.6	3.9		
Cd	21.8	15.26	28.34	15.8	2.4	OK	
Pd				0.0	1.7		
Ag	35.3	28.24	42.36	32.0	2.0	OK	
Mo	19	13.3	24.7	18.6	1.2	OK	
Th	13			15.9	7.4		
Zr				126.2	2.6		
Sr	330	247.5	412.5	327.4	2.3	OK	
U	25			36.4	4.2		
Rb	120	78	162	126.4	2.6	OK	
As	626			674.9	14.1		
Se				0.0	1.4		<LOD
Au	0.6			0.0	7.6		<LOD
Hg	32.6	26.08	39.12	31.8	8.6	OK	
Pb	5532	4425.6	6638.4	5889.0	18.7	OK	
W	93			242.1	22.5		
Zn	6952	5561.6	8342.4	7104.0	27.4	OK	
Cu	2950	2655	3245	2953.2	20.4	OK	
Ni	14.3			37.3	7.9		
Co	10			0.0	32.9		<LOD
Fe	33800	25350	42250	35741.6	122.9	OK	
Mn	10100	8080	12120	10147.0	80.1	OK	
Cr	39			36.6	5.8		
V	76.6	57.45	95.75	75.0	9.5	OK	
Ti	2830	2264	3396	2911.7	32.4	OK	
Sc	8.7			0.0	30.7		<LOD
Ca	12500	10000	15000	12072.0	136.4	OK	
K	21100	16880	25320	21738.7	206.0	OK	
S	2400			3292.6	170.4		

NIST 2711a 180-688

Elem	Certified	Low	High	Measured	2-sigma		
Ba	730	547.5	912.5	709.0	17.2	OK	
Cs				45.7	11.9		
Te				0.0	6.2		
Sb	23.8			9.6	4.0		
Sn				10.2	3.4		
Cd	54.1	45.99	62.22	46.7	2.5	OK	
Pd				0.0	1.2		<LOD
Ag	6			0.0	1.4		<LOD
Mo				0.0	1.1		<LOD
Th	15	7.5	11.25	15.6	3.6		
Zr				328.1	3.0		
Sr	242	193.6	290.4	231.2	1.7	OK	
U	3			8.5	2.8		
Rb	120			118.7	2.1		
As	107	85.6	128.4	112.8	6.4	OK	
Se	2			1.6	0.6		
Au				0.0	3.9		<LOD
Hg	7.42			9.9	3.2		
Pb	1400	1120	1680	1484.9	8.7	OK	
W				0.0	0.0		
Zn	414	331.2	496.8	403.2	6.4	OK	
Cu	140	110.6	169.4	129.3	4.8	OK	
Ni	21.7			21.1	6.8		
Co	9.9			0.0	43.9		<LOD
Fe	28200	25380	31020	27196.8	102.8	OK	
Mn	675	337.5	1012.5	609.6	23.4	OK	
Cr	52.3	26.15	78.45	56.1	4.7	OK	
V	80.47	64.376	96.564	75.5	7.8	OK	
Ti	3170	2853	3487	2970.8	26.8	OK	
Sc	8.5			0.0	33.9		<LOD
Ca	24200	20570	27830	24816.4	154.6	OK	
K	25300	22770	27830	24295.0	181.8	OK	
S				846.5	94.5		

NIST 2709 180-425

Elem	Certified	Low	High	Measured	2-sigma		
Ba	968	658.24	1277.76	810.5	16.7	OK	
Cs	5.3			43.4	11.4		
Te				0.0	5.9		
Sb	7.9			0.0	3.8		<LOD
Sn				4.9	3.3		
Cd	0.38			0.0	1.9		<LOD
Pd				0.0	1.1		<LOD
Ag	0.41			0.0	1.3		<LOD
Mo	2			0.0	1.4		<LOD
Th	11			10.5	1.5		
Zr	160	128	192	138.6	2.0	OK	
Sr	231	196.35	265.65	220.4	1.6	OK	
U	3			7.1	2.5		
Rb	96	76.8	115.2	89.5	1.8	OK	
As	17.7	12.39	23.01	19.0	1.1	OK	
Se	1.57			0.0	0.4		<LOD
Au	0.3			0.0	2.3		<LOD
Hg	1.4			3.2	2.8		<LOD
Pb	18.9	14.18	23.63	16.8	1.3	OK	
W	2			0.0	5.6		<LOD
Zn	106	74.2	137.8	89.0	3.4	OK	
Cu	34.6	20.76	48.44	24.4	3.1	OK	
Ni	88	61.6	114.4	88.0	8.1		
Co	13.4			35.2	28.9		<LOD
Fe	35000	31500	38500	34445.4	108.4	OK	
Mn	538	376.6	699.4	529.0	21.7	OK	
Cr	130	91	169	121.3	5.5	OK	
V	112	84	140	121.9	9.0	OK	
Ti	3420	2804.4	4035.6	3305.6	30.1	OK	
Sc	12			0.0	32.3		<LOD
Ca	18900	17010	20790	18841.8	143.2	OK	
K	20300	18270	22330	17420.6	166.2		
S	890	801	979	192.7	82.3		

DL-1a 180-612

Elem	Certified	Low	High	Measured	2-sigma		
Ba				360.4	13.8		
Cs				57.0	9.9		
Te				0.0	5.2		<LOD
Sb				0.0	3.3		<LOD
Sn				8.9	2.9		
Cd				0.0	1.7		<LOD
Pd				0.0	1.0		<LOD
Ag				0.0	1.1		<LOD
Mo				3.3	0.9		
Th	76	64.6	87.4	72.3	2.4	OK	
Zr				80.0	1.5		
Sr				16.4	0.5		
U	116	104.4	127.6	115.3	4.1	OK	
Rb				102.0	2.1		
As				3.3	1.4		
Se				3.4	0.4		
Au				0.0	0.0		
Hg				0.0	2.6		<LOD
Pb				65.9	2.0		
W				0.0	5.0		<LOD
Zn				69.2	2.8		
Cu				9.9	2.5		
Ni				0.0	7.1		<LOD
Co				0.0	21.7		<LOD
Fe	*9300*			7000.5	54.2		
Mn				28.9	12.8		
Cr				59.7	3.3		
V				25.2	4.2		
Ti				854.8	14.6		
Sc				0.0	11.4		<LOD
Ca				2987.7	57.6		
K				22390.3	142.7		
S	*4100*			1275.3	62.7		

TILL 4 180-646

Elem	Certified	Low	High	Measured	2-sigma		
Ba	395	237	553	476.2	15.0	OK	
Cs	12			55.3	10.7		
Te				0.0	5.6		
Sb	1			0.0	3.5		<LOD
Sn				19.2	3.1		
Cd				0.0	1.8		<LOD
Pd				0.0	1.1		<LOD
Ag				0.0	1.2		<LOD
Mo	16	8	24	17.4	0.9	OK	
Th	17.4	8.7	26.1	20.8	2.4	OK	
Zr	385	346.5	423.5	366.1	2.6	OK	
Sr	109	98.1	119.9	118.9	1.1	OK	
U	5			6.8	2.3		
Rb	161	144.9	177.1	166.7	2.1	OK	
As	111	83.25	138.75	108.9	2.0	OK	
Se				2.1	0.4		
Au				9.8	2.9		
Hg				7.5	4.0		
Pb	50	42.5	57.5	51.7	1.7	OK	
W	204	183.6	224.4	199.9	8.2	OK	
Zn	70	52.5	87.5	55.9	3.0	OK	
Cu	237.0	189.6	284.4	249.9	5.4	OK	
Ni	17			18.7	6.4		
Co	8			0.0	27.8		<LOD
Fe	39378	35440.2	43315.8	40542.8	102.5	OK	
Mn	490	343	637	458.7	18.5	OK	
Cr	53			68.8	4.6		
V	67	46.9	87.1	83.7	8.2	OK	
Ti	4840	3872	5324	4625.5	27.6	OK	
Sc	10			0.0	20.1		<LOD
Ca	8934	7147.2	10720.8	8281.7	95.2	OK	
K	26980	22933	31027	24488.3	173.1	OK	
S	800	600	1000	389.8	78.7		

NIST 2780 180-601

Elem	Certified	Low	High	Measured	2-sigma		
Ba	993	695.1	1290.9	1005.1	19.3	OK	
Cs	*13*			62.0	13.0		
Te	*5*			0.0	6.7		<LOD
Sb	*160*	144	176	161.9	5.0	OK	
Sn				15.8	3.7		
Cd	12.1			0.0	2.4		<LOD
Pd				0.0	1.3		<LOD
Ag	27	18.9	35.1	25.0	1.8	OK	
Mo	*11*	7.7	14.3	9.9	1.0	OK	
Th	12			19.1	6.6		
Zr	*176*	132	220	188.0	2.7	OK	
Sr	217	173.6	260.4	234.9	1.8	OK	
U	*4*	3.2	4.8	11.2	3.3		
Rb	*175*	140	210	179.6	2.7	OK	
As	48.8			50.7	12.1		
Se	*5*			2.6	0.9		
Au	0.18			0.0	9.3		<LOD
Hg	0.71			0.0	5.2		<LOD
Pb	5770	4904.5	6635.5	5348.2	16.8	OK	
W				66.3	12.4		
Zn	2570	1799	3341	2033.7	14.4	OK	
Cu	215.5	150.85	280.15	178.7	5.6	OK	
Ni	*12*			9.5	6.8		<LOD
Co	*2.2*			0.0	28.2		<LOD
Fe	27840	25056	30624	27442.3	107.1	OK	
Mn	462	369.6	554.4	450.0	22.1	OK	
Cr	*44*			45.2	5.2		
V	268	241.2	294.8	242.7	11.7	OK	
Ti	6990	6291	7689	7122.6	37.5	OK	
Sc	*23*			0.0	16.3		<LOD
Ca	1950			1892.8	77.0		
K	33800	30420	37180	36584.3	224.7	OK	
S	12630	11367	13893	12652.3	212.1	OK	

JSAC 403 180-726

Elem	Certified	Low	High	Measured	2-sigma		
Ba				387.6	15.7		
Cs				43.1	11.3		
Te				0.0	5.9		<LOD
Sb				0.0	3.9		<LOD
Sn				7.0	3.2		
Cd	183	164.7	201.3	185.4	3.2	OK	
Pd				0.0	1.5		<LOD
Ag				0.0	1.3		<LOD
Mo				0.0	0.9		<LOD
Th				10.2	2.1		
Zr				264.8	2.5		
Sr				54.3	0.9		
U				5.0	2.2		
Rb				86.9	1.8		
As	199	159.2	238.8	204.3	3.5	OK	
Se	169	152.1	185.9	169.0	1.4	OK	
Au				0.0	6.6		<LOD
Hg	11.1	3.33	19.98	13.1	3.4	OK	
Pb	224	179.2	268.8	232.6	3.8	OK	
W				0.0	5.6		<LOD
Zn	91.8	68.85	114.75	100.1	3.6	OK	
Cu	26	13.1	39.3	22.4	3.0	OK	
Ni	26.2			26.4	7.1		
Co				0.0	31.0		<LOD
Fe				39085.7	113.6		
Mn	252	189	315	246.4	18.2	OK	
Cr	257	205.6	308.4	256.5	6.3	OK	
V	101	75.75	126.25	124.3	9.7	OK	
Ti				4953.6	31.8		
Sc				0.0	16.6		<LOD
Ca				4036.9	79.2		
K				14769.6	158.9		
S				342.1	90.8		

AGV-2 180-678

Elem	Certified	Low	High	Measured	2-sigma		
Ba	1140	**912**	**1368**	1207.3	19.8	OK	
Cs				72.5	13.1		
Te				0.0	6.8		<LOD
Sb	*0.6*			0.0	4.3		<LOD
Sn	2.3			13.0	3.7		
Cd				0.0	2.1		<LOD
Pd				0.0	1.3		<LOD
Ag				0.0	1.4		<LOD
Mo				0.0	1.0		<LOD
Th	6.1	**4.27**	**7.93**	4.8	1.5		
Zr	230	**207**	**253**	251.4	3.0		
Sr	658	**592.2**	**723.8**	658.4	3.0		
U	1.88			10.7	3.3		
Rb	68.6	**61.74**	**75.46**	66.2	1.8		
As				1.9	0.9		
Se				0.0	0.4		<LOD
Au				0.0	2.5		<LOD
Hg				0.0	4.2		<LOD
Pb	**13**	**7.8**	**18.2**	11.8	1.3	OK	
W				0.0	6.0		<LOD
Zn	**86**	**68.8**	**103.2**	66.8	3.5		
Cu	**53**	**37.1**	**68.9**	48.0	3.8	OK	
Ni	19			26.3	7.9		
Co	16			0.0	39.8		<LOD
Fe	**46800**	**42120**	**51480**	46088.8	128.7	OK	
Mn	**770**	**577.5**	**962.5**	763.3	26.1	OK	
Cr	17			41.0	5.9		
V	**120**	**102**	**138**	124.3	12.2	OK	
Ti	**6300**	**5670**	**6930**	6339.7	41.9	OK	
Sc	13	11.7	14.3	0.0	73.4		<LOD
Ca	**37200**	**33480**	**40920**	37098.7	211.1	OK	
K	**23900**	**21510**	**26290**	24805.6	212.0	OK	
S				0.0	90.6		<LOD

NCS DC 73309 180-727

Elem	Certified	Low	High	Measured	2-sigma		
Ba	260			304.0	17.0		
Cs				54.0	12.5		
Te				0.0	6.4		<LOD
Sb	14.9			7.7	4.1		
Sn	**370**	**333**	**407**	370.0	5.3	OK	
Cd	2.3			0.0	2.1		<LOD
Pd				0.0	1.2		<LOD
Ag	3.2			0.0	1.4		<LOD
Mo	**5.9**	**4.13**	**7.67**	5.2	0.9	OK	
Th	**23.3**	**11.65**	**34.95**	31.0	3.6	OK	
Zr	**153**	**137.7**	**168.3**	147.7	2.0	OK	
Sr	**29**	**23.2**	**34.8**	28.5	0.7	OK	
U	9.1			11.7	3.2		
Rb	**408**	**367.2**	**448.8**	403.7	3.6	OK	
As	**188**	**141**	**235**	178.7	4.7	OK	
Se	0.2			0.0	0.6		
Au				3.7	3.7		
Hg	0.072			0.0	5.4		
Pb	**636**	**572.4**	**699.6**	673.3	6.0	OK	
W	**126**	**100.8**	**151.2**	127.4	9.1	OK	
Zn	**373**	**298.4**	**447.6**	415.9	6.6	OK	
Cu	**79**	**59.25**	**98.75**	73.2	4.0	OK	
Ni	14.3			20.3	6.8		
Co	8.5			0.0	27.8		<LOD
Fe	**30705**	**27634.5**	**33775.5**	29564.8	105.6	OK	
Mn	**2490**	**1867.5**	**3112.5**	2318.7	39.2	OK	
Cr	40	36	44	57.2	4.5		
V	**47**	**42.3**	**51.7**	41.2	6.5		
Ti	**2100**	**1890**	**2310**	2026.9	21.9	OK	
Sc	**7.4**	**6.66**	**8.14**	0.0	15.0		<LOD
Ca	**2723**	**2042.25**	**3403.75**	2698.2	73.6	OK	
K	**27229**	**24506.1**	**29951.9**	26250.6	191.6	OK	
S	170			633.6	86.9		

NCS DC 93007 180-707

Elem	Certified	Low	High	Measured	2-sigma		
Ba				534.3	28.9		
Cs				96.7	20.6		
Te				18.1	10.7		
Sb				0.0	6.6		<LOD
Sn				38.6	6.2		
Cd				0.0	3.3		<LOD
Pd				0.0	2.0		<LOD
Ag	**26.2**	**19.65**	**32.75**	31.2	3.0	OK	
Mo				49.9	1.7		
Th				0.0	4.7		<LOD
Zr				26.1	2.1		
Sr				86.8	1.8		
U				5.2	4.0		<LOD
Rb				83.7	3.0		
As				28.9	4.5		
Se				0.0	1.0		<LOD
Au	37.3			53.9	7.6		
Hg				66.8	8.7		
Pb				250.5	6.3		
W				0.0	16.5		<LOD
Zn				406.9	14.6		
Cu				8091.3	48.0		
Ni				363.9	29.4		
Co				146.3	93.3		
Fe				267529.9	282.2		
Mn				332.5	29.2		
Cr				0.0	15.2		<LOD
V				46.4	16.6		
Ti				1856.5	56.1		
Sc				0.0	52.3		<LOD
Ca				9659.8	215.8		
K				19961.5	338.9		
S				179221.5	1095.9		

G310-10 180-728

Elem	Certified	Low	High	Measured	2-sigma		
Ba				619.1	18.1		
Cs				0.0	4.2		<LOD
Te				0.0	7.3		<LOD
Sb				0.0	4.2		<LOD
Sn				16.9	3.7		
Cd				0.0	2.1		<LOD
Pd				0.0	1.3		<LOD
Ag	*10.5*			7.3	1.6		
Mo				0.0	0.9		<LOD
Th				13.0	1.7		
Zr				131.5	2.1		
Sr				180.3	1.6		
U				11.2	2.8		
Rb				108.2	2.1		
As				2.0	1.1		
Se				0.0	0.5		<LOD
Au	**48**	**36**	**60**	48.0	4.2	OK	
Hg				0.0	3.8		<LOD
Pb				24.7	1.6		
W				0.0	0.0		
Zn				58.6	3.3		
Cu				28.3	3.4		
Ni				33.1	8.0		
Co				0.0	48.9		<LOD
Fe				47245.8	128.8		
Mn				713.0	25.4		
Cr				77.2	6.0		
V				138.9	11.8		
Ti				6425.9	38.7		
Sc				69.3	47.8		<LOD
Ca				38425.4	212.7		
K				19870.2	193.2		
S				0.0	99.3		<LOD

Certificate of Calibration

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
The measurements were found to be within specification limits at the time of manufacture and calibration.

Standards used for factory calibrations are either certified reference standards (CRM) or reference samples (RM).
Certificates of Analysis (CoA) are available on request, if available.
Values in italics are informational only (i.e. not certified)

Signed:

Lee A. Graham
Director of Quality, FSI

Gmail by Google

Darby Soza <dsoza@mferentals.com>

SE-1805235601 for X500946 - XL5

1 message

James Collins <james.collins@thermofisher.com> Tue, May 29, 2018 at 5:10 AM
To: "dsoza@mferentals.com" <dsoza@mferentals.com>

ThermoFisher SCIENTIFIC

5/29/2018

MFE Enterprises Incorporated

Darby Soza

2330 E. Artesia Blvd
Long Beach, California 90805
United States

dsoza@mferentals.com

Subject: SE-1805235601 for Thermo Scientific X500946 - XL5

Dear Darby Soza,

No XL5 models avaliabler as loaner at this time.

SE-1805235601 has been assigned as the reference number for your service case - please ensure that all subsequent paperwork and inquiries reference this number.

When returning your Thermo Scientific X500946 - XL5 and associated equipment, please make sure that the equipment is in its original packaging and note the following:

- **Return shipment**
    - DO NOT SHIP US MAIL! IT IS ILLEGAL TO SHIP ANY XRF DEVICE THIS METHOD.
    - Identify the Service Event Number (SE-1805235601) on the outside of the box.

- Instrument MUST be returned in its original hard-shell case and packed into a larger cardboard box
- Please **DO NOT** ship any batteries with your analyzer unless specifically instructed by the customer support representative.
- DO NOT return any accessory or check sample(s) unless specifically requested by the technical support representative. Please contact your TSR with any questions.

- **License Requirement**
  - If you are returning an isotope based analyzer (models XLp, XLi, or XL3p), please be sure to include a copy of either your radioactive materials license (issued by State) or a signed general license acknowledgement.
  - If you are returning an x-ray tube based analyzer (models XL3t, XL2, XLt, DXL, or FXL), please be sure to include a copy of your tube registration. (A tube registration is state specific and does not apply to all states)

- **Leak test**
  - When returning an isotope-based instrument, regulations require that you provide a copy of a valid leak test with the shipment. (Does NOT apply to x-ray tube based analyzers).
  - By returning your equipment, you acknowledge the leak test requirement as well as the consequences of returning that equipment without a valid leak test.

Full shipment requirements for your Thermo Scientific Niton analyzer can be found on Portables.com. You will need to login to access the shipment instructions.

- **Saving of data/readings (including custom libraries, data fields, signatures etc)**
  - Safekeeping of your data is our top priority. Due to procedures that may be necessary during the course of servicing your analyzer, however, it is not possible for us to guarantee that we will be able to download and save the data (including custom libraries, data fields, signatures, etc) stored in your analyzer when it arrives.
  - For this reason, ***please be sure that you have downloaded all readings, custom libraries, data fields, signatures, etc, that you wish to retain from your analyzer prior to sending it in for service.***
  - If you have questions or need assistance with the above, please don't hesitate to contact us.

Return address for your Niton Analyzer is:

Thermo Fisher Scientific PAI

C/O Depot Repair

2 Radcliff Road

Tewksbury, MA 01876

We sincerely apologize for any inconvenience, and we appreciate your patience while we service your equipment. Thank you for giving us the opportunity, and we look forward to your continued business.

Sincerely,

James Collins
Technical Support Engineer
Telephone #: 800-875-1578 Option 2

Email: james.collins@thermofisher.com

Thermo Scientific
Portable Analytical Instruments

2 Radcliff Road
Tewksbury, Massachusetts 01876

1 800 875-1578
+1 978 670-7460

info.pai@thermofisher.com
www.thermoscientific.com/pai

ATTACHMENT B3

EX SITU BULK SAMPLE REGRESSION MODELS

TABLE OF CONTENTS

Section		Page
1.0	**SUMMARY OF BULK SAMPLE REGRESSION MODELS**	**B3-1**
2.0	**ARSENIC EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-2**
2.1	ARSENIC STATISTICAL OUTPUT (MODEL AS-1)	B3-2
2.2	ARSENIC STATISTICAL OUTPUT (MODEL AS-2)	B3-6
2.3	ARSENIC STATISTICAL OUTPUT (MODEL AS-3)	B3-10
3.0	**IRON EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-14**
3.1	IRON STATISTICAL OUTPUT (MODEL FE-1)	B3-14
4.0	**MANGANESE EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-18**
4.1	MANGANESE STATISTICAL OUTPUT (MODEL MN-1)	B3-18
4.2	MANGANESE STATISTICAL OUTPUT (MODEL MN-2)	B3-22
5.0	**MOLYBDENUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-26**
5.1	MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-1)	B3-26
5.2	MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-1A)	B3-30
5.3	MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-2)	B3-34
5.4	MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-2A)	B3-38
5.5	MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-1B)	B3-42
6.0	**LEAD EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-46**
6.1	LEAD STATISTICAL OUTPUT (MODEL PB-1)	B3-46
6.2	LEAD STATISTICAL OUTPUT (MODEL PB-2)	B3-50
6.3	LEAD STATISTICAL OUTPUT (MODEL PB-1A)	B3-54
6.4	LEAD STATISTICAL OUTPUT (MODEL PB-2A)	B3-58
7.0	**THORIUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-62**
7.1	THORIUM STATISTICAL OUTPUT (MODEL TH-1)	B3-62
7.2	THORIUM STATISTICAL OUTPUT (MODEL TH-2)	B3-66
7.3	THORIUM STATISTICAL OUTPUT (MODEL TH-1A)	B3-70
7.4	THORIUM STATISTICAL OUTPUT (MODEL TH-2A)	B3-74
8.0	**URANIUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-78**
8.1	URANIUM STATISTICAL OUTPUT (MODEL U-1)	B3-78
8.2	URANIUM STATISTICAL OUTPUT (MODEL U-2)	B3-82
8.3	URANIUM STATISTICAL OUTPUT (MODEL U-2A)	B3-86
8.4	URANIUM STATISTICAL OUTPUT (MODEL U-1A)	B3-90
9.0	**VANADIUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS**	**B3-94**
9.1	VANADIUM STATISTICAL OUTPUT (MODEL VA-1)	B3-94
9.2	VANADIUM STATISTICAL OUTPUT (MODEL VA-2)	B3-98

TABLE OF CONTENTS (CONTINUED)

Section **Page**

10.0 ZINC EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS B3-102

10.1 ZINC STATISTICAL OUTPUT (MODEL ZN-1) B3-102

10.2 ZINC STATISTICAL OUTPUT (MODEL ZN-2) B3-106

10.3 ZINC STATISTICAL OUTPUT (MODEL ZN-3) B3-110

LIST OF TABLES

Table B3-1. Summary of Final Ex Situ Bulk Sample Method Regression Model Parameters.B3-1

LIST OF FIGURES

Figure B3-1. Minitab Prediction Report for Model AS-1 .... B3-2
Figure B3-2. Minitab Residuals Report for Model AS-1 .... B3-3
Figure B3-3. Ex Situ Bulk Sample Fitted Line Plot for Arsenic Model AS-1 .... B3-4
Figure B3-4. Ex Situ Bulk Sample Normal Probability Plot of Arsenic Standardized Residuals for Model AS-1 .... B3-4
Figure B3-5. Ex Situ Bulk Sample Versus Fits Residuals Arsenic for Model AS-1 .... B3-5
Figure B3-6. Ex Situ Bulk Sample Histogram of Arsenic Standardized Residuals for Model AS-1 .... B3-5
Figure B3-7. Minitab Prediction Report for Model AS-2 .... B3-6
Figure B3-8. Minitab Residuals Report for Model AS-2 .... B3-7
Figure B3-9. Ex Situ Bulk Sample Fitted Line Plot for Arsenic Model AS-2 .... B3-8
Figure B3-10. Ex Situ Bulk Sample Normal Probability Plot of Arsenic Standardized Residuals for Model AS-2 .... B3-8
Figure B3-11. Ex Situ Bulk Sample Versus Fits Residuals Arsenic for Model AS-2 .... B3-9
Figure B3-12. Ex Situ Bulk Sample Histogram for Standardized Arsenic Residuals for Model AS-2 .... B3-9
Figure B3-13. Minitab Prediction Report for Model AS-3 .... B3-10
Figure B3-14. Minitab Residuals Report for Model AS-3 .... B3-11
Figure B3-15. Ex Situ Bulk Sample Fitted Line Plot for Arsenic Model AS-3 .... B3-12
Figure B3-16. Ex Situ Bulk Sample Normal Probability Plot of Arsenic Standardized Residuals for Model AS-3 .... B3-12
Figure B3-17. Ex Situ Bulk Sample Versus Fits Residuals Arsenic for Model AS-3 .... B3-13
Figure B3-18. Ex Situ Bulk Sample Histogram of Standardized Arsenic Residuals for Model AS-3 .... B3-13
Figure B3-19. Minitab Prediction Report for Model FE-1 .... B3-14
Figure B3-20. Minitab Residuals Report for Model FE-1 .... B3-15
Figure B3-21. Ex Situ Bulk Sample Fitted Line Plot for Iron Model FE-1 .... B3-16
Figure B3-22. Ex Situ Bulk Sample Normal Probability Plot of Iron Standardized Residuals for Model FE-1 .... B3-16
Figure B3-23. Ex Situ Bulk Sample Versus Fits Residuals Iron for Model FE-1 .... B3-17
Figure B3-24. Ex Situ Bulk Sample Histogram of Standardized Iron Residuals for Model FE-1 .... B3-17
Figure B3-30. Minitab Prediction Report for Model MN-1 .... B3-18
Figure B3-25. Minitab Residuals Report for Model MN-1 .... B3-19
Figure B3-26. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MN-1 .... B3-20
Figure B3-27. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MN-1 .... B3-20
Figure B3-28. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MN-1 .... B3-21
Figure B3-29. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MN-1 .... B3-21
Figure B3-30. Minitab Prediction Report for Model MN-2 .... B3-22
Figure B3-31. Minitab Residuals Report for Model MN-2 .... B3-23

LIST OF FIGURES (CONTINUED)

Figure B3-32. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MN-2 .... B3-24
Figure B3-33. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MN-2 .... B3-24
Figure B3-34. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MN-2..... B3-25
Figure B3-35. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MN-2 .... B3-25
Figure B3-36. Minitab Prediction Report for Model MO-1 .... B3-26
Figure B3-37. Minitab Residuals Report for Model MO-1 .... B3-27
Figure B3-38. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-1 .... B3-28
Figure B3-39. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-1 .... B3-28
Figure B3-40. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-1..... B3-29
Figure B3-41. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-1 .... B3-29
Figure B3-42. Minitab Prediction Report for Model MO-1A B3-30
Figure B3-43. Minitab Residuals Report for Model MO-1A B3-31
Figure B3-44. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-1A B3-32
Figure B3-45. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-1A B3-32
Figure B3-46. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-1A.. B3-33
Figure B3-47. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-1A B3-33
Figure B3-48. Minitab Prediction Report for Model MO-2 .... B3-34
Figure B3-49. Minitab Residuals Report for Model MO-2 .... B3-35
Figure B3-50. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-2 .... B3-36
Figure B3-51. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-2 .... B3-36
Figure B3-52. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-2..... B3-37
Figure B3-53. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-2 .... B3-37
Figure B3-54. Minitab Prediction Report for Model MO-2A B3-38
Figure B3-55. Minitab Residuals Report for Model MO-2A B3-39
Figure B3-56. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-2A B3-40
Figure B3-57. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-2A B3-40
Figure B3-58. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-2A.. B3-41
Figure B3-59. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-2A B3-41
Figure B3-60. Minitab Prediction Report for Model MO-1B.............. B3-42
Figure B3-61. Minitab Residuals Report for Model MO-1B B3-43
Figure B3-62. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-1B............ B3-44
Figure B3-63. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-1B B3-44
Figure B3-64. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-1B.. B3-45

LIST OF FIGURES (CONTINUED)

Figure B3-65. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-1B B3-45
Figure B3-66. Minitab Prediction Report for Model PB-1 ..... B3-46
Figure B3-67. Minitab Residuals Report for Model PB-1 ..... B3-47
Figure B3-68. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-1 ..... B3-48
Figure B3-69. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-1 ..... B3-48
Figure B3-70. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-1 ..... B3-49
Figure B3-71. Ex Situ Bulk Sample Historgram of Lead Standardized Residuals for Model PB-1 ..... B3-49
Figure B3-72. Minitab Prediction Report for Model PB-2 ..... B3-50
Figure B3-73. Minitab Residuals Report for Model PB-12 ..... B3-51
Figure B3-74. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-2 ..... B3-52
Figure B3-75. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-2 ..... B3-52
Figure B3-76. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-2 ..... B3-53
Figure B3-77. Ex Situ Bulk Sample Historgram of Lead Standardized Residuals for Model PB-2 ..... B3-53
Figure B3-78. Minitab Prediction Report for Model PB-1A B3-54
Figure B3-79. Minitab Residuals Report for Model PB-1A B3-55
Figure B3-80. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-1A B3-56
Figure B3-81. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-1A B3-56
Figure B3-82. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-1A B3-57
Figure B3-83. Ex Situ Bulk Sample Historgram of Lead Standardized Residuals for Model PB-1A B3-57
Figure B3-84. Minitab Prediction Report for Model PB-2A B3-58
Figure B3-85. Minitab Residuals Report for Model PB-2A B3-59
Figure B3-86. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-2A B3-60
Figure B3-87. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-2A B3-60
Figure B3-88. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-2A B3-61
Figure B3-89. Ex Situ Bulk Sample Historgram of Lead Standardized Residals for Model PB-2A B3-61
Figure B3-90. Minitab Prediction Report for Model TH-1 ..... B3-62
Figure B3-91. Minitab Residuals Report for Model TH-1 ..... B3-63
Figure B3-92. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-1 ..... B3-64
Figure B3-93. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-1 ..... B3-64
Figure B3-94. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-1 ..... B3-65
Figure B3-95. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-1 ..... B3-65
Figure B3-96. Minitab Prediction Report for Model TH-2 ..... B3-66
Figure B3-97. Minitab Residuals Report for Model TH-2 ..... B3-67
Figure B3-98. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-2 ..... B3-68

LIST OF FIGURES (CONTINUED)

Figure B3-99. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-2 ..... B3-68
Figure B3-100. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-2 ..... B3-69
Figure B3-101. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-2 ..... B3-69
Figure B3-102. Minitab Prediction Report for Model TH-1A B3-70
Figure B3-103. Minitab Residuals Report for Model TH-1A B3-71
Figure B3-104. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-1A B3-72
Figure B3-105. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-1A B3-72
Figure B3-106. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-1A B3-73
Figure B3-107. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-1A B3-73
Figure B3-108. Minitab Prediction Report for Model TH-2A B3-74
Figure B3-109. Minitab Residuals Report for Model TH-2A B3-75
Figure B3-110. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-2A B3-76
Figure B3-111. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-2A B3-76
Figure B3-112. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-2A B3-77
Figure B3-113. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-2A B3-77
Figure B3-114. Minitab Prediction Report for Model U-1 ..... B3-78
Figure B3-115. Minitab Residuals Report for Model U-1 ..... B3-79
Figure B3-116. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-1 ..... B3-80
Figure B3-117. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-1 ..... B3-80
Figure B3-118. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-1 ..... B3-81
Figure B3-119. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-1 ..... B3-81
Figure B3-120. Minitab Prediction Report for Model U-2 ..... B3-82
Figure B3-121. Minitab Residuals Report for Model U-2 ..... B3-83
Figure B3-122. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-2 ..... B3-84
Figure B3-123. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-2 ..... B3-84
Figure B3-124. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-2 ..... B3-85
Figure B3-125. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-2 ..... B3-85
Figure B3-126. Minitab Prediction Report for Model U-2A B3-86
Figure B3-127. Minitab Residuals Report for Model U-2A B3-87
Figure B3-128. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-2A B3-88
Figure B3-129. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-2A B3-88
Figure B3-130. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-2A B3-89
Figure B3-131. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-2A B3-89
Figure B3-132. Minitab Prediction Report for Model U-1A B3-90
Figure B3-133. Minitab Residuals Report for Model U-1A B3-91
Figure B3-134. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-1A B3-92

LIST OF FIGURES (CONTINUED)

Figure B3-135. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-1A ... B3-92
Figure B3-136. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-1A ... B3-93
Figure B3-137. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-1 ... B3-93
Figure B3-138. Minitab Prediction Report for Model VA-1 ... B3-94
Figure B3-139. Minitab Residuals Report for Model VA-1 ... B3-95
Figure B3-140. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model VA-1 ... B3-96
Figure B3-141. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model VA-1 ... B3-96
Figure B3-142. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model VA-1 ... B3-97
Figure B3-143. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model VA-1 ... B3-97
Figure B3-144. Minitab Prediction Report for Model VA-2 ... B3-98
Figure B3-145. Minitab Residuals Report for Model VA-12 ... B3-99
Figure B3-146. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model VA-2 ... B3-100
Figure B3-147. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model VA-2 ... B3-100
Figure B3-148. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model VA-2 ... B3-101
Figure B3-149. Ex Situ Bulk Sample Histogram of Standarized Vanadium Residuals for Model VA-2 ... B3-101
Figure B3-150. Minitab Prediction Report for Model ZN-1 ... B3-102
Figure B3-151. Minitab Residuals Report for Model ZN-1 ... B3-103
Figure B3-152. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model ZN-1 ... B3-104
Figure B3-153. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model ZN-1 ... B3-104
Figure B3-154. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model ZN-1 ... B3-105
Figure B3-155. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model ZN-1 ... B3-105
Figure B3-156. Minitab Prediction Report for Model ZN-2 ... B3-106
Figure B3-157. Minitab Residuals Report for Model ZN-2 ... B3-107
Figure B3-158. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model ZN-2 ... B3-108
Figure B3-159. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model ZN-2 ... B3-108
Figure B3-160. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model ZN-2 ... B3-109
Figure B3-161. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model ZN-2 ... B3-109
Figure B3-162. Minitab Prediction Report for Model ZN-3 ... B3-110
Figure B3-163. Minitab Residuals Report for Model ZN-3 ... B3-111
Figure B3-164. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model ZN-3 ... B3-112
Figure B3-165. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model ZN-3 ... B3-112
Figure B3-166. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model ZN-3 ... B3-113
Figure B3-167. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model ZN-3 ... B3-113

1.0 SUMMARY OF BULK SAMPLE REGRESSION MODELS

Table B3-1. Summary of Final Ex Situ Bulk Sample Method Regression Model Parameters

Analyte	Final Selected Model Name	XRF Data Applied To[1]	Total # of Data Pairs Used in Model Development[2]	XRF_{MIN} (ppm)	XRF_{MAX} (ppm)	Censored Data Pairs Removed[3]	Outliers Data Pairs Removed[4]	Instrument Setting[5]	Greater than Threshold[6]	Total Data Pairs[7]	XRF_O (ppm)	R^2	R	Slope (m)	y-intercept (b)
Arsenic	Model AS-3	All	131	1.6	53	131	2	0	0	264	0.53	0.94	0.97	1.0407	-0.5494
Iron	Model FE-1	All	256	2,839	39,954	0	0	8	0	264	-547.13	0.82	0.91	0.5179	283.36
Lead	Model PB-2A	< 30	254	2.7	29.9	7	2	0	1	264	1.55	0.79	0.89	0.9519	-1.4758
	Model PB-1A	≥ 30	255		120	7	2	0	0	264	NA	0.95	0.97	1.0120	-1.9935
Manganese	Model MN-2	All	251	31.3	454	0	0	10	3	264	-69.88	0.74	0.86	0.8912	62.274
Molybdenum	Model MO-1	All	153	1.6	76	102	1	8	0	264	2.11	0.99	0.99	0.7964	-1.6827
Thorium	Model TH-2A	< 12	254	2.0	12	5	3	0	2	264	0.06	0.70	0.84	0.5189	-0.0333
	Model TH-1A	≥ 12	256		55	5	3	0	0	264	NA	0.97	0.98	0.6955	-0.8443
Uranium	Model U-2A	< 100	184	2.99	95	47	6	0	27	264	2.82	0.89	0.94	0.8031	-2.266
	Model U-1A	≥ 100	207		509	47	10	0	0	264	NA	0.92	0.96	0.7677	-0.0998
Vanadium	Model VA-2	All	252	14.3	1,298	8	4	0	0	264	23.0	0.91	0.95	0.7963	-18.33
Zinc	Model ZN-3	All	243	5.2	80	10	11	0	0	264	-6.2	0.82	0.91	0.6919	4.2593

Notes:

[1] Refers to which XRF measurement values the model is applied to when converting in situ XRF database data to laboratory equivalent concentrations.
[2] Total data pairs used in regression model development.
[3] Refers to the number of data pairs removed from the model development that included either a (1) a minimum of one XRF measurement containing a LOD value or (2) a laboratory reported concentration below the laboratory MDL.
[4] Refers to the number of data pairs removed from the model development that were identified as extreme outliers by visual inspection or residual analysis. Models are shown for both with and without outliers in this attachment.
[5] Refers to the number of data pairs removed from the model development because of an instrument setting or operator error during the XRF measurement process.
[6] Refers to the number of data pairs removed from the model development because they were greater than a given threshold; two models were developed for different ranges of XRF values (that is, uranium, thorium, and lead).
[7] Indicates the total number of possible XRF versus laboratory data pairs from the Baseline Study (Mobilization #1 through Mobilization #6).

LOD Limit of detection for XRF
MDL Method detection limit for laboratory
NA Not applicable
ppm Parts per million
R Pearson's correlation coeffiicent
R^2 Coefficient of determination
XRF X-ray fluoresence
XRF_{MAX} Defined as the maximum raw in situ XRF measurement value used in the regression model development.
XRF_{MIN} Defined as the minimum raw in situ XRF measurement value used in the regression model development.
XRF_O Defined as the XRF measurement value equal to the laboratory equivalent value of 0 milligrams per kilogram; when using the regression model (that is, the x-value when the y-value is zero).

2.0 ARSENIC EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

2.1 ARSENIC STATISTICAL OUTPUT (MODEL AS-1)

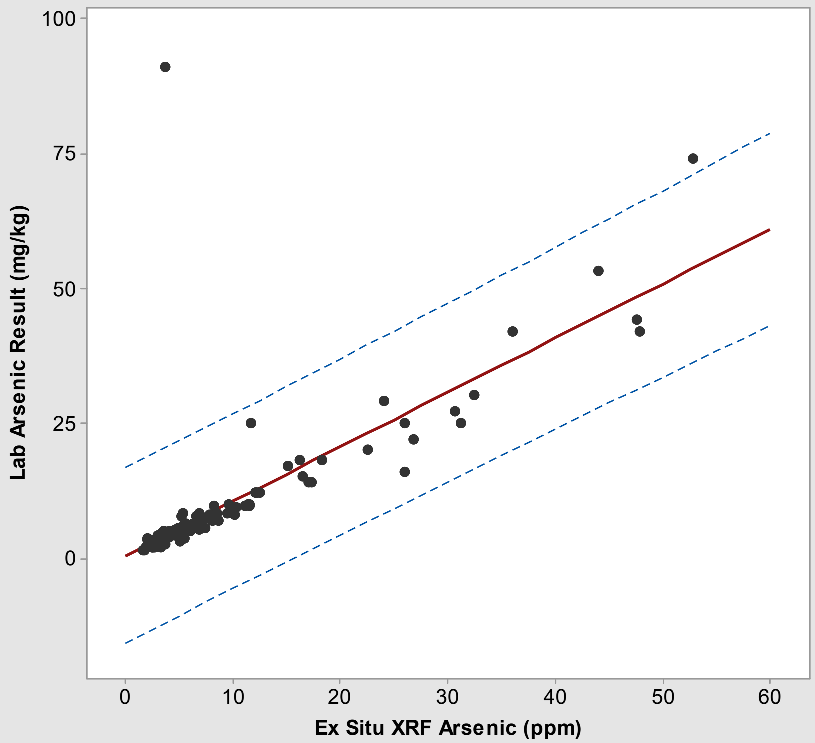
Regression for Lab Arsenic Result (mg/kg) vs Ex Situ XRF Arsenic (ppm)

Prediction Report for Model AS-1

Y: Lab Arsenic Result (mg/kg)
X: Ex Situ XRF Arsenic (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	0.49428	(-15.756, 16.744)
2.5	3.0146	(-13.211, 19.241)
5	5.5348	(-10.675, 21.745)
7.5	8.0551	(-8.1471, 24.257)
10	10.575	(-5.6271, 26.778)
12.5	13.096	(-3.1152, 29.307)
15	15.616	(-0.61136, 31.843)
17.5	18.136	(1.8844, 34.388)
20	20.657	(4.3721, 36.941)
22.5	23.177	(6.8519, 39.502)
25	25.697	(9.3237, 42.071)
27.5	28.217	(11.788, 44.647)
30	30.738	(14.244, 47.232)
32.5	33.258	(16.692, 49.824)
35	35.778	(19.133, 52.423)
37.5	38.299	(21.567, 55.030)
40	40.819	(23.993, 57.645)
42.5	43.339	(26.412, 60.266)
45	45.859	(28.824, 62.895)
47.5	48.380	(31.228, 65.531)
50	50.900	(33.626, 68.174)
52.5	53.420	(36.018, 70.823)
55	55.941	(38.402, 73.479)
57.5	58.461	(40.781, 76.141)
60	60.981	(43.153, 78.810)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-1. Minitab Prediction Report for Model AS-1

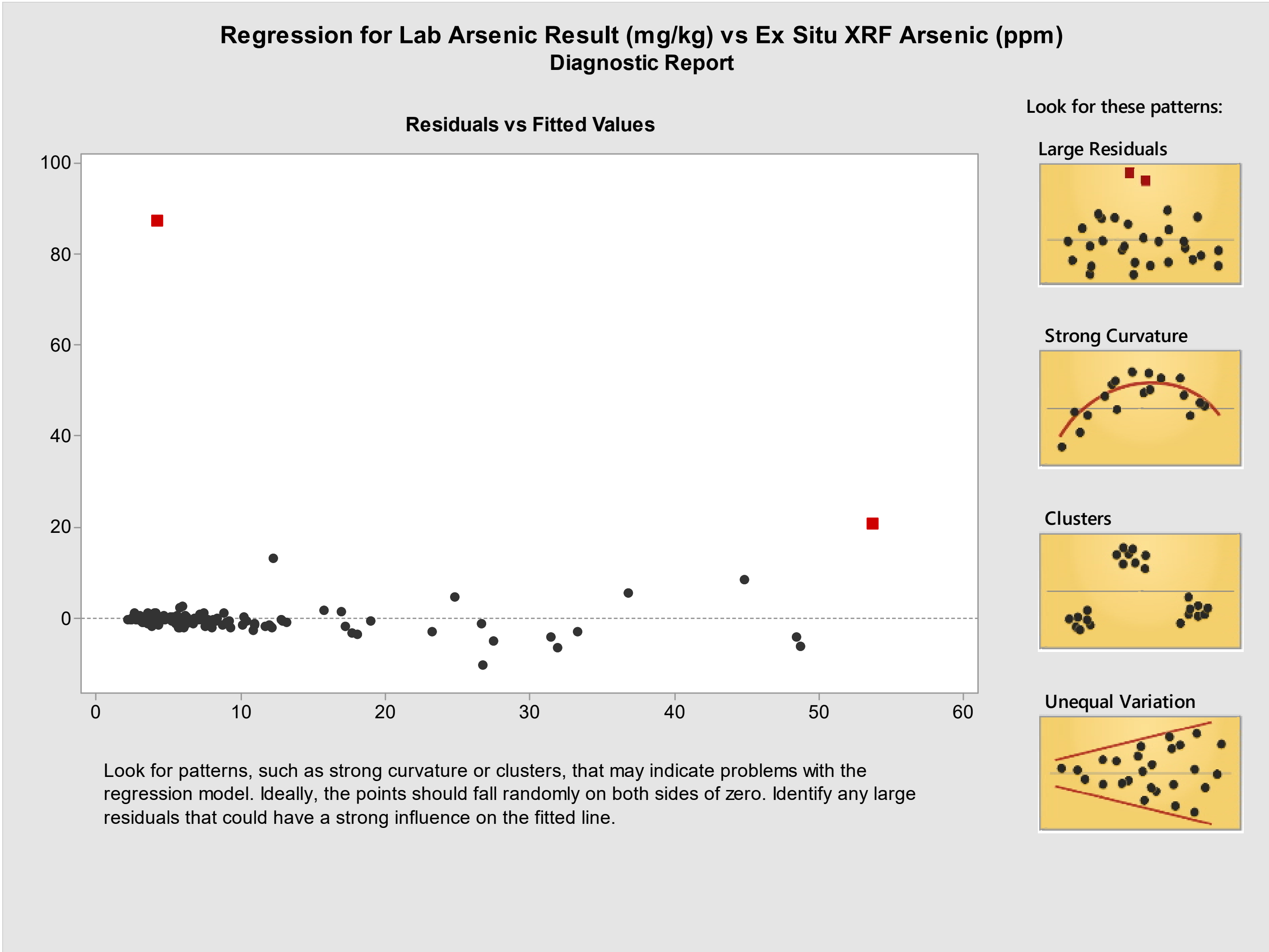


Figure B3-2. Minitab Residuals Report for Model AS-1

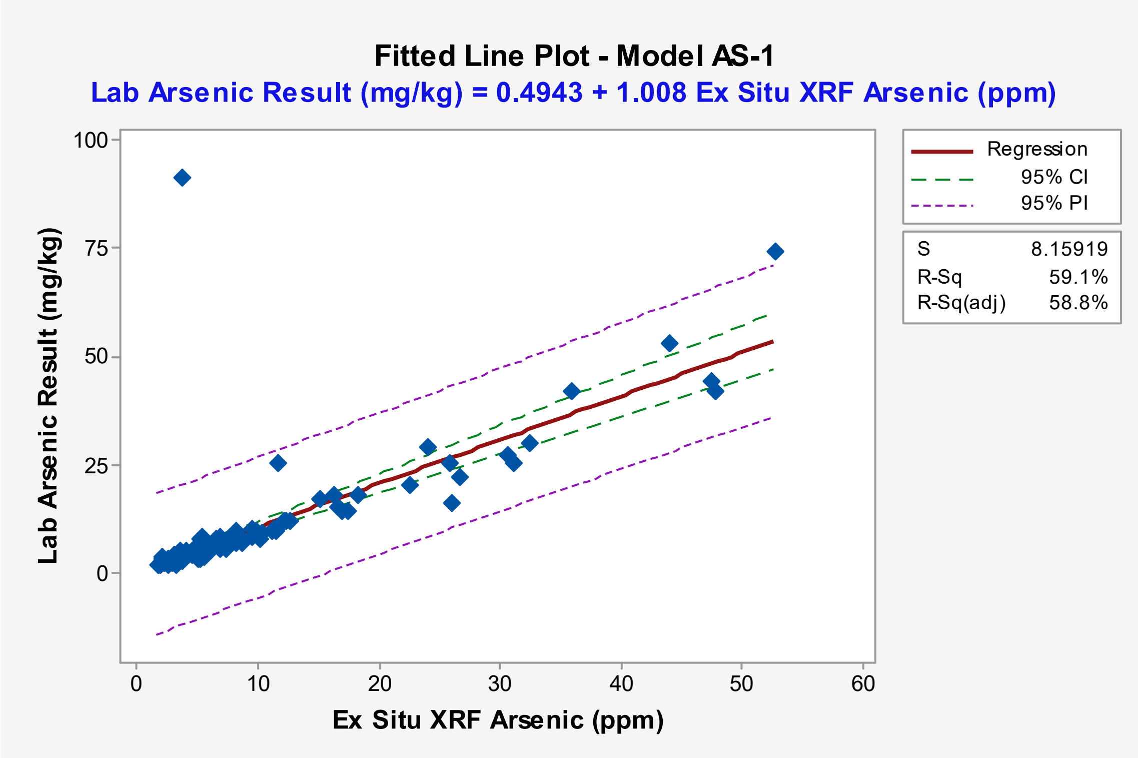


Figure B3-3. Ex Situ Bulk Sample Fitted Line Plot for Arsenic Model AS-1

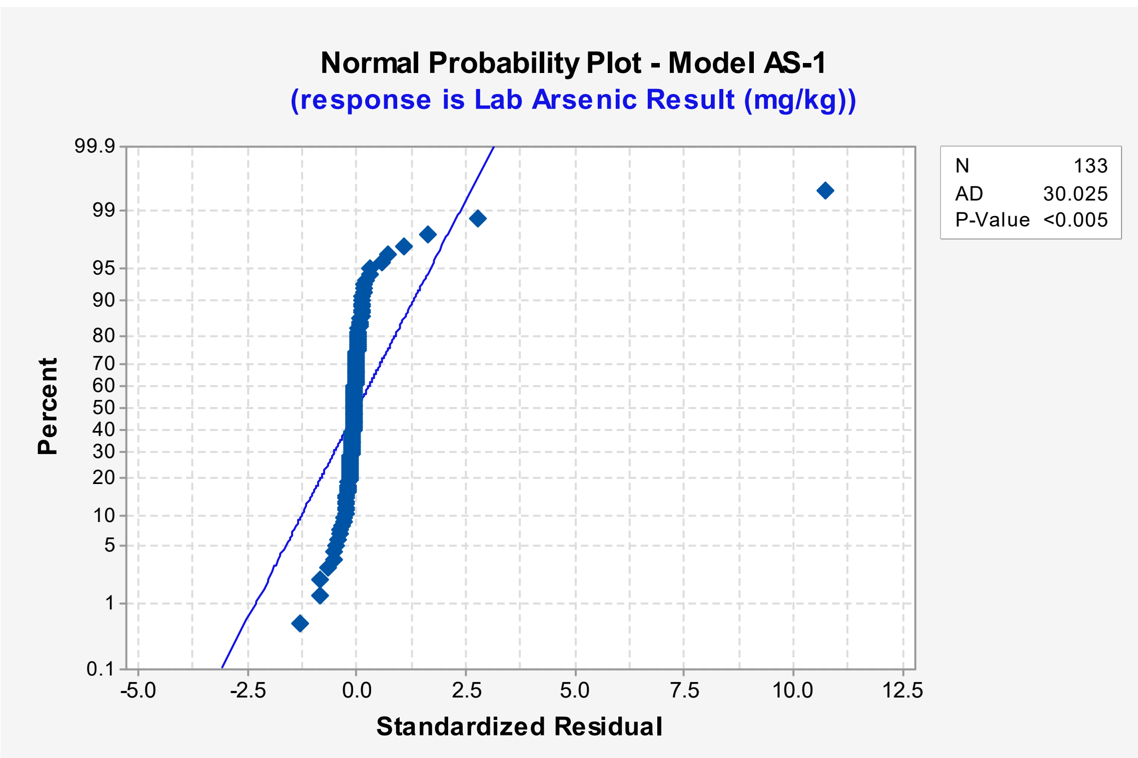


Figure B3-4. Ex Situ Bulk Sample Normal Probability Plot of Arsenic Standardized Residuals for Model AS-1

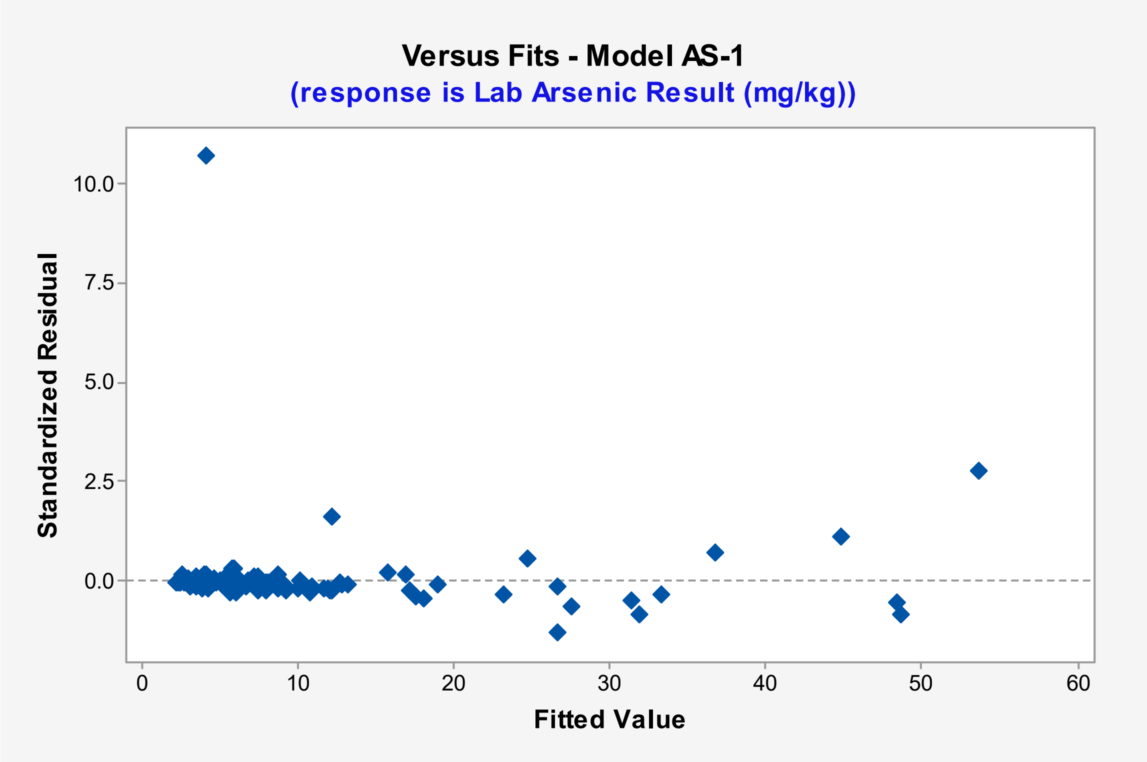


Figure B3-5. Ex Situ Bulk Sample Versus Fits Residuals Arsenic for Model AS-1

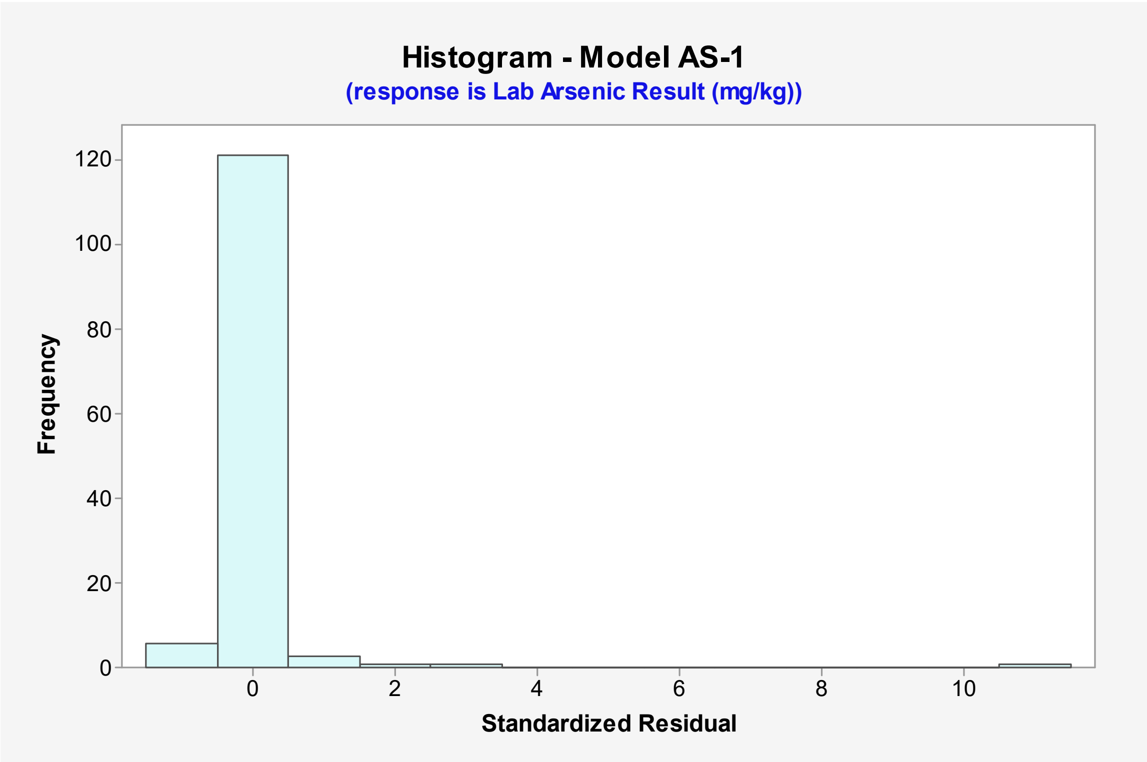


Figure B3-6. Ex Situ Bulk Sample Histogram of Arsenic Standardized Residuals for Model AS-1

2.2 ARSENIC STATISTICAL OUTPUT (MODEL AS-2)

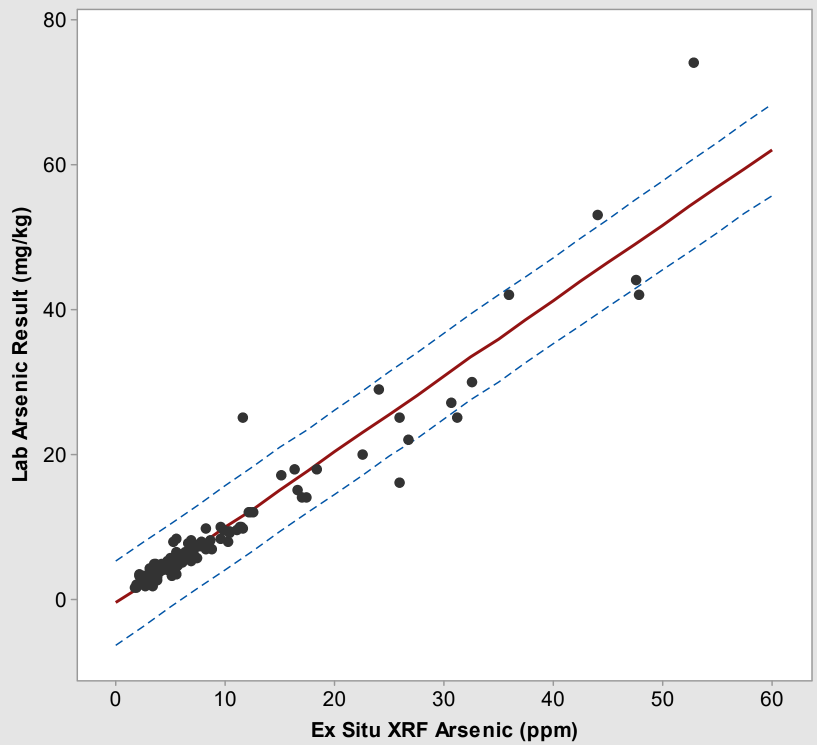
Regression for Lab Arsenic Result (mg/kg) vs Ex Situ XRF Arsenic (ppm)

Prediction Report for Model AS-2

Y: Lab Arsenic Result (mg/kg)
X: Ex Situ XRF Arsenic (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	-0.47465	(-6.2803, 5.3310)
2.5	2.1349	(-3.6622, 7.9320)
5	4.7445	(-1.0469, 10.536)
7.5	7.3540	(1.5656, 13.142)
10	9.9636	(4.1751, 15.752)
12.5	12.573	(6.7817, 18.365)
15	15.183	(9.3854, 20.980)
17.5	17.792	(11.986, 23.598)
20	20.402	(14.584, 26.219)
22.5	23.011	(17.179, 28.843)
25	25.621	(19.771, 31.470)
27.5	28.230	(22.361, 34.100)
30	30.840	(24.948, 36.732)
32.5	33.450	(27.531, 39.368)
35	36.059	(30.113, 42.006)
37.5	38.669	(32.691, 44.646)
40	41.278	(35.267, 47.289)
42.5	43.888	(37.840, 49.935)
45	46.497	(40.411, 52.584)
47.5	49.107	(42.979, 55.234)
50	51.716	(45.545, 57.888)
52.5	54.326	(48.109, 60.543)
55	56.936	(50.670, 63.201)
57.5	59.545	(53.228, 65.862)
60	62.155	(55.785, 68.524)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-7. Minitab Prediction Report for Model AS-2

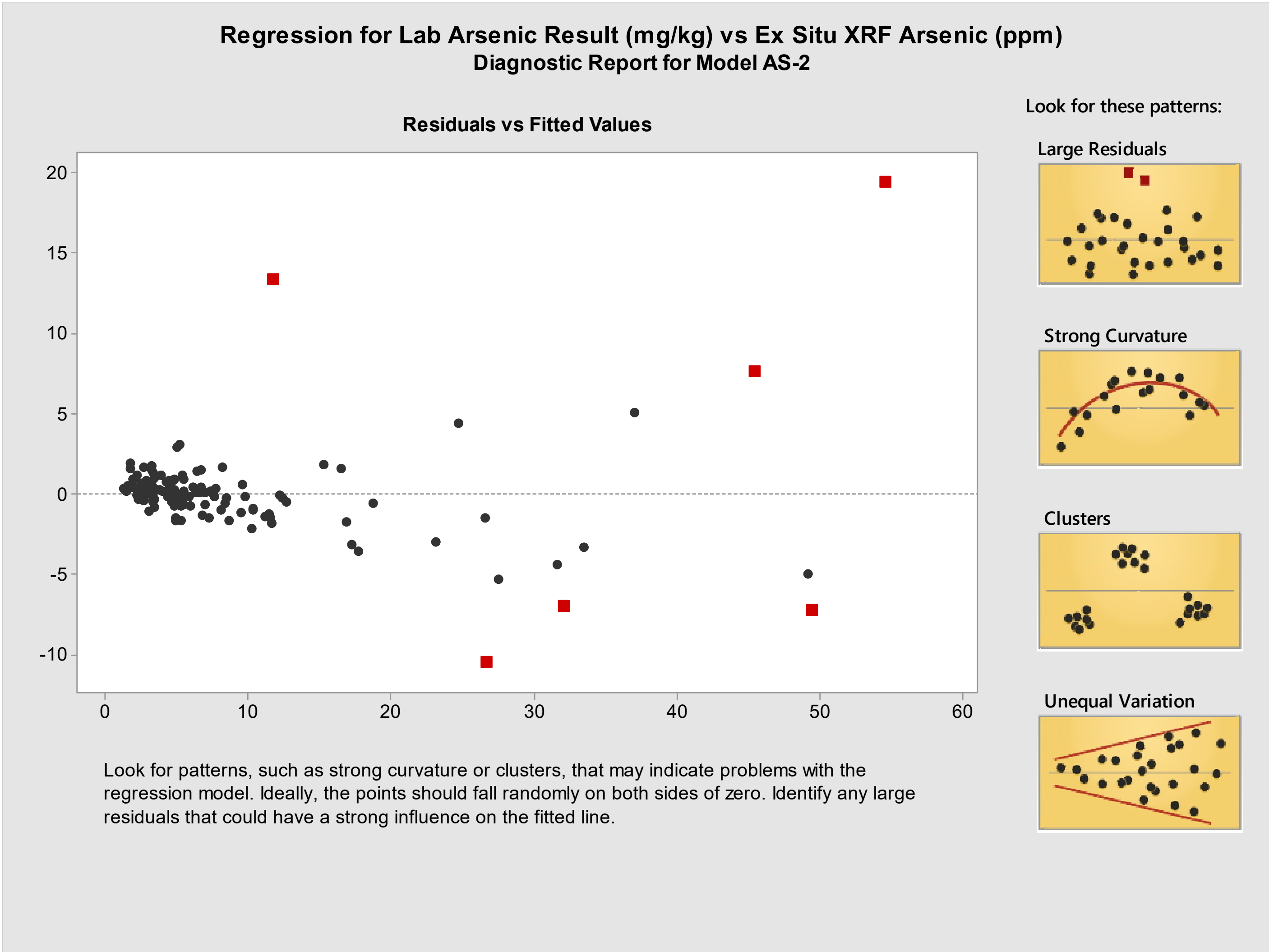


Figure B3-8. Minitab Residuals Report for Model AS-2

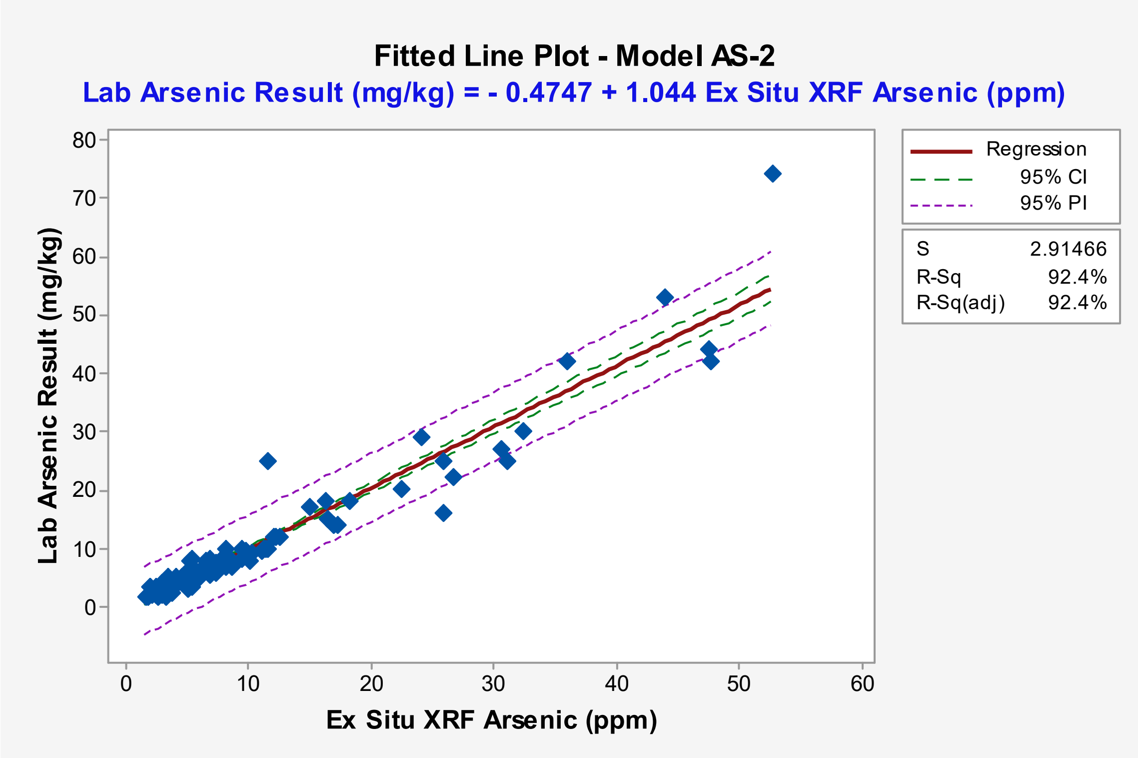


Figure B3-9. Ex Situ Bulk Sample Fitted Line Plot for Arsenic Model AS-2

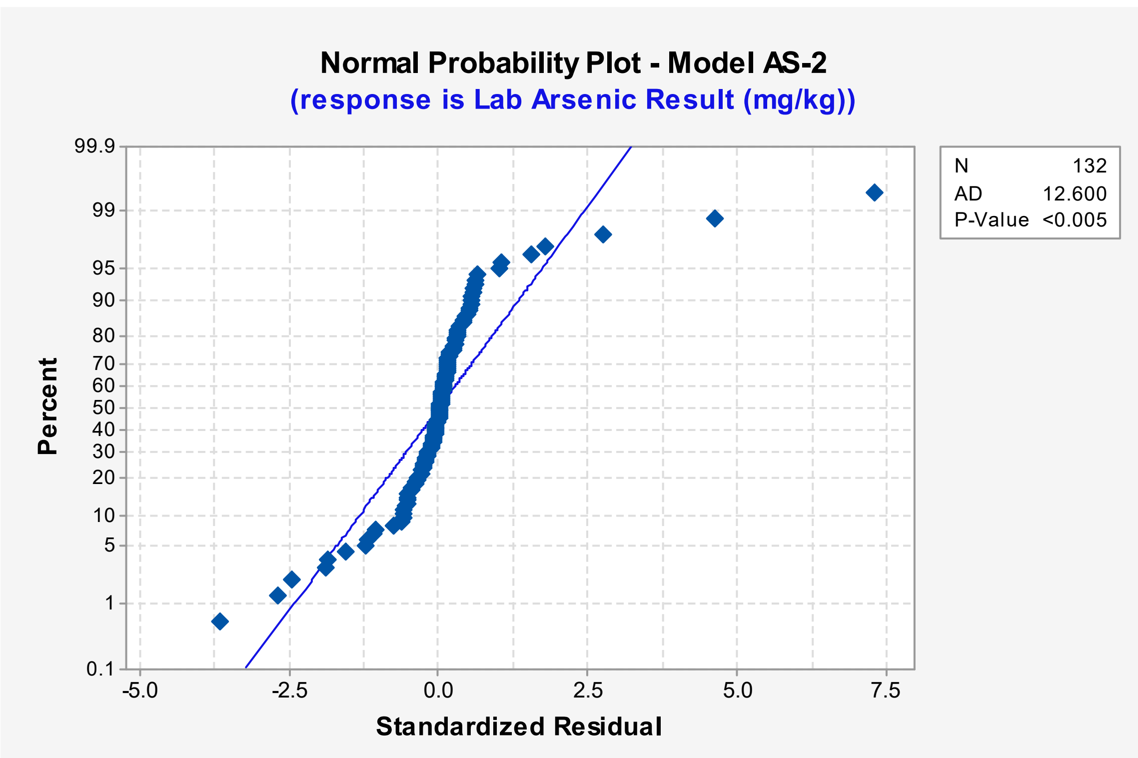


Figure B3-10. Ex Situ Bulk Sample Normal Probability Plot of Arsenic Standardized Residuals for Model AS-2

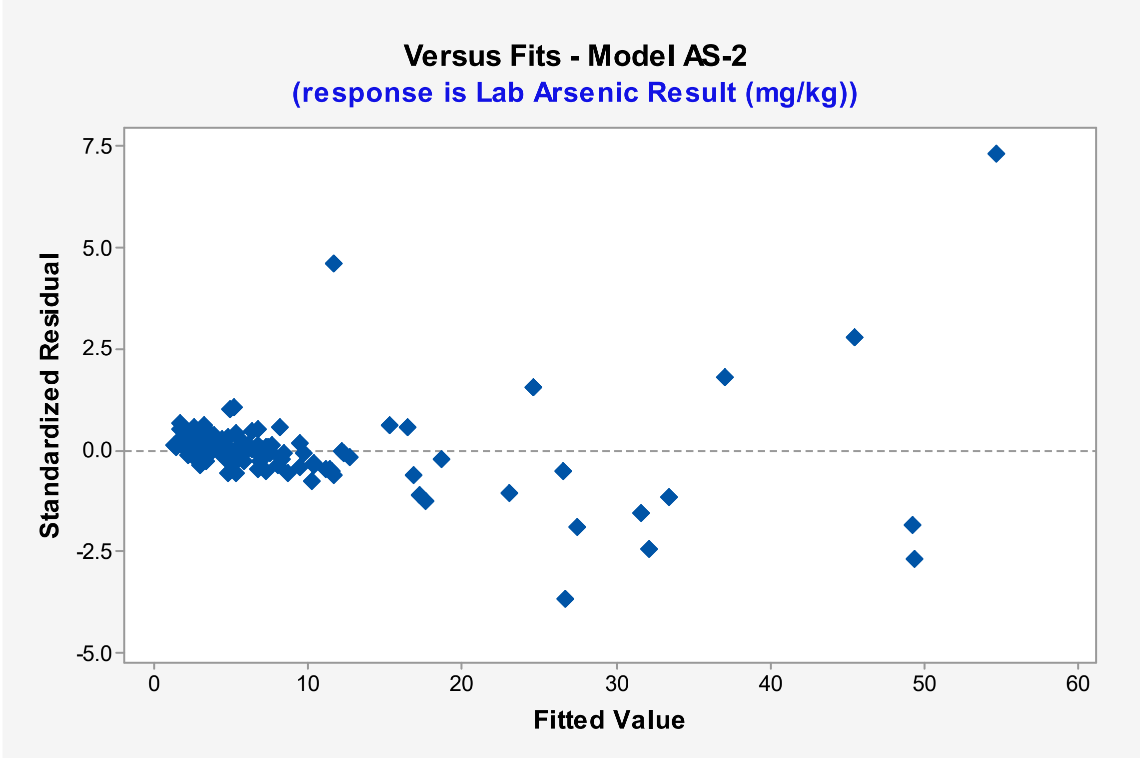


Figure B3-11. Ex Situ Bulk Sample Versus Fits Residuals Arsenic for Model AS-2

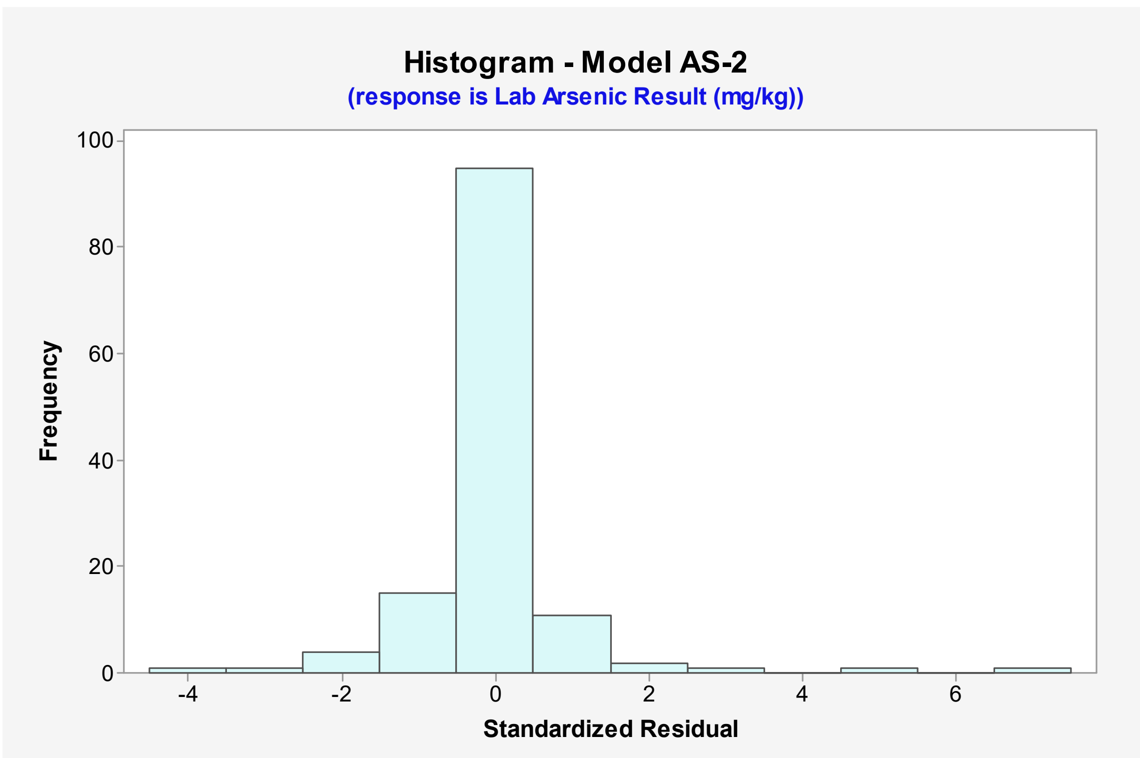


Figure B3-12. Ex Situ Bulk Sample Histogram for Standardized Arsenic Residuals for Model AS-2

2.3 ARSENIC STATISTICAL OUTPUT (MODEL AS-3)

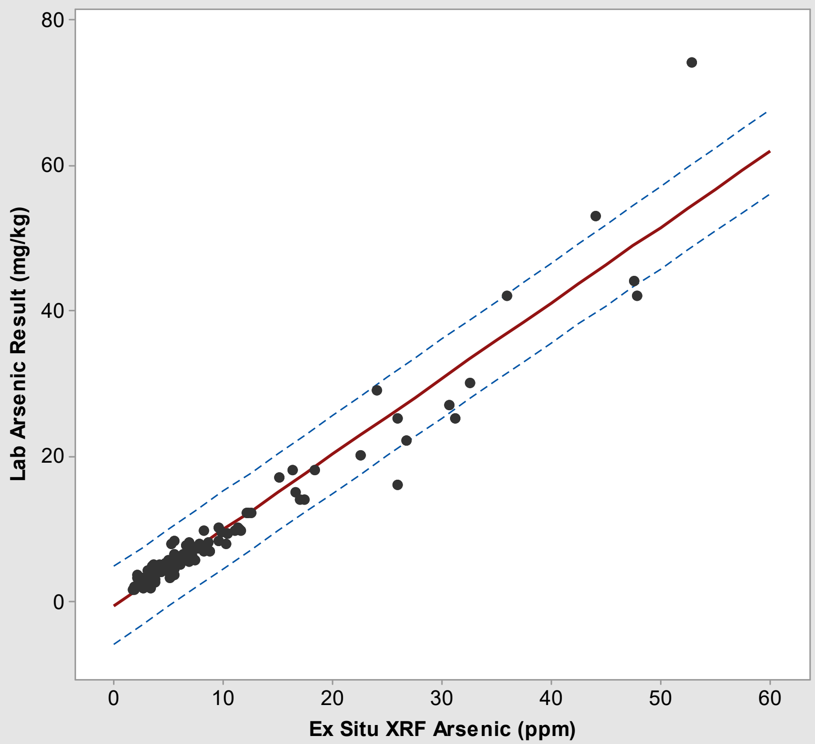
Regression for Lab Arsenic Result (mg/kg) vs Ex Situ XRF Arsenic (ppm)

Prediction Report for Model AS-3

Y: Lab Arsenic Result (mg/kg)
X: Ex Situ XRF Arsenic (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	-0.54937	(-5.8812, 4.7825)
2.5	2.0523	(-3.2716, 7.3763)
5	4.6540	(-0.66470, 9.9727)
7.5	7.2557	(1.9396, 12.572)
10	9.8574	(4.5412, 15.174)
12.5	12.459	(7.1402, 17.778)
15	15.061	(9.7364, 20.385)
17.5	17.662	(12.330, 22.995)
20	20.264	(14.921, 25.607)
22.5	22.866	(17.509, 28.222)
25	25.467	(20.095, 30.840)
27.5	28.069	(22.678, 33.460)
30	30.671	(25.259, 36.083)
32.5	33.273	(27.837, 38.708)
35	35.874	(30.413, 41.336)
37.5	38.476	(32.986, 43.966)
40	41.078	(35.557, 46.599)
42.5	43.679	(38.125, 49.234)
45	46.281	(40.691, 51.871)
47.5	48.883	(43.255, 54.511)
50	51.484	(45.816, 57.153)
52.5	54.086	(48.375, 59.797)
55	56.688	(50.932, 62.443)
57.5	59.289	(53.487, 65.091)
60	61.891	(56.040, 67.742)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-13. Minitab Prediction Report for Model AS-3

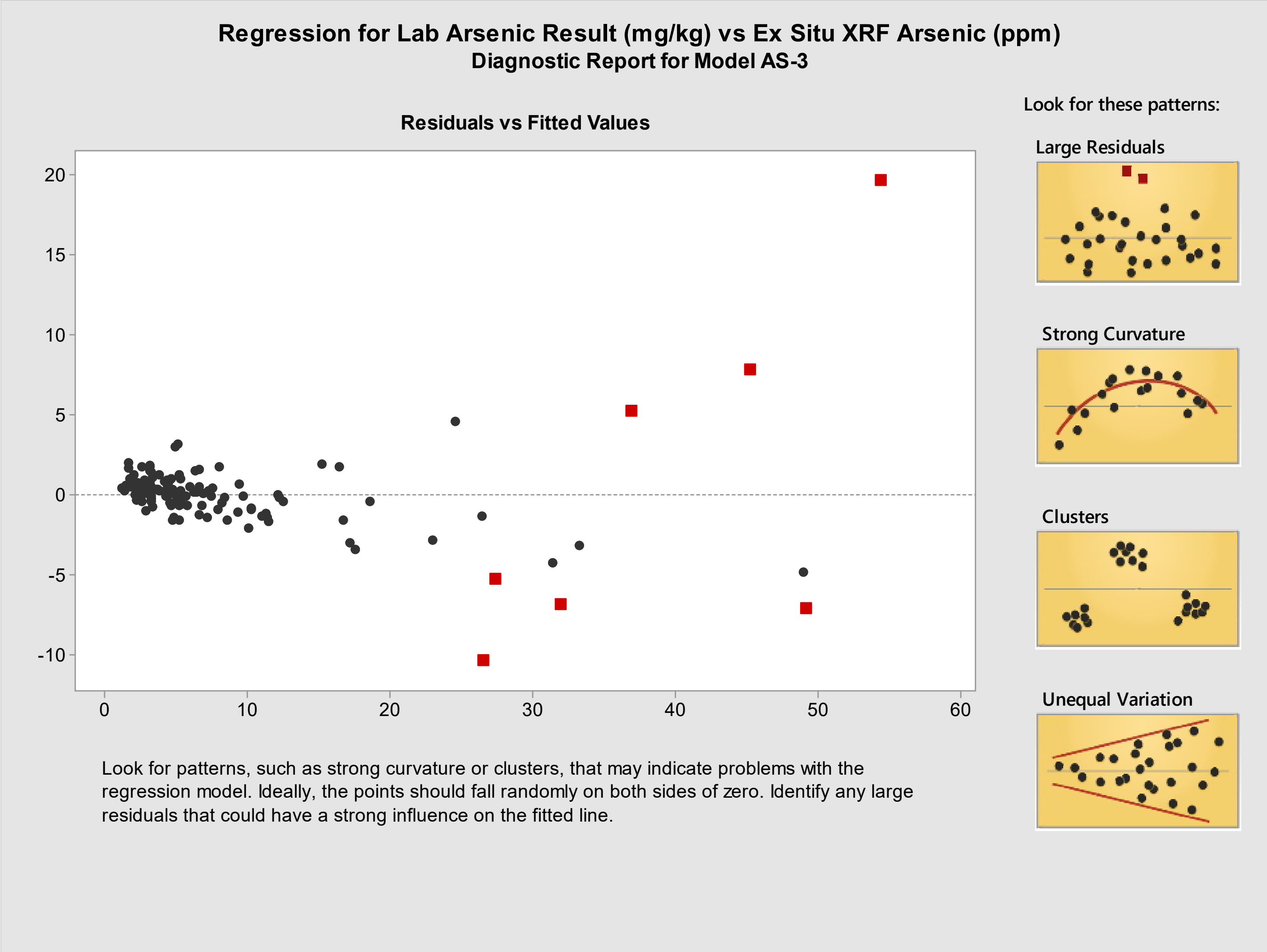


Figure B3-14. Minitab Residuals Report for Model AS-3

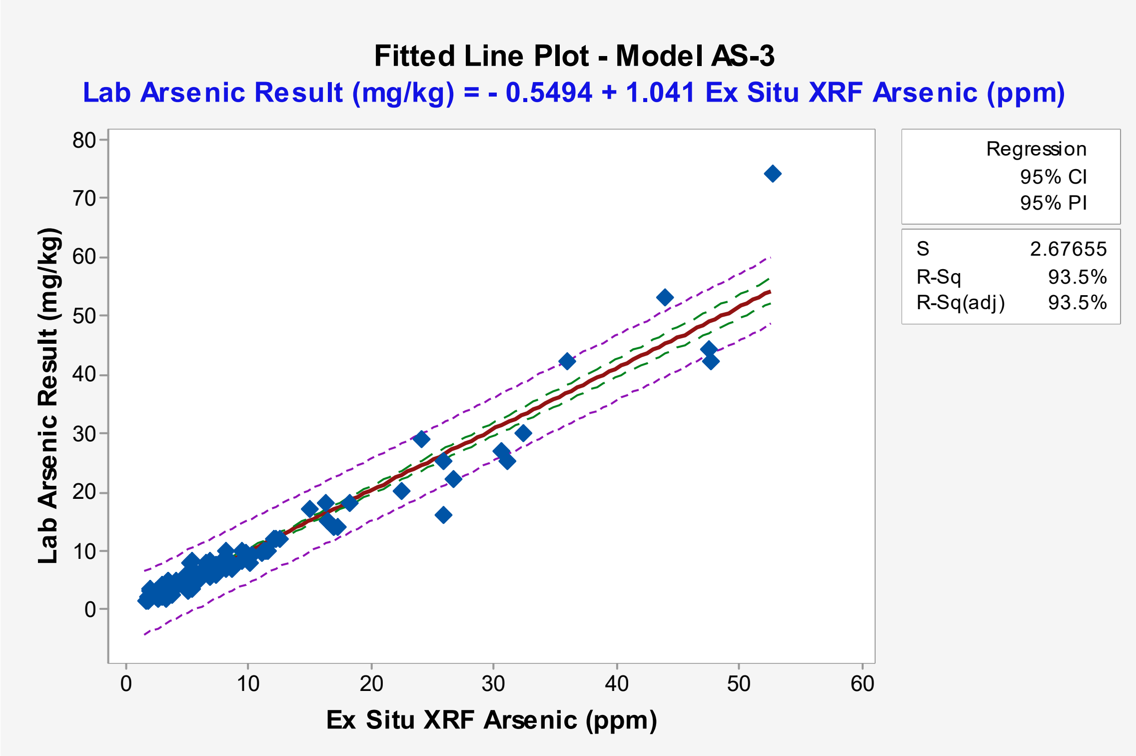


Figure B3-15. Ex Situ Bulk Sample Fitted Line Plot for Arsenic Model AS-3

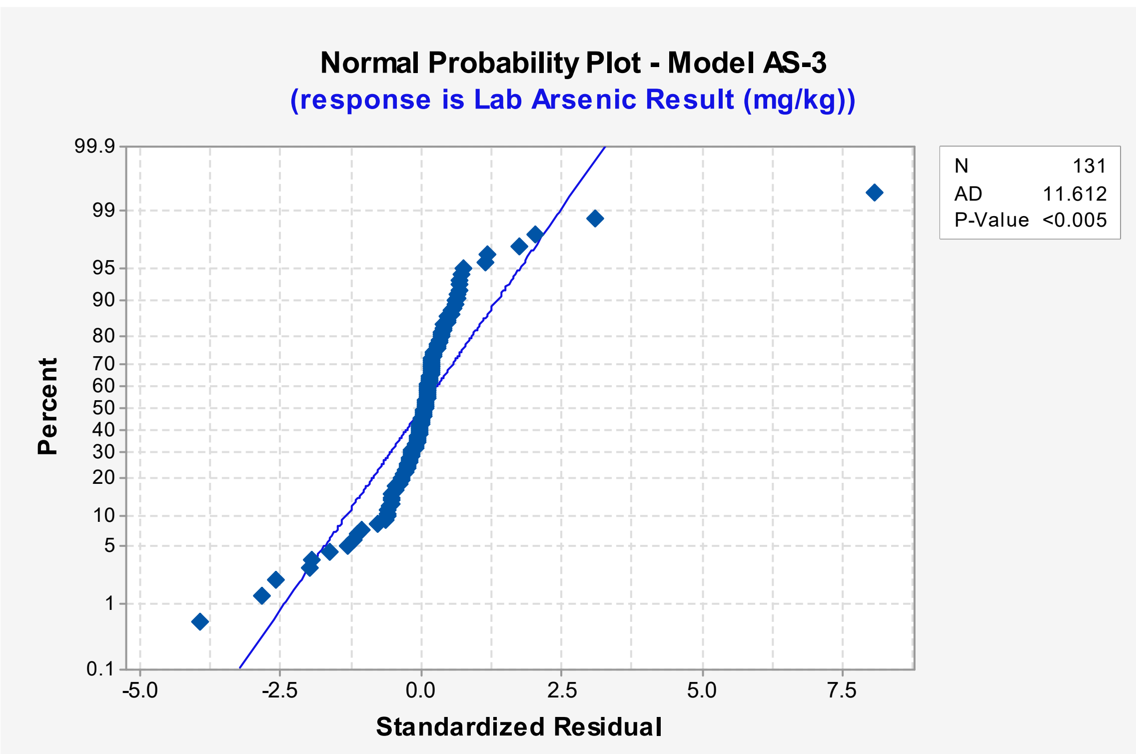


Figure B3-16. Ex Situ Bulk Sample Normal Probability Plot of Arsenic Standardized Residuals for Model AS-3

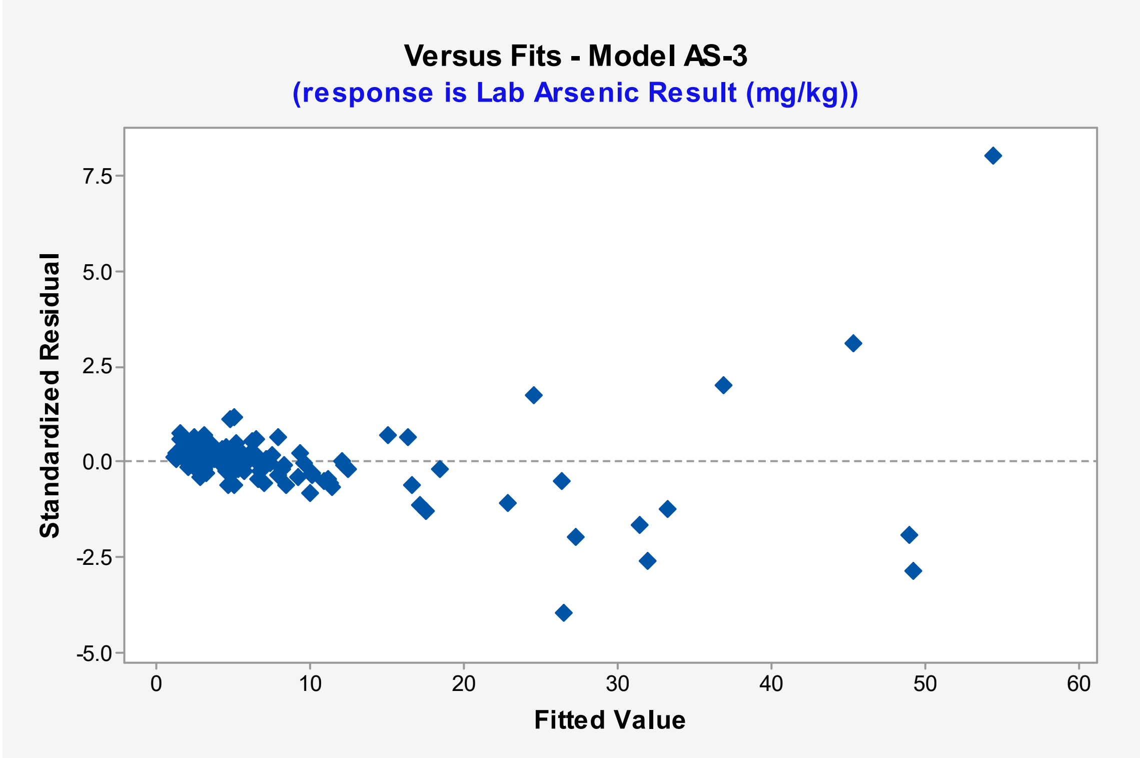


Figure B3-17. Ex Situ Bulk Sample Versus Fits Residuals Arsenic for Model AS-3

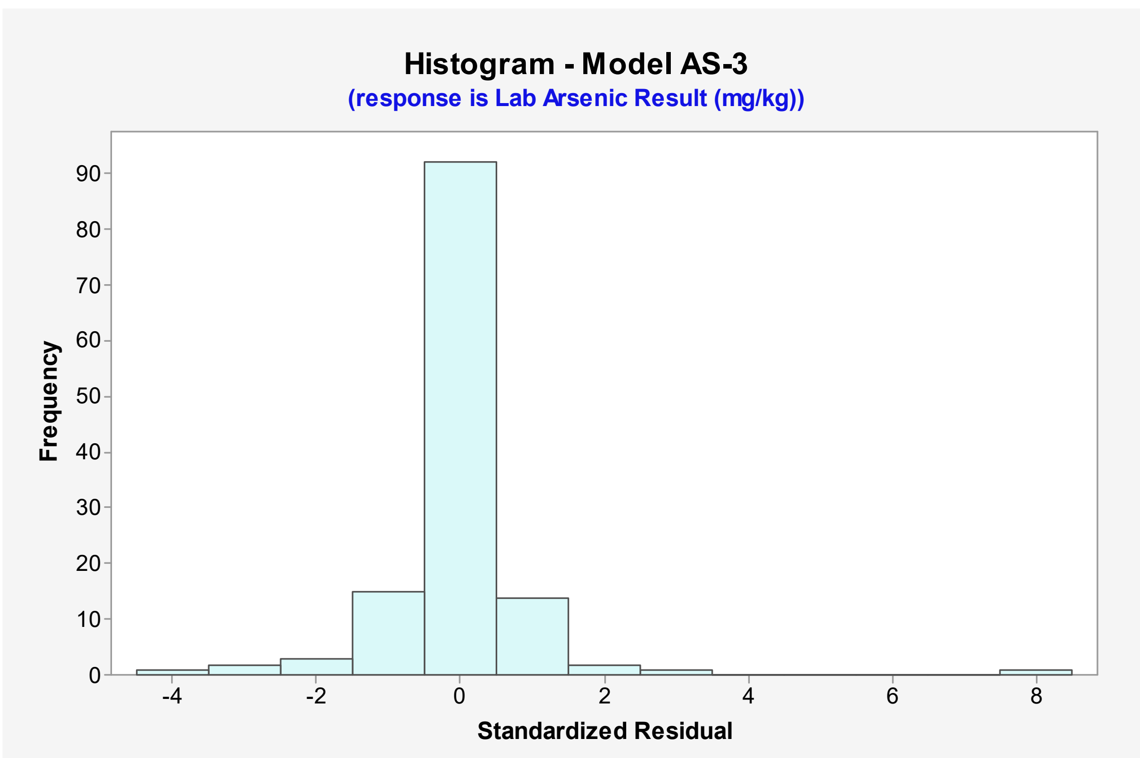


Figure B3-18. Ex Situ Bulk Sample Histogram of Standardized Arsenic Residuals for Model AS-3

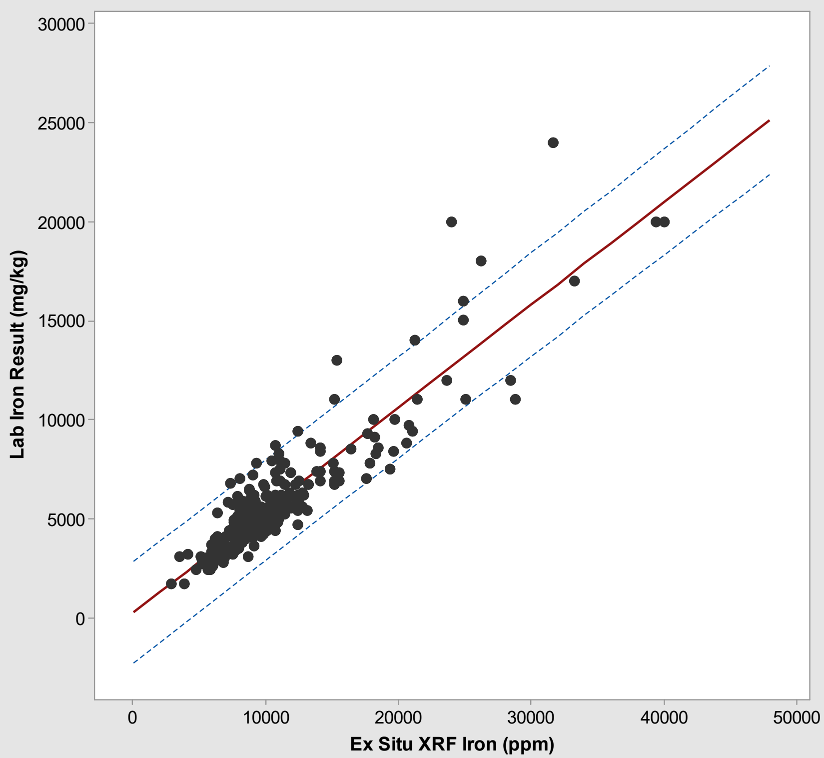
3.0 IRON EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

3.1 IRON STATISTICAL OUTPUT (MODEL FE-1)

Regression for Lab Iron Result (mg/kg) vs Ex Situ XRF Iron (ppm)
Prediction Report - Model FE-1

Y: Lab Iron Result (mg/kg)
X: Ex Situ XRF Iron (ppm)

Prediction Plot
The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	283.36	(-2277.1, 2843.8)
2000	1319.2	(-1234.4, 3872.9)
4000	2355.1	(-193.12, 4903.4)
6000	3391.0	(846.83, 5935.2)
8000	4426.9	(1885.4, 6968.4)
10000	5462.8	(2922.6, 8002.9)
12000	6498.6	(3958.4, 9038.9)
14000	7534.5	(4992.8, 10076)
16000	8570.4	(6025.9, 11115)
18000	9606.3	(7057.6, 12155)
20000	10642	(8087.9, 13196)
22000	11678	(9116.8, 14239)
24000	12714	(10144, 15283)
26000	13750	(11171, 16329)
28000	14786	(12196, 17376)
30000	15822	(13219, 18424)
32000	16857	(14242, 19473)
34000	17893	(15263, 20524)
36000	18929	(16283, 21576)
38000	19965	(17301, 22629)
40000	21001	(18319, 23683)
42000	22037	(19335, 24739)
44000	23073	(20350, 25795)
46000	24109	(21364, 26853)
48000	25145	(22377, 27912)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-19. Minitab Prediction Report for Model FE-1

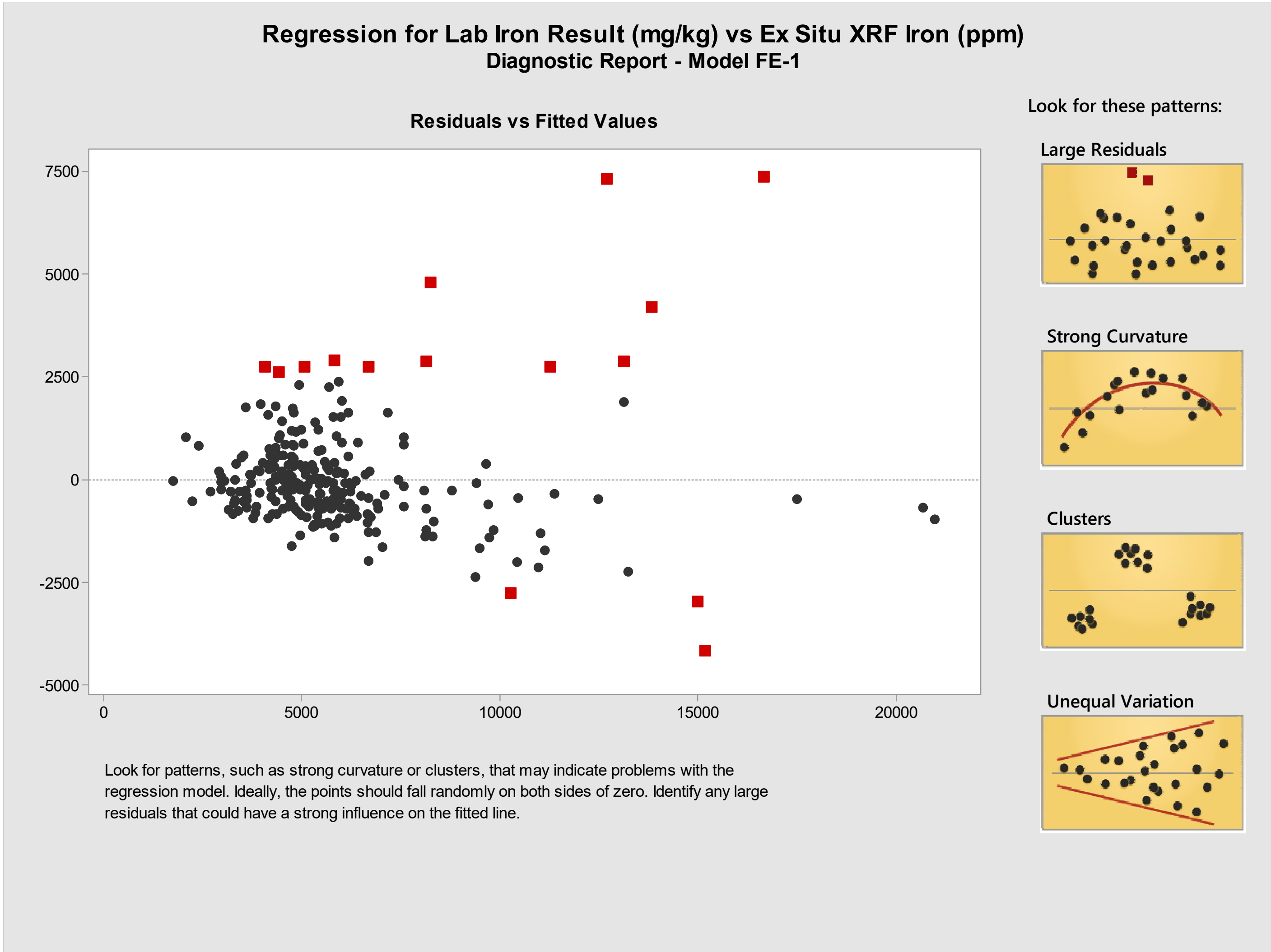


Figure B3-20. Minitab Residuals Report for Model FE-1

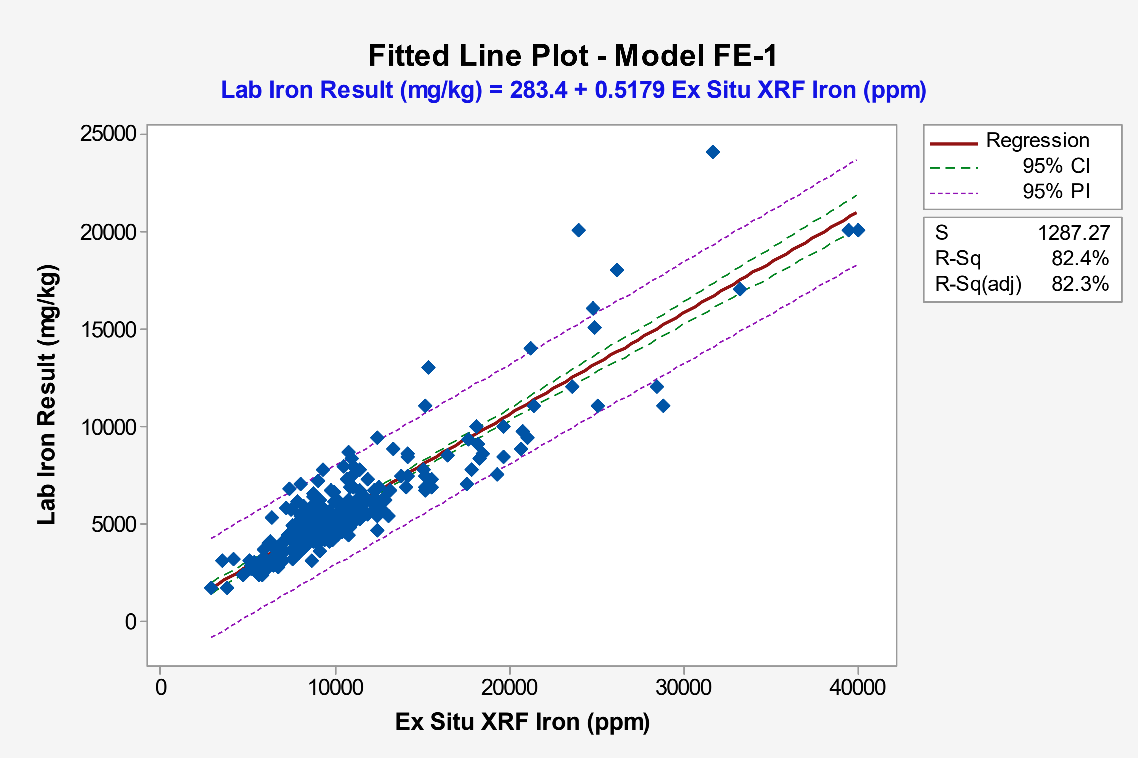


Figure B3-21. Ex Situ Bulk Sample Fitted Line Plot for Iron Model FE-1

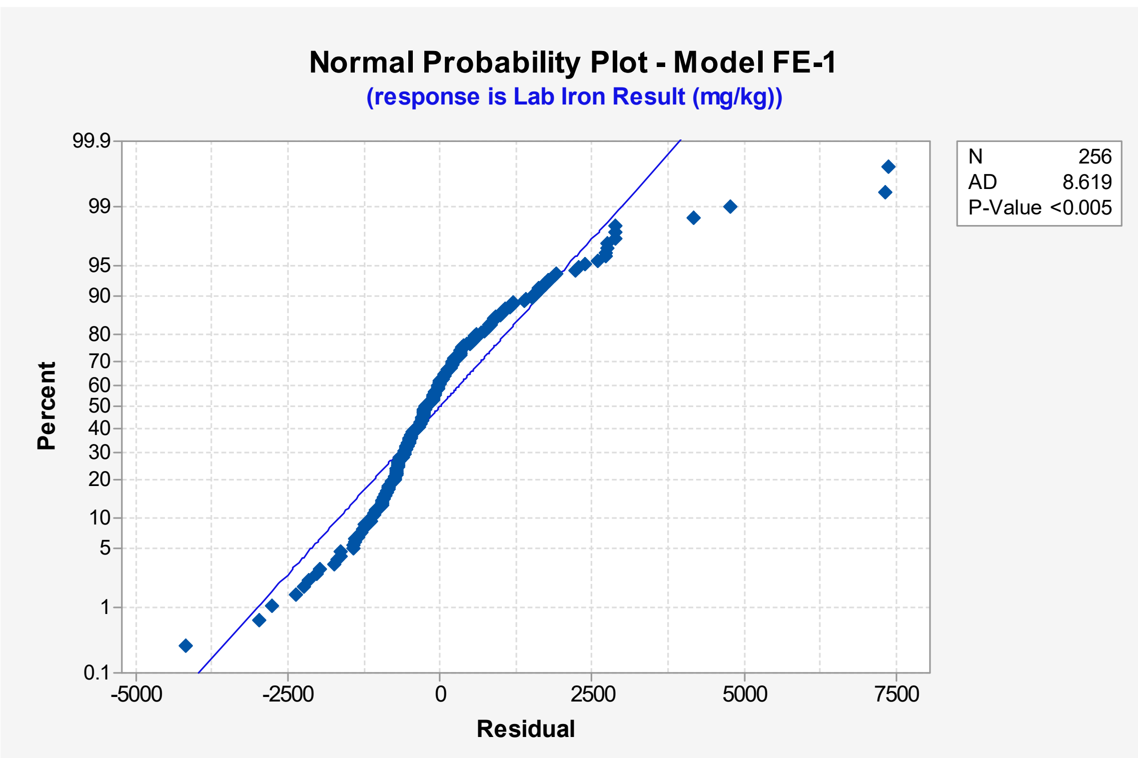


Figure B3-22. Ex Situ Bulk Sample Normal Probability Plot of Iron Standardized Residuals for Model FE-1

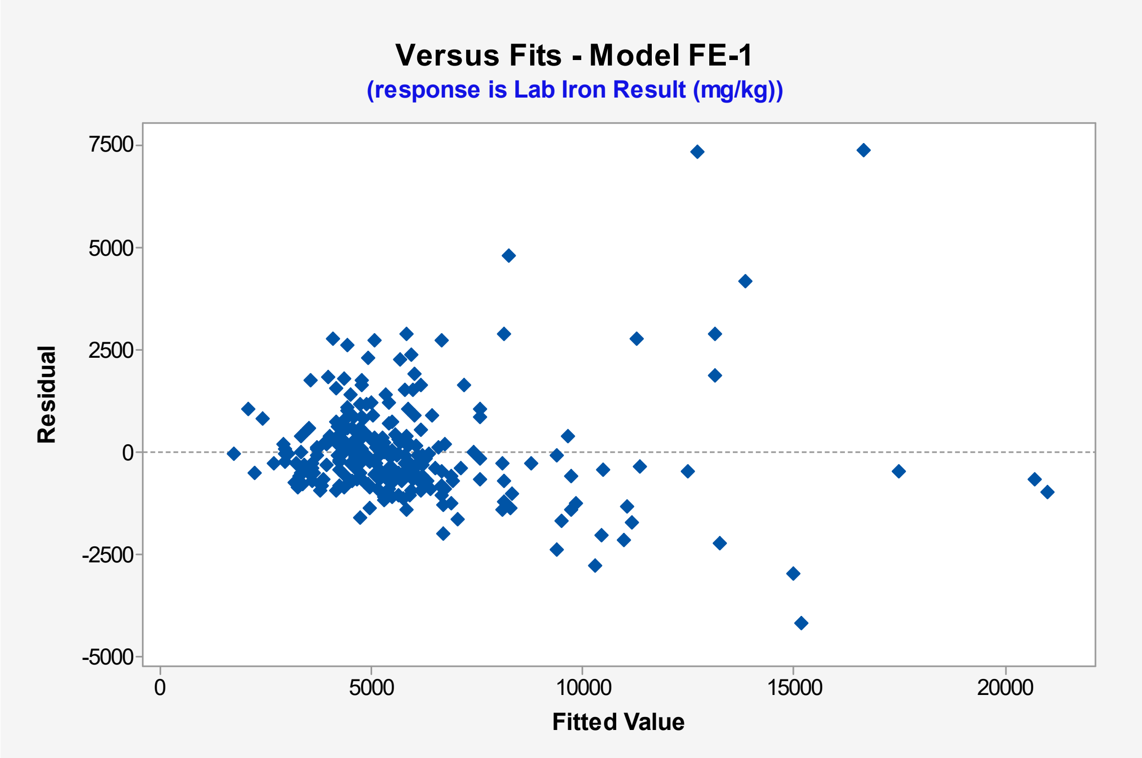


Figure B3-23. Ex Situ Bulk Sample Versus Fits Residuals Iron for Model FE-1

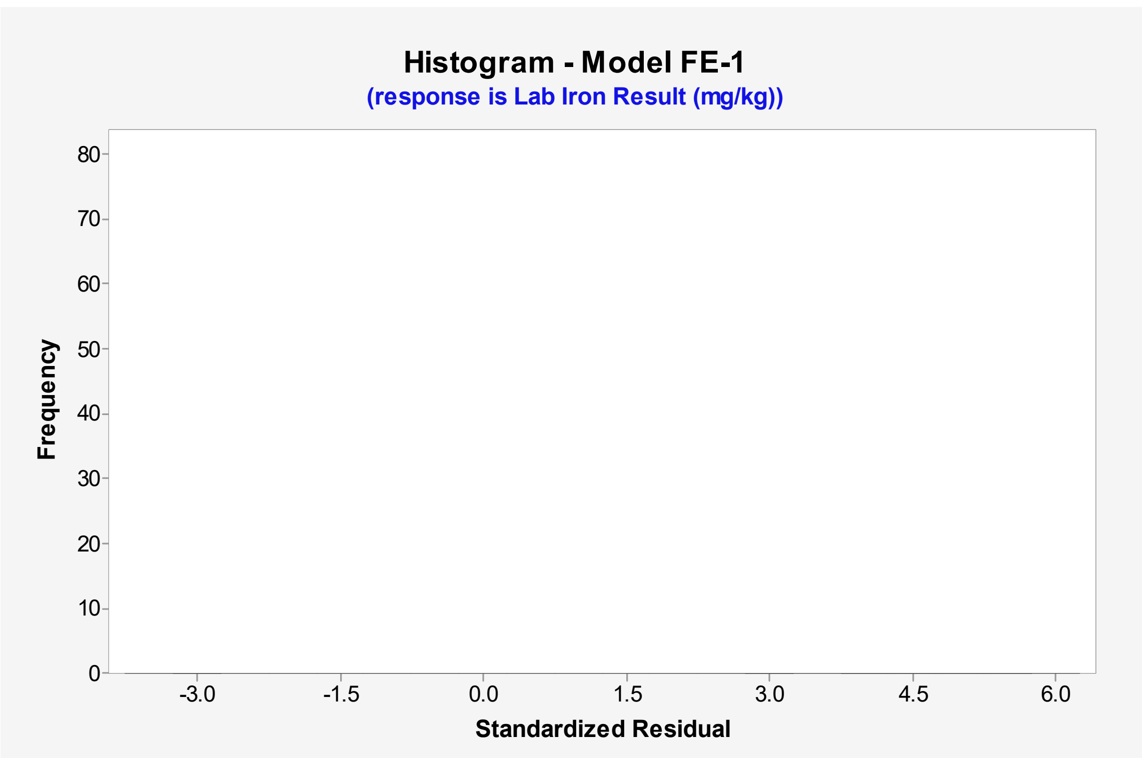


Figure B3-24. Ex Situ Bulk Sample Histogram of Standardized Iron Residuals for Model FE-1

4.0 MANGANESE EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

4.1 MANGANESE STATISTICAL OUTPUT (MODEL MN-1)

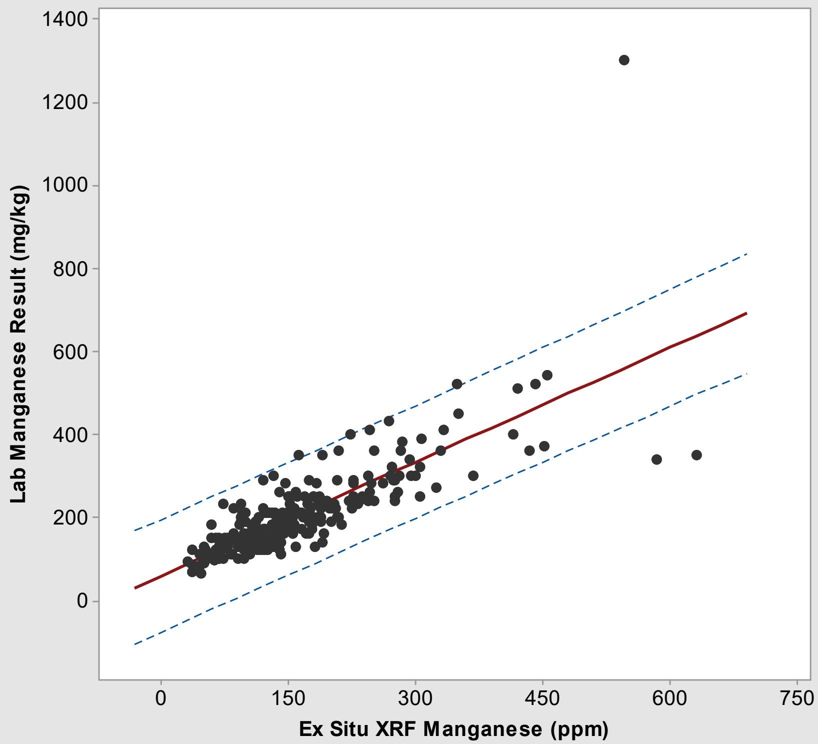
Regression for Lab Manganese Result (mg/kg) vs Ex Situ Manganese (ppm)

Prediction Report - Model MN-1

Y: Lab Manganese Result (mg/kg)
X: Ex Situ Manganese (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-30	31.752	(-104.34, 167.85)
0	59.243	(-76.554, 195.04)
30	86.734	(-48.817, 222.29)
60	114.23	(-21.132, 249.58)
90	141.72	(6.5020, 276.93)
120	169.21	(34.084, 304.33)
150	196.70	(61.613, 331.79)
180	224.19	(89.091, 359.29)
210	251.68	(116.52, 386.85)
240	279.17	(143.89, 414.46)
270	306.66	(171.21, 442.12)
300	334.16	(198.48, 469.83)
330	361.65	(225.70, 497.59)
360	389.14	(252.87, 525.41)
390	416.63	(279.99, 553.27)
420	444.12	(307.05, 581.19)
450	471.61	(334.07, 609.15)
480	499.10	(361.04, 637.17)
510	526.59	(387.96, 665.23)
540	554.09	(414.83, 693.34)
570	581.58	(441.65, 721.50)
600	609.07	(468.43, 749.70)
630	636.56	(495.16, 777.96)
660	664.05	(521.85, 806.25)
690	691.54	(548.49, 834.59)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-25. Minitab Prediction Report for Model MN-1

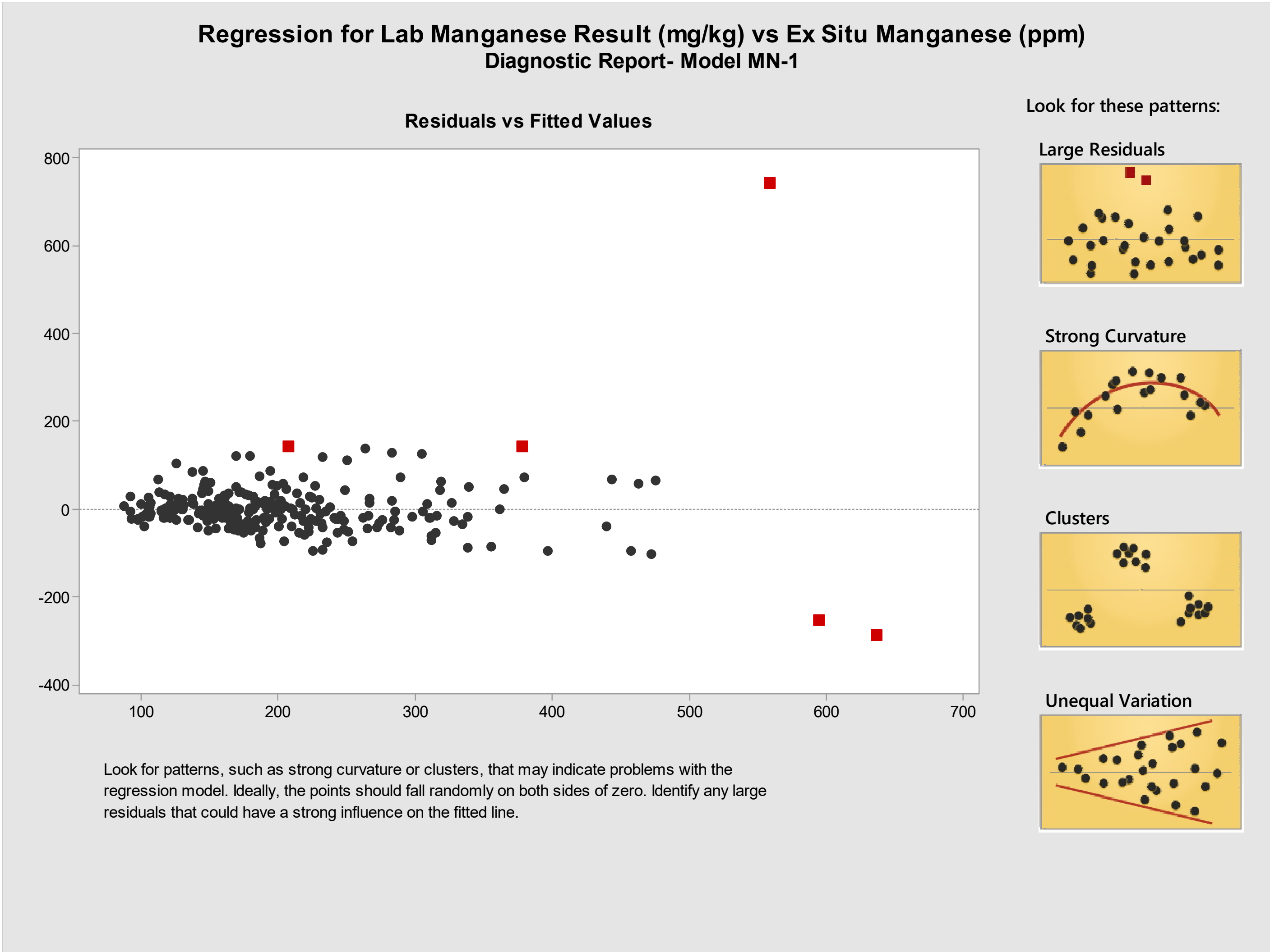


Figure B3-26. Minitab Residuals Report for Model MN-1

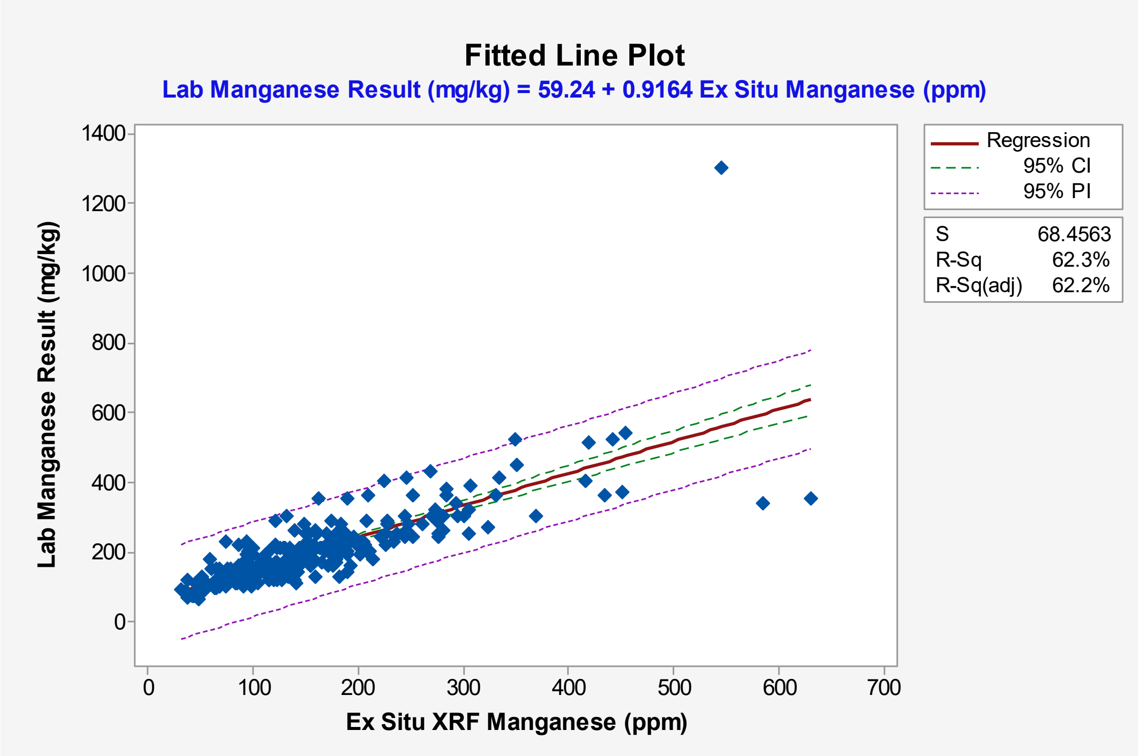


Figure B3-27. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MN-1

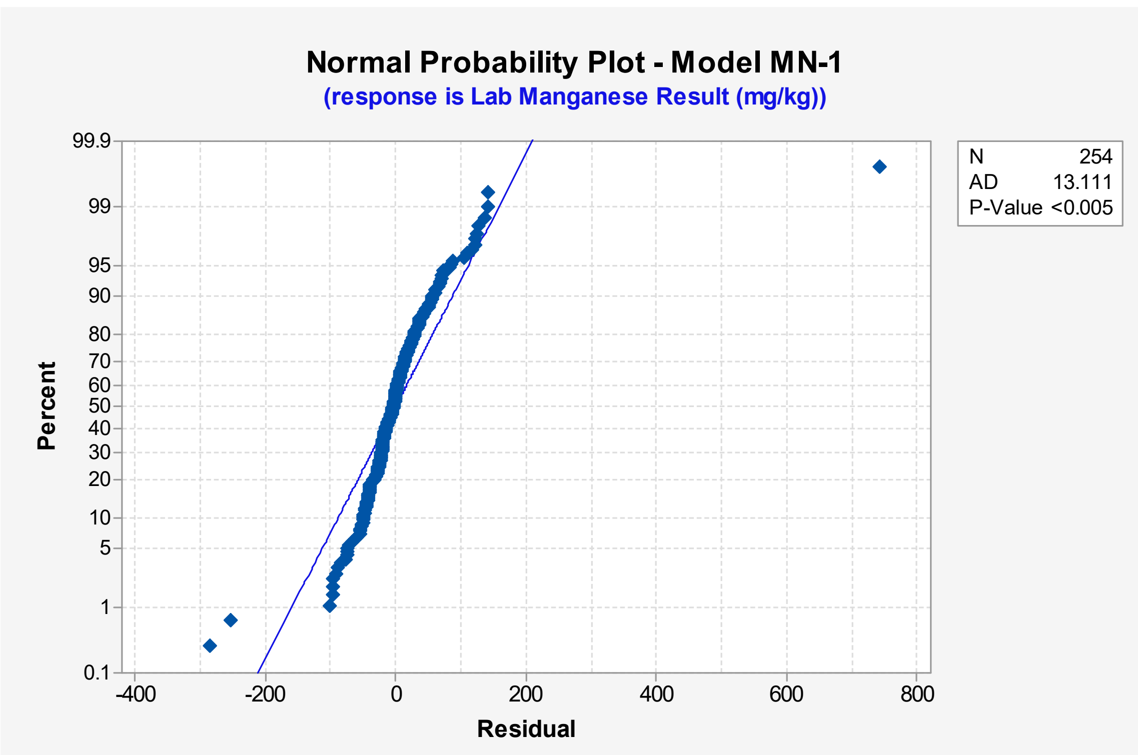


Figure B3-28. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MN-1

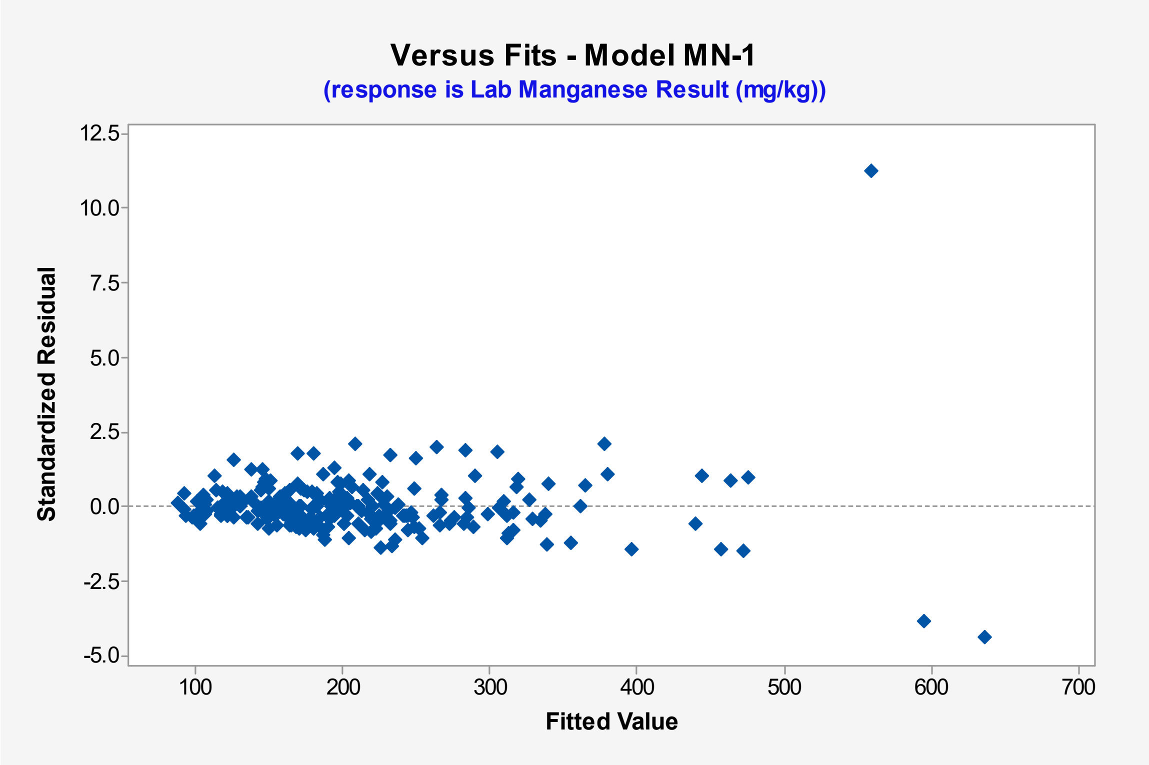


Figure B3-29. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MN-1

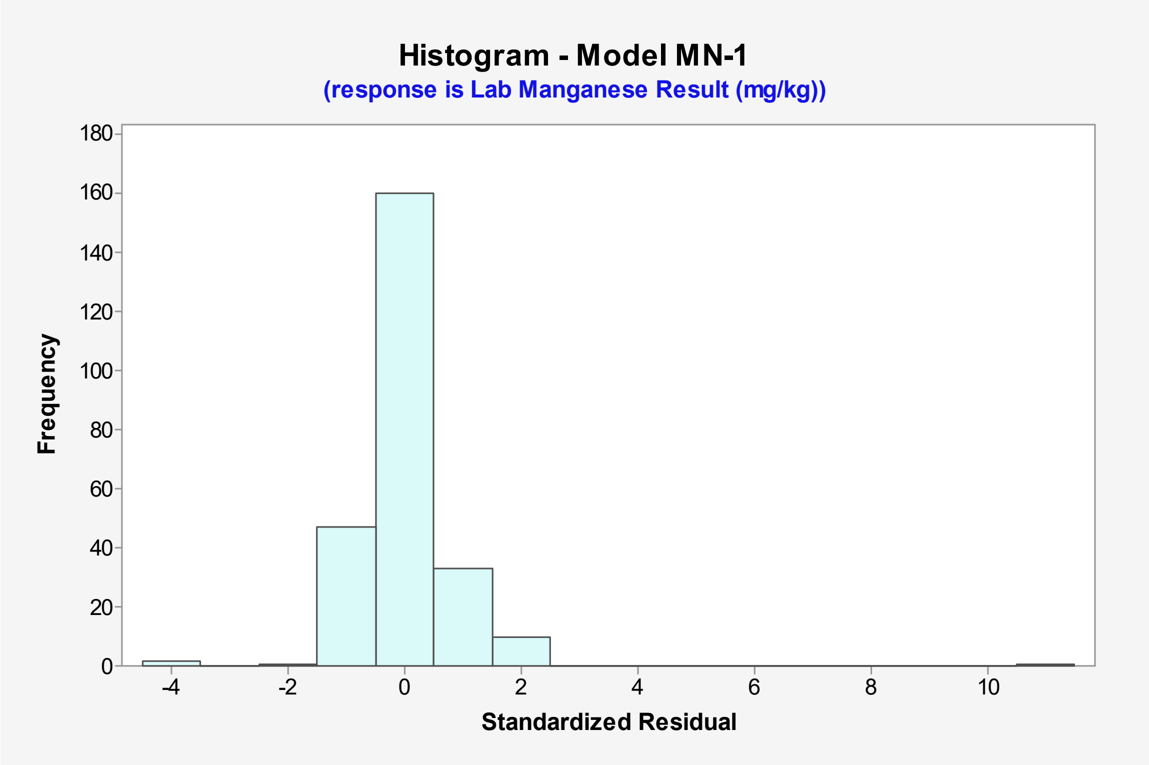


Figure B3-30. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MN-1

4.2 MANGANESE STATISTICAL OUTPUT (MODEL MN-2)

Regression for Lab Manganese Result (mg/kg) vs Ex Situ Manganese (ppm)

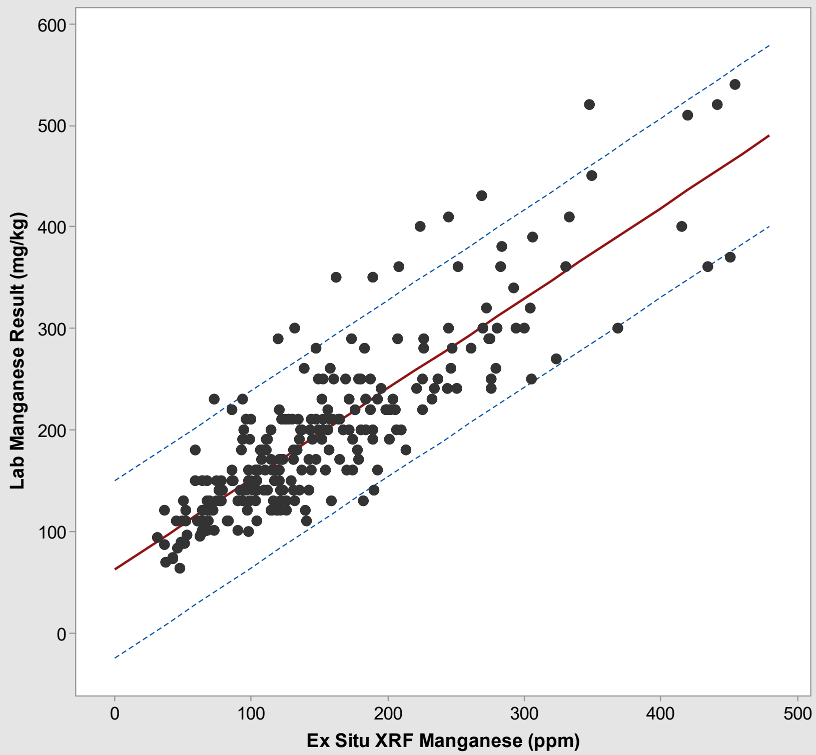
Prediction Report - Model MN-2

Y: Lab Manganese Result (mg/kg)

X: Ex Situ Manganese (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	62.274	(-25.242, 149.79)
20	80.098	(-7.2789, 167.48)
40	97.922	(10.664, 185.18)
60	115.75	(28.588, 202.90)
80	133.57	(46.493, 220.65)
100	151.39	(64.378, 238.41)
120	169.22	(82.243, 256.19)
140	187.04	(100.09, 274.00)
160	204.87	(117.91, 291.82)
180	222.69	(135.72, 309.66)
200	240.51	(153.51, 327.52)
220	258.34	(171.28, 345.40)
240	276.16	(189.02, 363.30)
260	293.99	(206.75, 381.22)
280	311.81	(224.46, 399.16)
300	329.63	(242.15, 417.12)
320	347.46	(259.82, 435.10)
340	365.28	(277.47, 453.10)
360	383.11	(295.10, 471.11)
380	400.93	(312.72, 489.15)
400	418.76	(330.31, 507.20)
420	436.58	(347.89, 525.27)
440	454.40	(365.44, 543.36)
460	472.23	(382.98, 561.47)
480	490.05	(400.50, 579.60)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-31. Minitab Prediction Report for Model MN-2

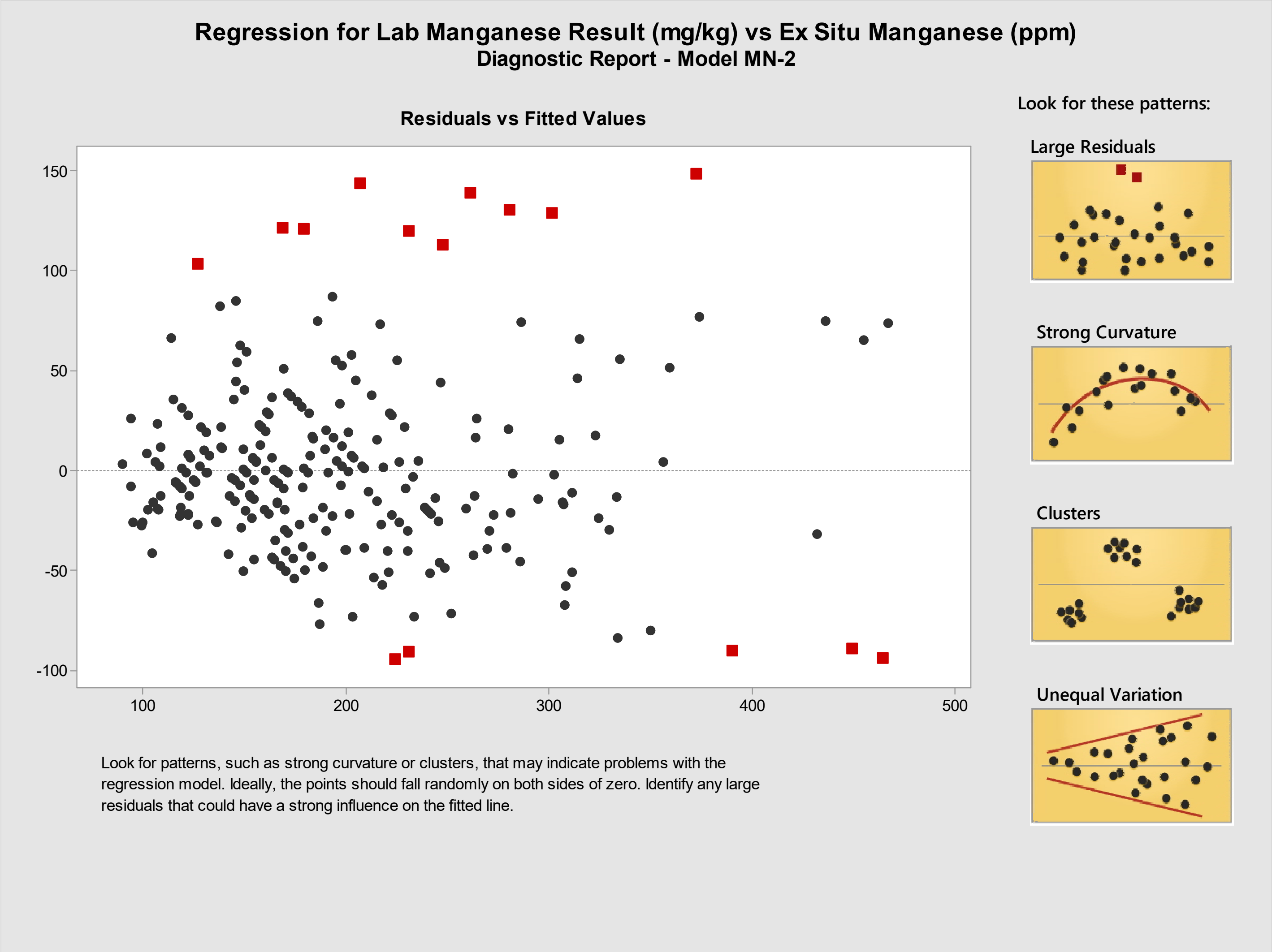


Figure B3-32. Minitab Residuals Report for Model MN-2

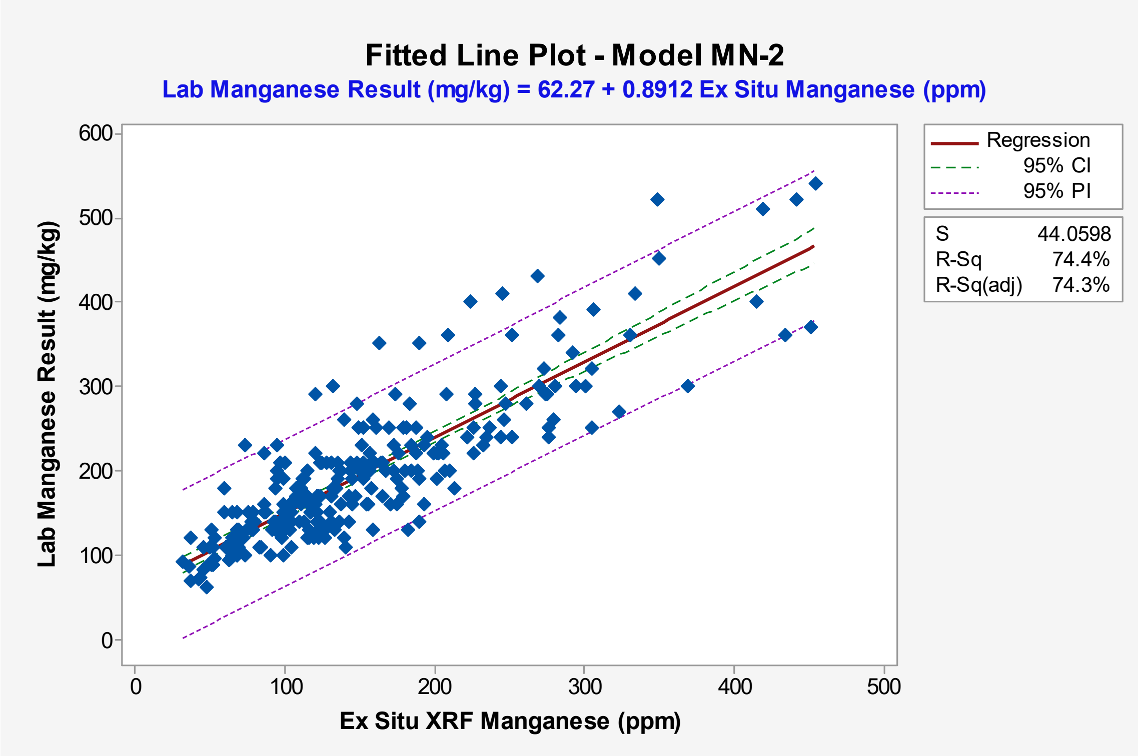


Figure B3-33. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MN-2

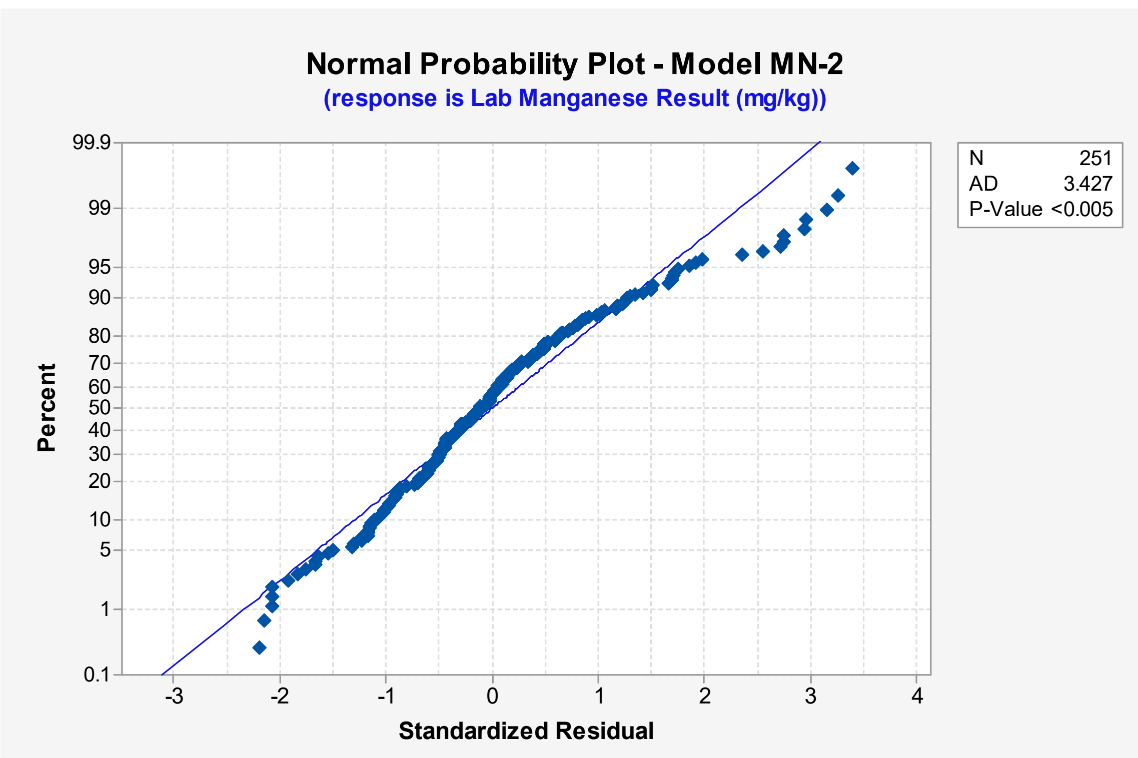


Figure B3-34. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MN-2

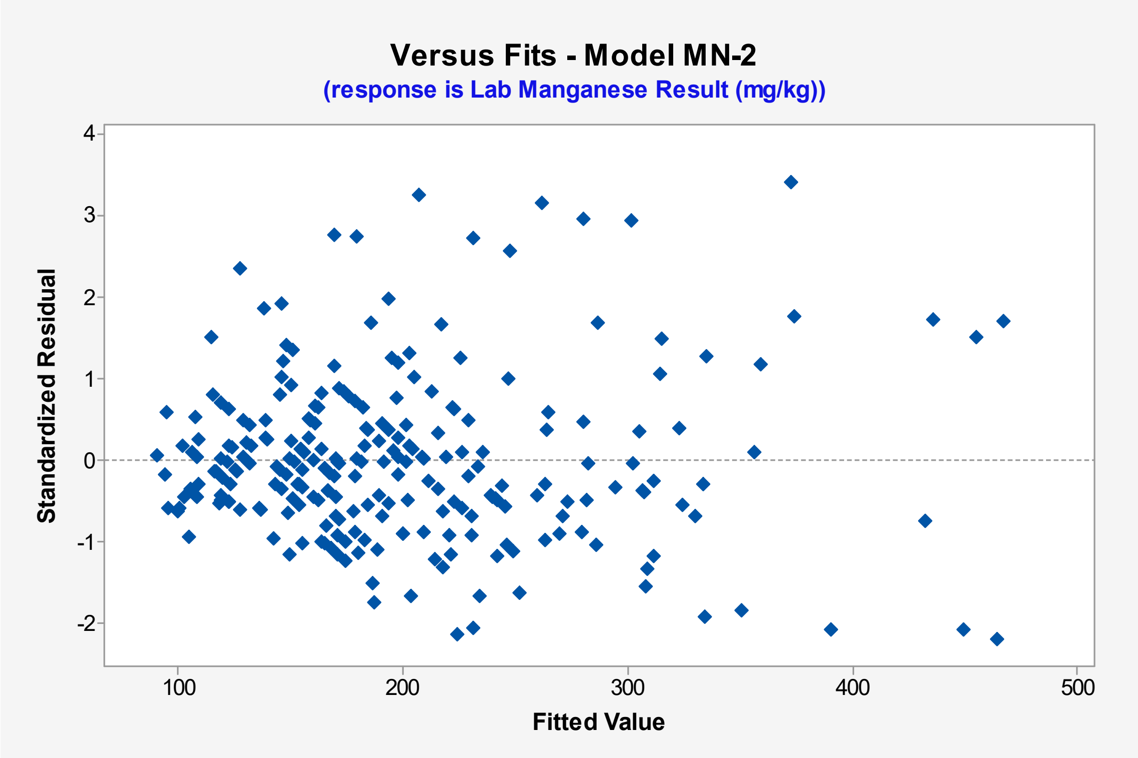


Figure B3-35. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MN-2

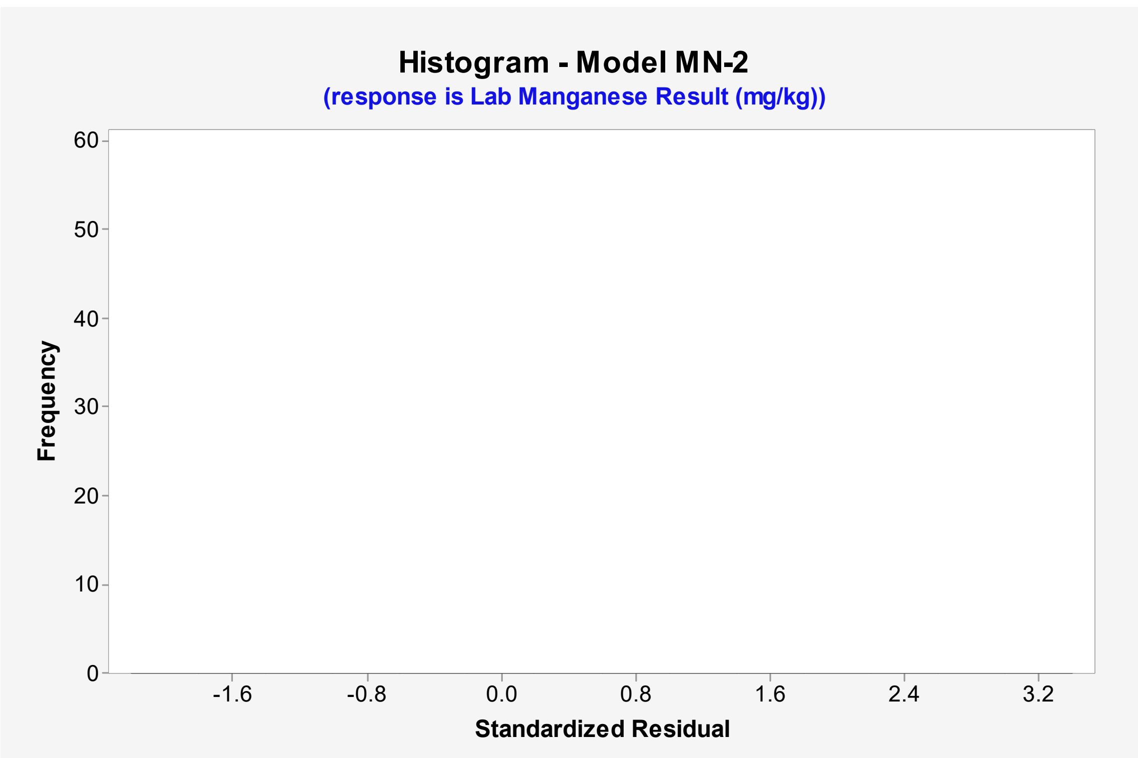


Figure B3-36. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MN-2

5.0 MOLYBDENUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

5.1 MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-1)

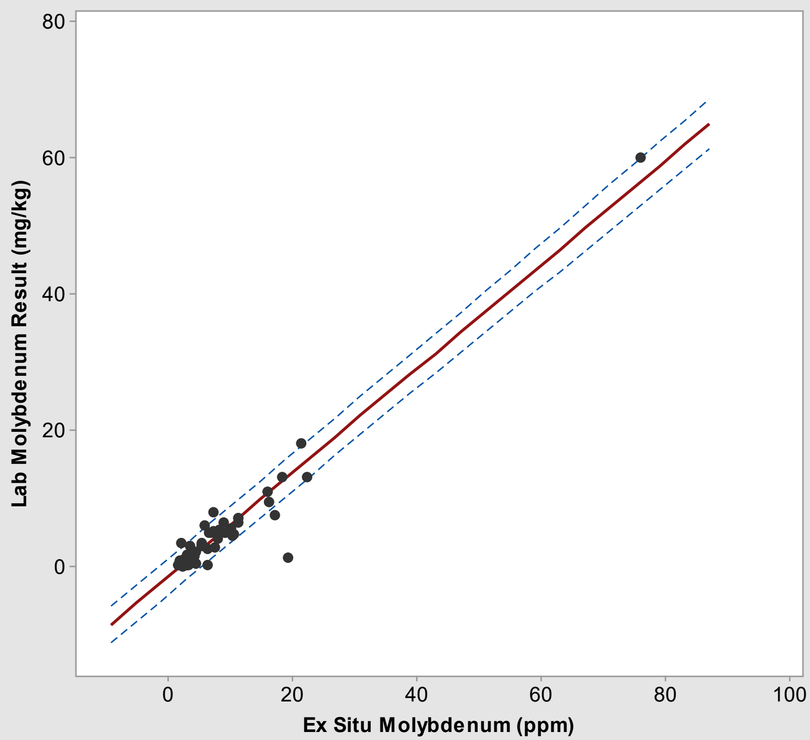
Regression for Lab Molybdenum Result (mg/kg) vs Ex Situ Molybdenum (ppm)

Prediction Report - Model MO-1

Y: Lab Molybdenum Result (mg/kg)
X: Ex Situ Molybdenum (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.

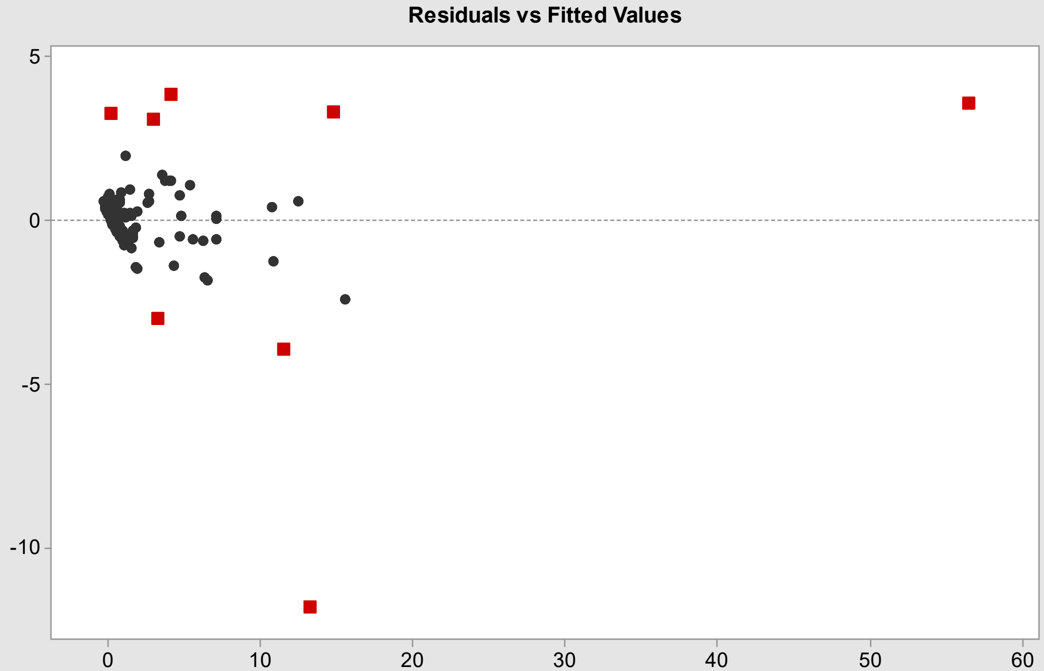


X	Predicted Y	95% PI
-9	-8.4643	(-11.168, -5.7609)
-5	-5.4073	(-8.0941, -2.7205)
-1	-2.3504	(-5.0263, 0.32550)
3	0.70651	(-1.9642, 3.3772)
7	3.7634	(1.0922, 6.4347)
11	6.8204	(4.1428, 9.4979)
15	9.8773	(7.1878, 12.567)
19	12.934	(10.227, 15.641)
23	15.991	(13.261, 18.721)
27	19.048	(16.290, 21.806)
31	22.105	(19.313, 24.897)
35	25.162	(22.331, 27.993)
39	28.219	(25.345, 31.093)
43	31.276	(28.354, 34.198)
47	34.333	(31.358, 37.307)
51	37.390	(34.359, 40.421)
55	40.446	(37.355, 43.538)
59	43.503	(40.348, 46.659)
63	46.560	(43.337, 49.784)
67	49.617	(46.323, 52.911)
71	52.674	(49.306, 56.042)
75	55.731	(52.286, 59.176)
79	58.788	(55.264, 62.312)
83	61.845	(58.239, 65.451)
87	64.902	(61.211, 68.592)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-37. Minitab Prediction Report for Model MO-1

Regression for Lab Molybdenum Result (mg/kg) vs Ex Situ Molybdenum (ppm)
Diagnostic Report



Look for patterns, such as strong curvature or clusters, that may indicate problems with the regression model. Ideally, the points should fall randomly on both sides of zero. Identify any large residuals that could have a strong influence on the fitted line.

Look for these patterns:

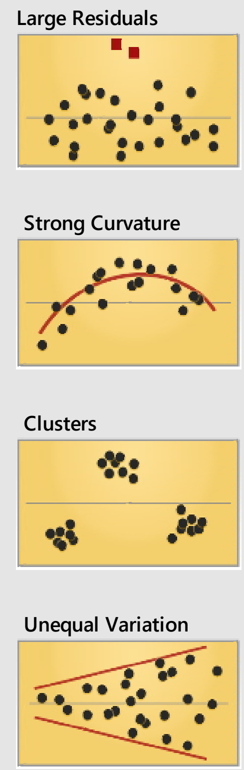


Figure B3-38. Minitab Residuals Report for Model MO-1

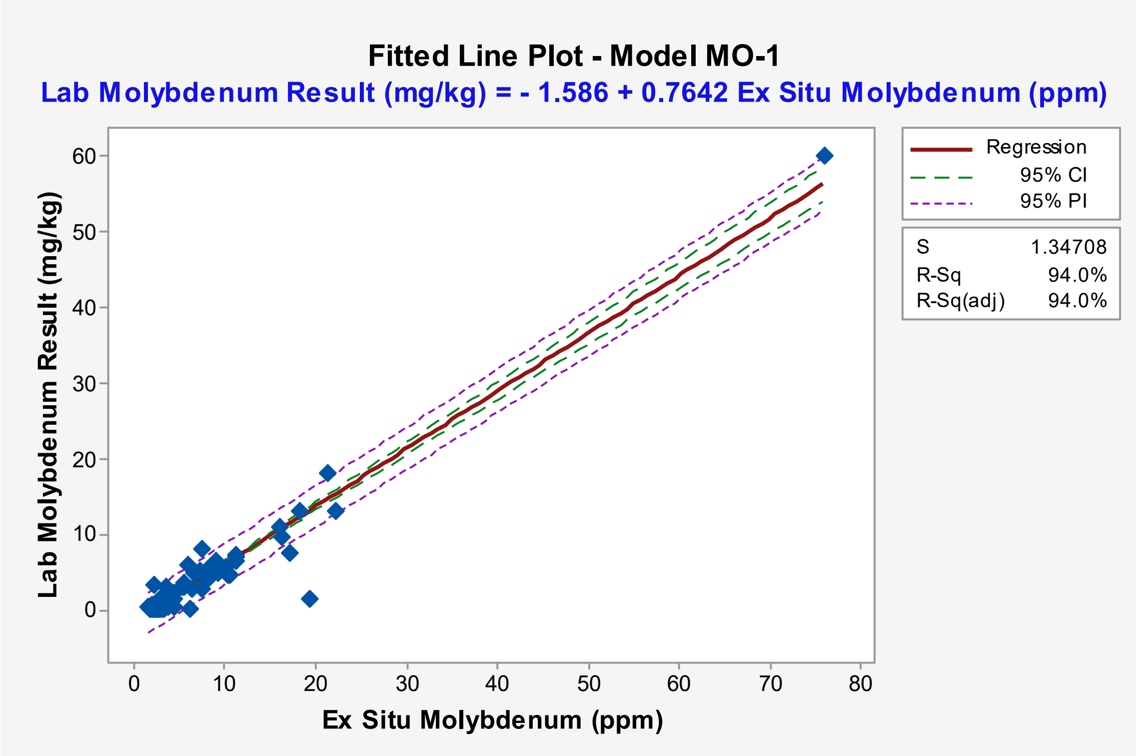


Figure B3-39. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-1

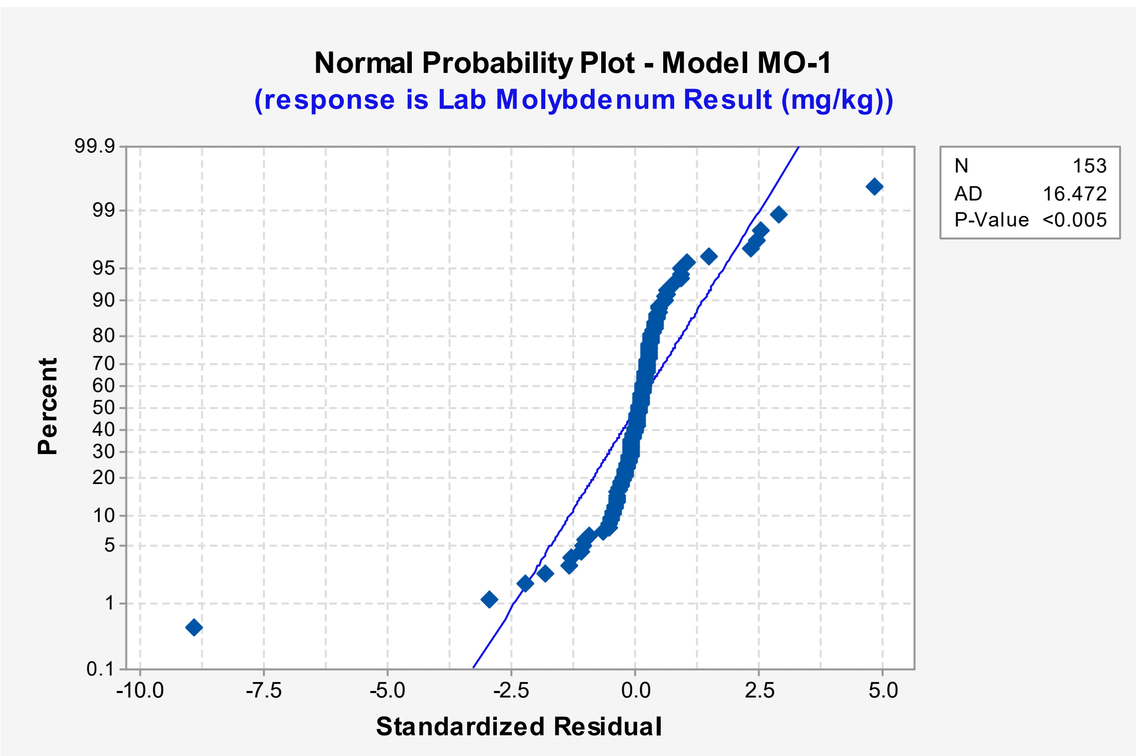


Figure B3-40. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-1

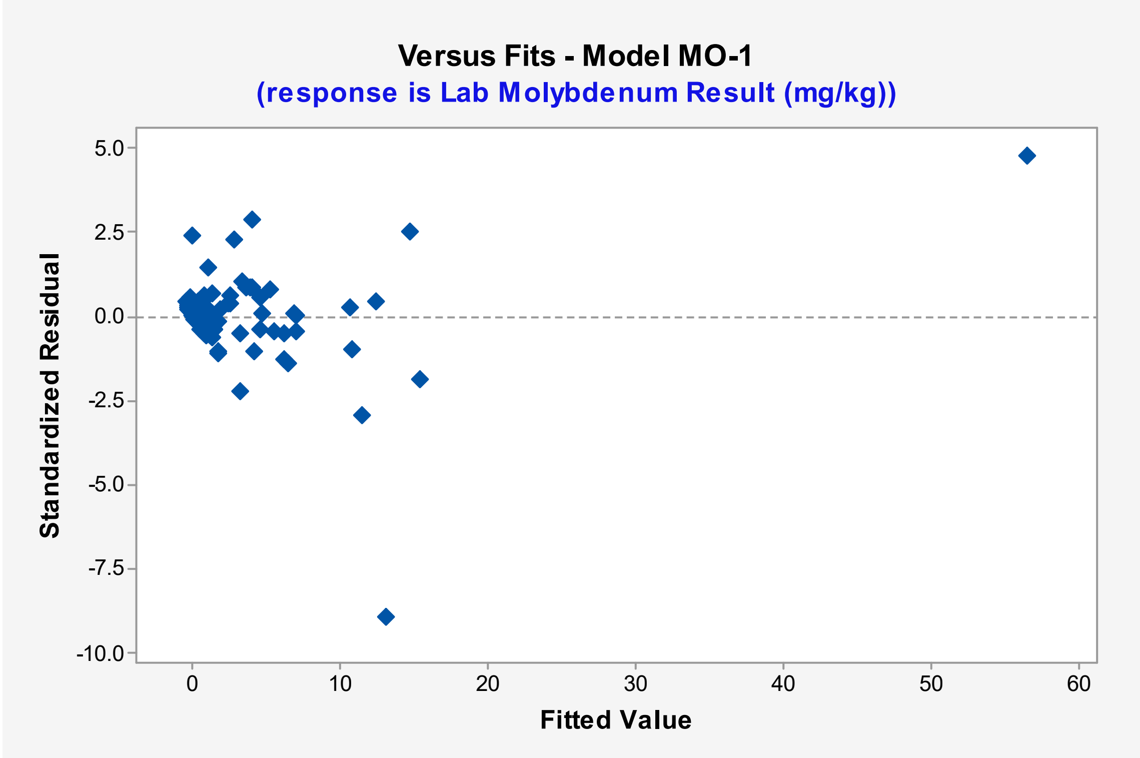


Figure B3-41. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-1

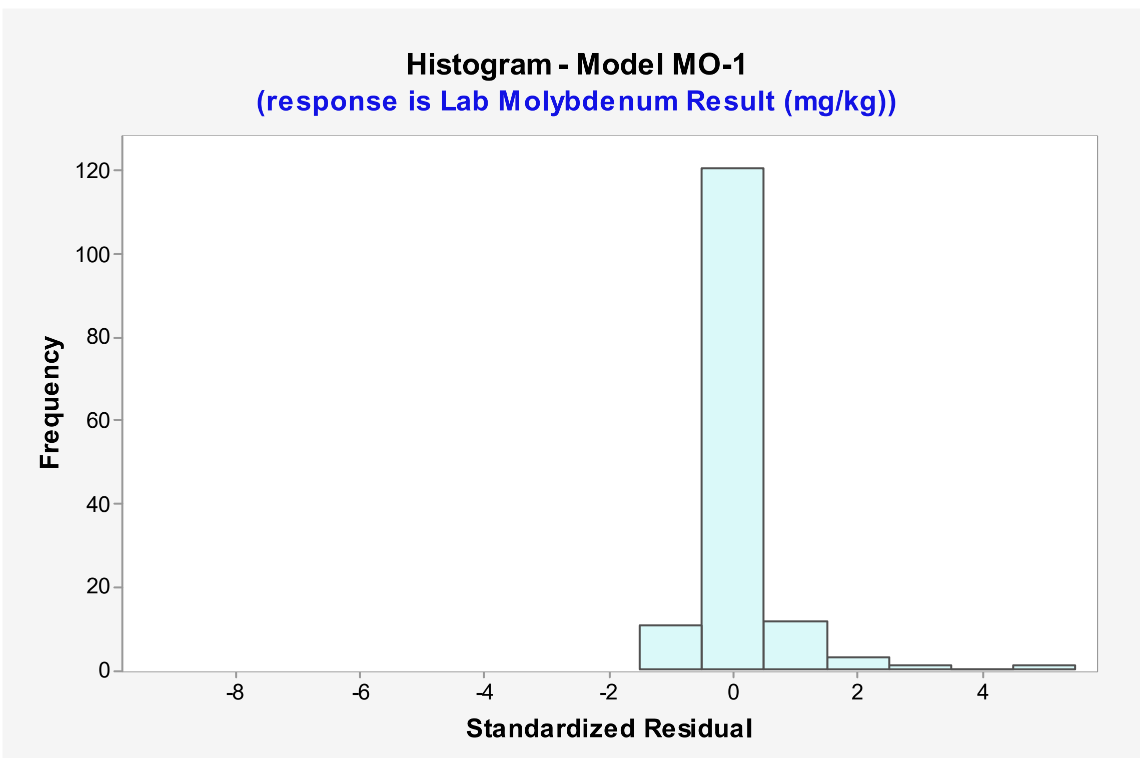


Figure B3-42. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-1

5.2 MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-1A)

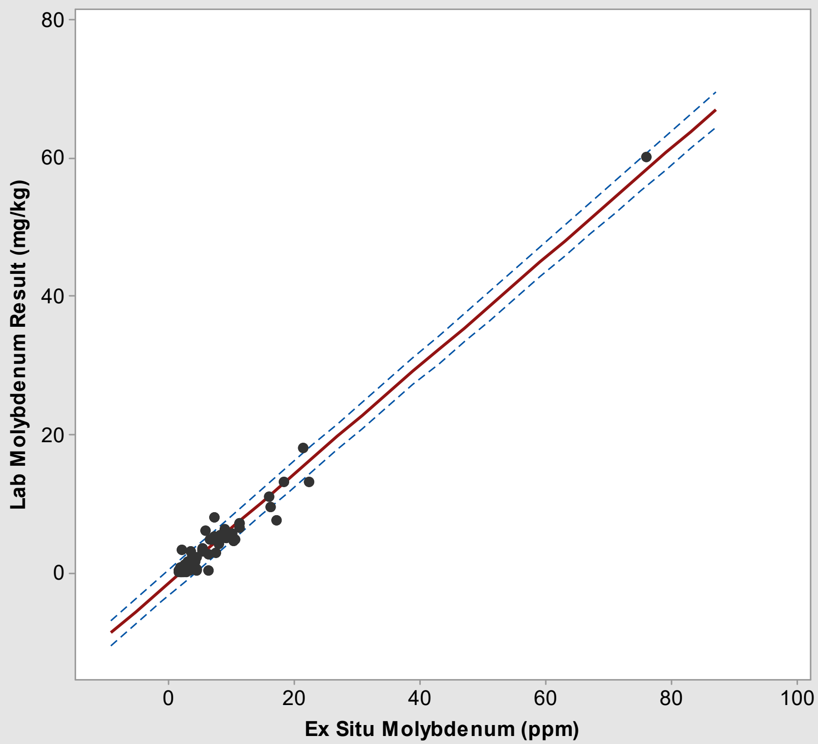
Regression for Lab Molybdenum Result (mg/kg) vs Ex Situ Molybdenum (ppm)

Prediction Report - Model MO-1A

Y: Lab Molybdenum Result (mg/kg)
X: Ex Situ Molybdenum (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-9	-8.7157	(-10.572, -6.8596)
-5	-5.5614	(-7.4059, -3.7169)
-1	-2.4071	(-4.2440, -0.57021)
3	0.74716	(-1.0862, 2.5805)
7	3.9014	(2.0676, 5.7352)
11	7.0557	(5.2174, 8.8940)
15	10.210	(8.3631, 12.057)
19	13.364	(11.505, 15.224)
23	16.519	(14.643, 18.394)
27	19.673	(17.777, 21.569)
31	22.827	(20.907, 24.747)
35	25.981	(24.034, 27.928)
39	29.136	(27.158, 31.113)
43	32.290	(30.278, 34.302)
47	35.444	(33.395, 37.493)
51	38.598	(36.510, 40.687)
55	41.753	(39.621, 43.884)
59	44.907	(42.730, 47.084)
63	48.061	(45.837, 50.285)
67	51.216	(48.941, 53.490)
71	54.370	(52.044, 56.696)
75	57.524	(55.144, 59.904)
79	60.678	(58.242, 63.114)
83	63.833	(61.339, 66.326)
87	66.987	(64.434, 69.540)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-43. Minitab Prediction Report for Model MO-1A

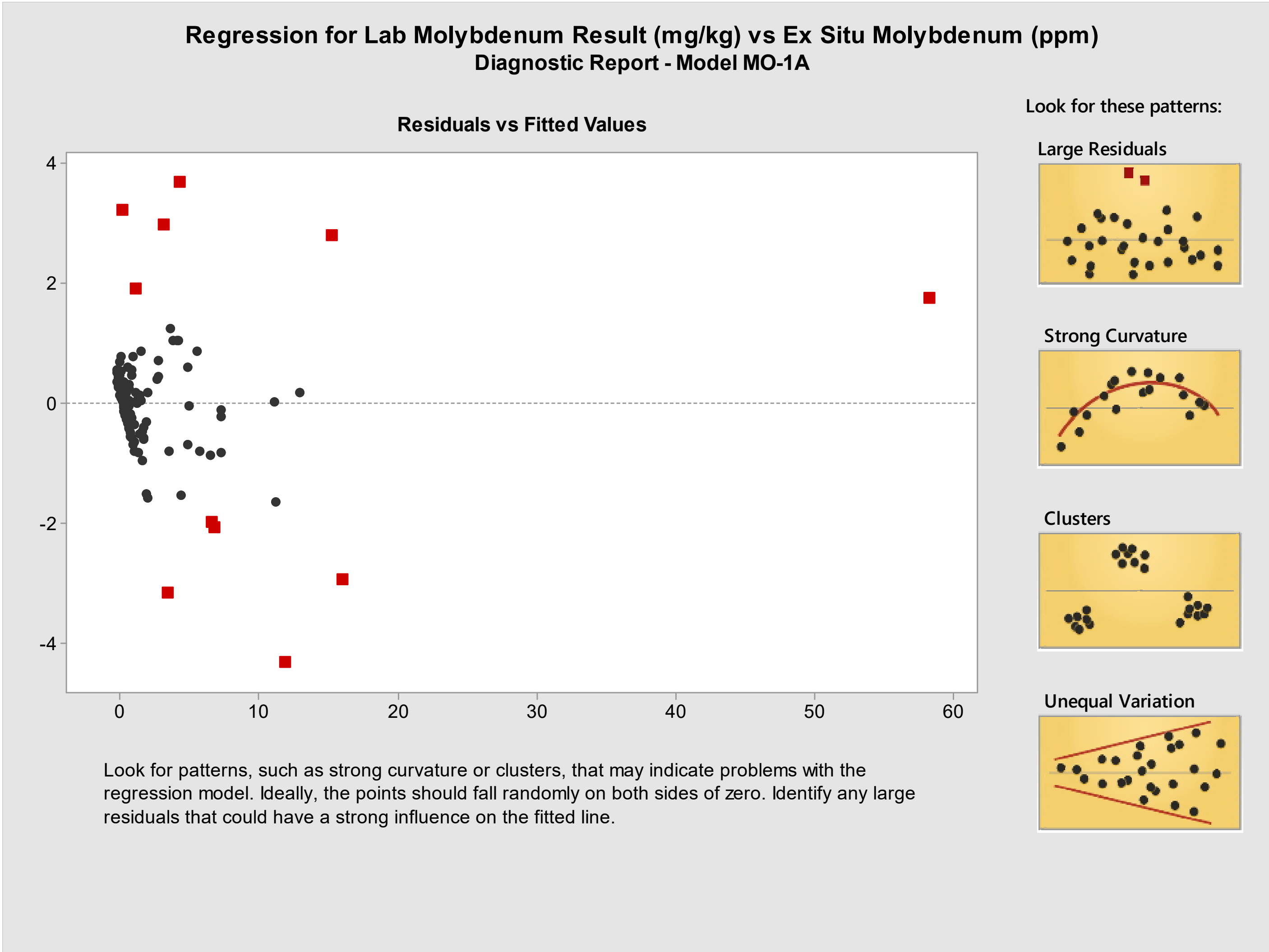


Figure B3-44. Minitab Residuals Report for Model MO-1A

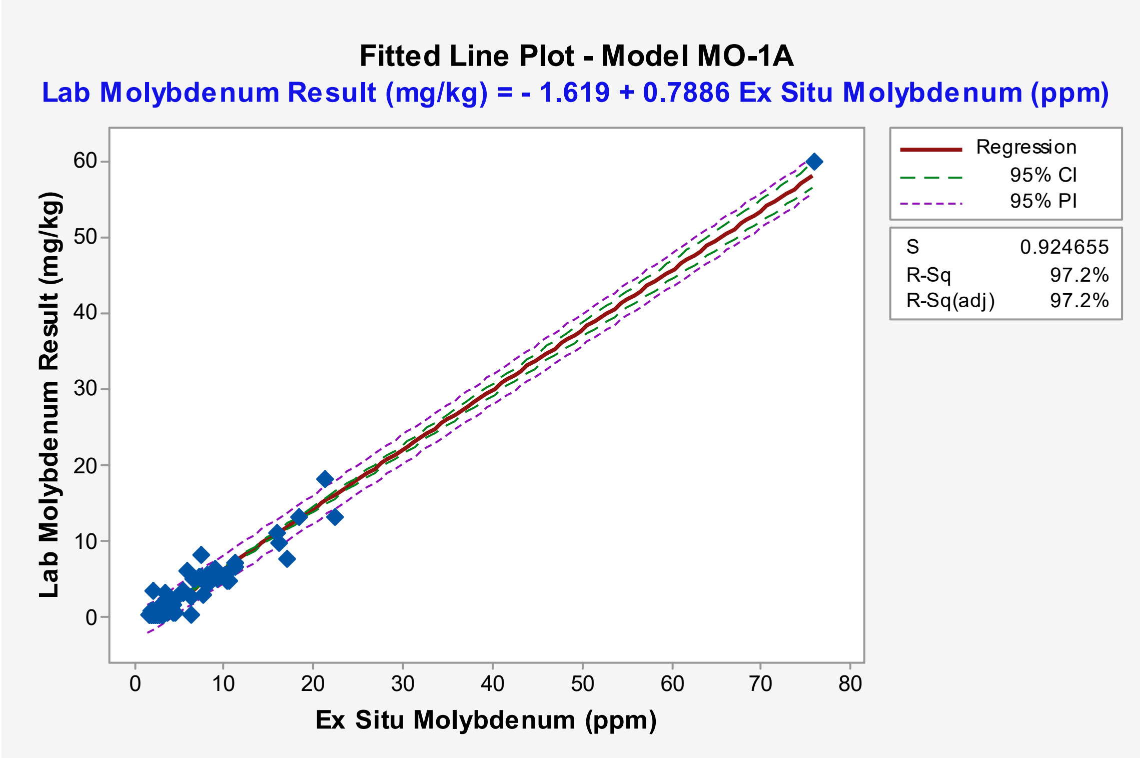


Figure B3-45. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-1A

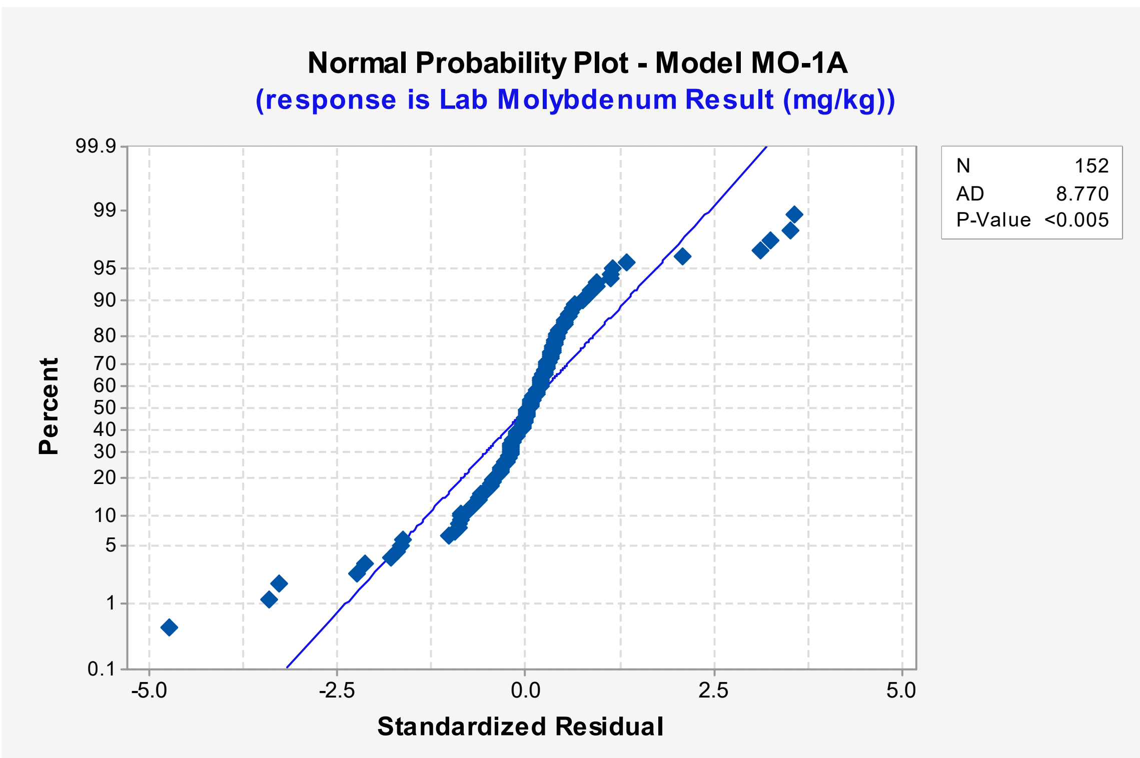


Figure B3-46. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-1A

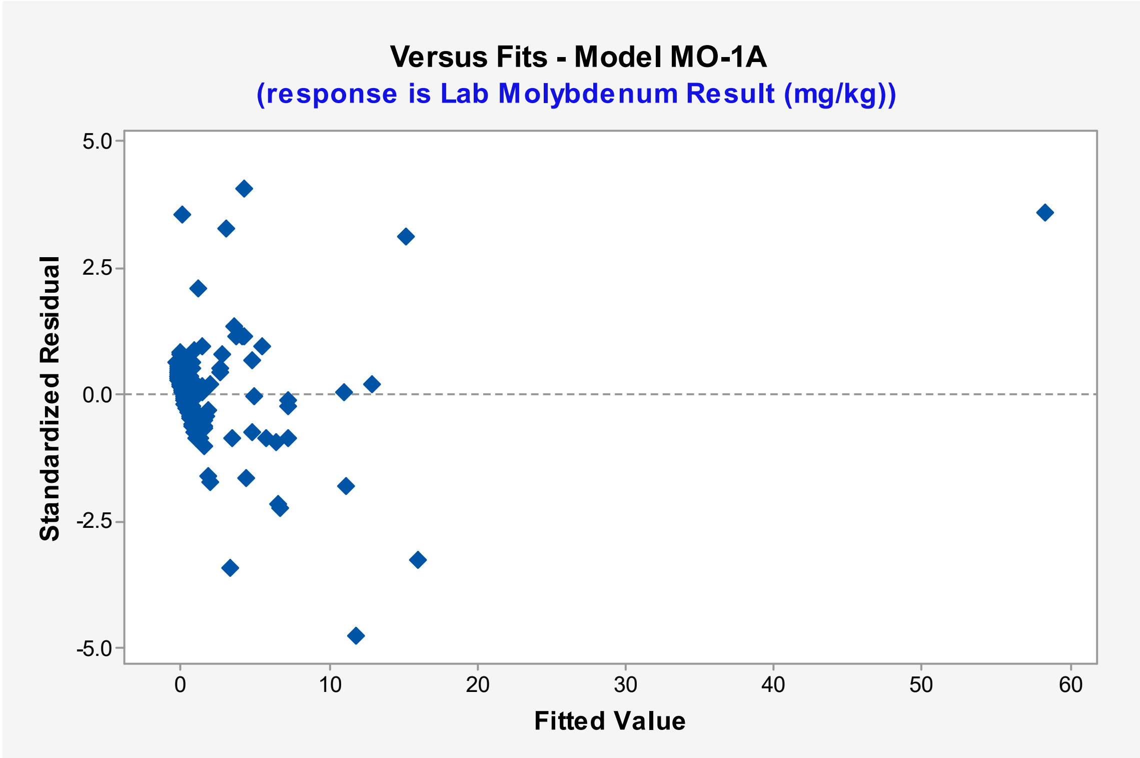


Figure B3-47. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-1A

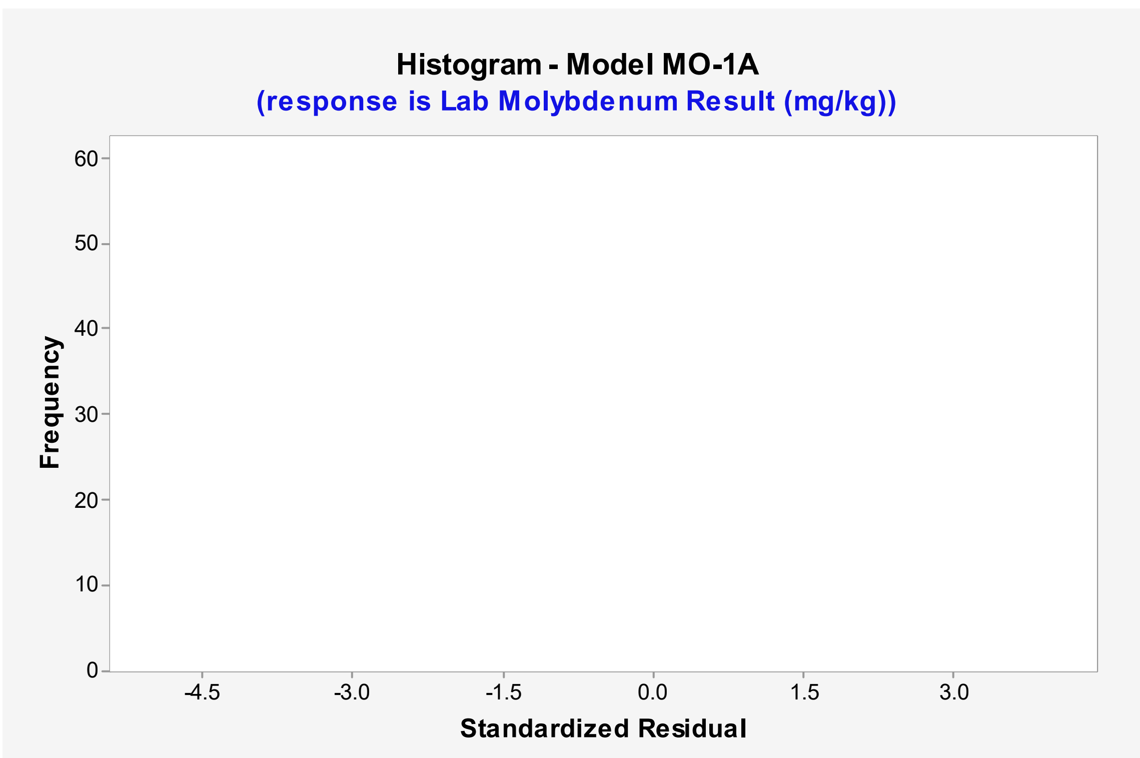


Figure B3-48. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-1A

5.3 MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-2)

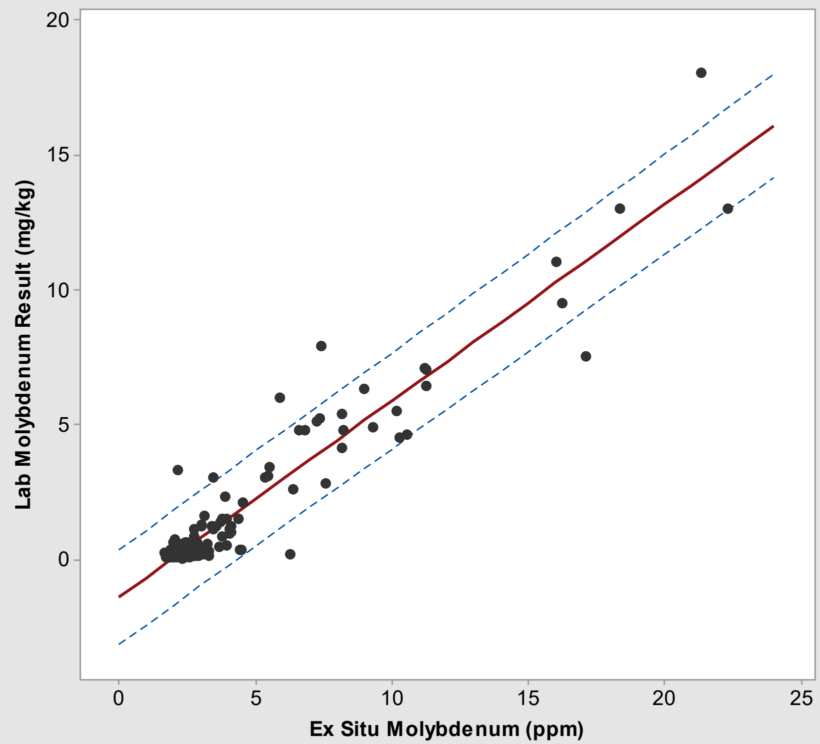
Regression for Lab Molybdenum Result (mg/kg) vs Ex Situ Molybdenum (ppm)

Prediction Report - Model MO-2

Y: Lab Molybdenum Result (mg/kg)
X: Ex Situ Molybdenum (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	-1.3810	(-3.1476, 0.38559)
1	-0.65379	(-2.4174, 1.1098)
2	0.073431	(-1.6880, 1.8349)
3	0.80065	(-0.95945, 2.5608)
4	1.5279	(-0.23175, 3.2875)
5	2.2551	(0.49511, 4.0151)
6	2.9823	(1.2211, 4.7435)
7	3.7095	(1.9463, 5.4728)
8	4.4368	(2.6706, 6.2030)
9	5.1640	(3.3941, 6.9339)
10	5.8912	(4.1167, 7.6657)
11	6.6184	(4.8385, 8.3984)
12	7.3457	(5.5595, 9.1318)
13	8.0729	(6.2797, 9.8661)
14	8.8001	(6.9991, 10.601)
15	9.5273	(7.7177, 11.337)
16	10.255	(8.4355, 12.074)
17	10.982	(9.1525, 12.811)
18	11.709	(9.8688, 13.549)
19	12.436	(10.584, 14.288)
20	13.163	(11.299, 15.028)
21	13.891	(12.013, 15.768)
22	14.618	(12.727, 16.509)
23	15.345	(13.439, 17.251)
24	16.072	(14.152, 17.993)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-49. Minitab Prediction Report for Model MO-2

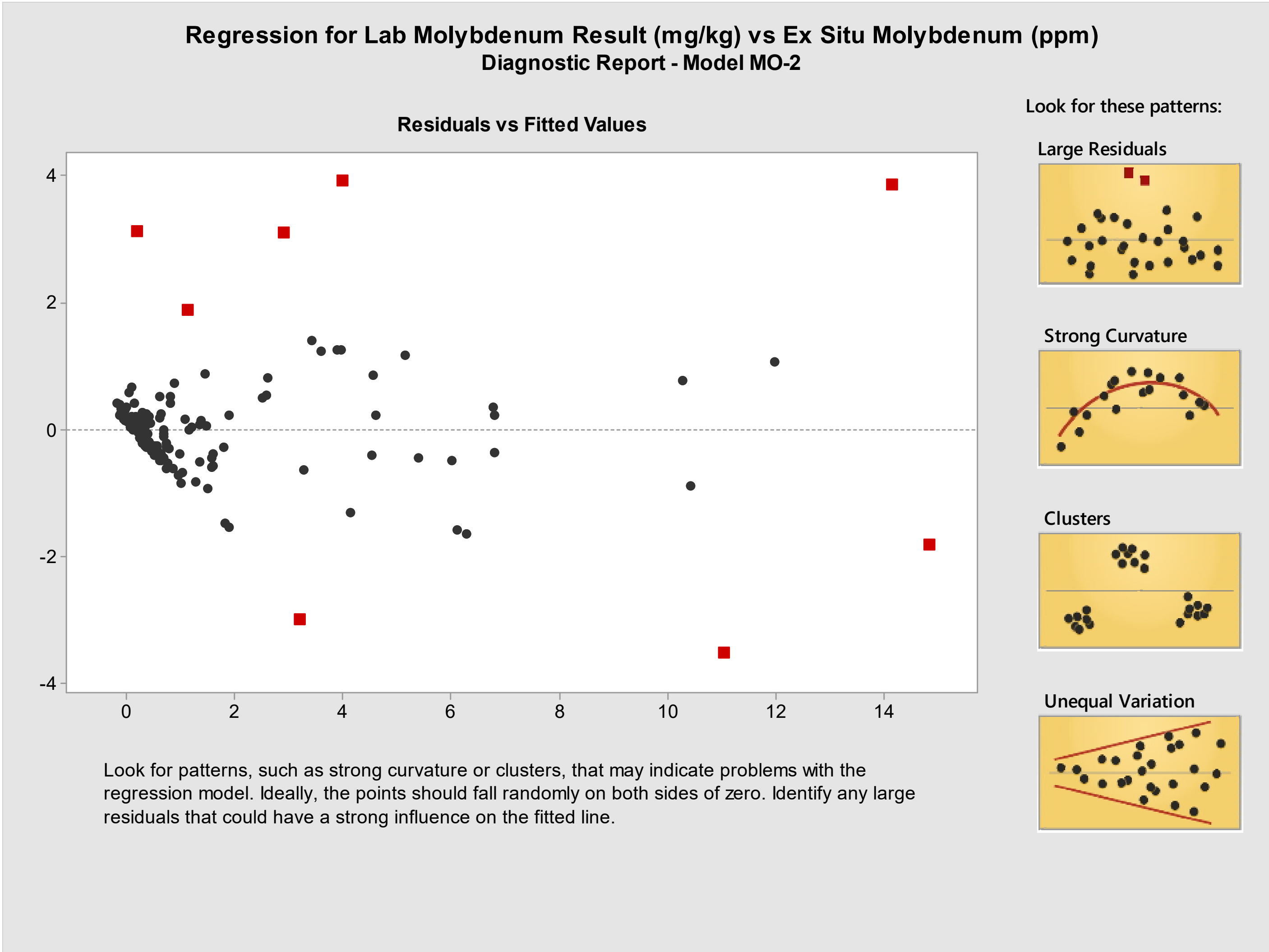


Figure B3-50. Minitab Residuals Report for Model MO-2

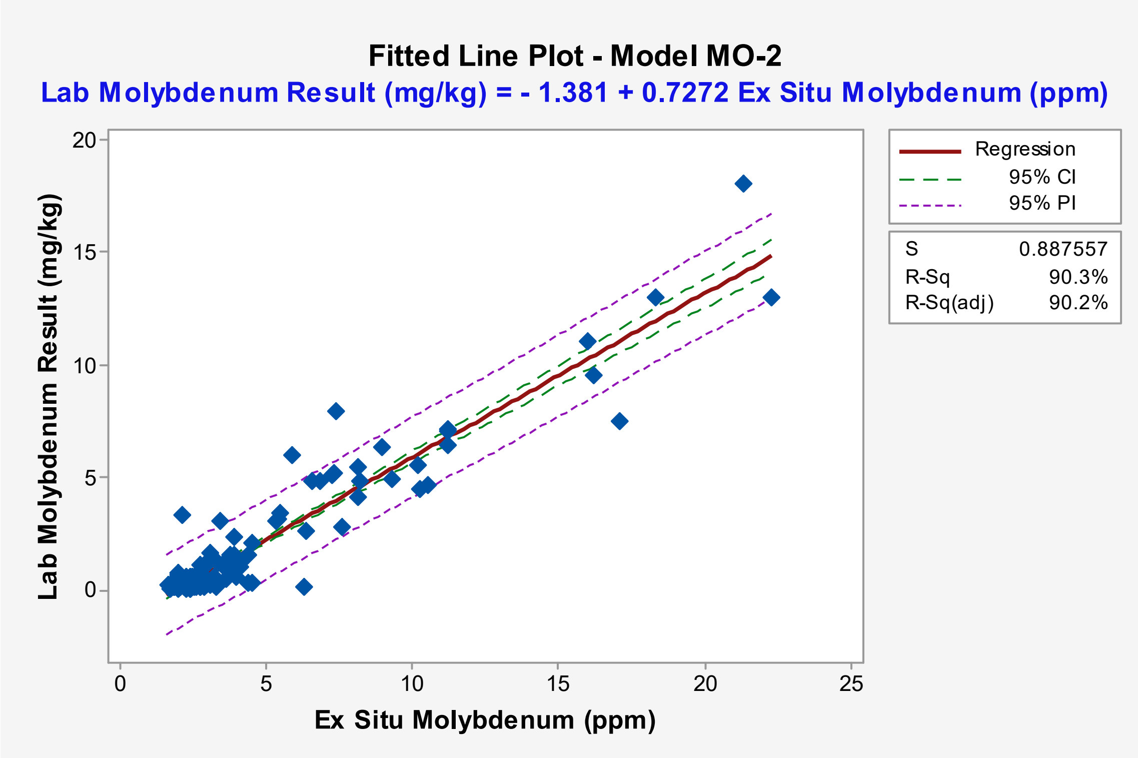


Figure B3-51. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-2

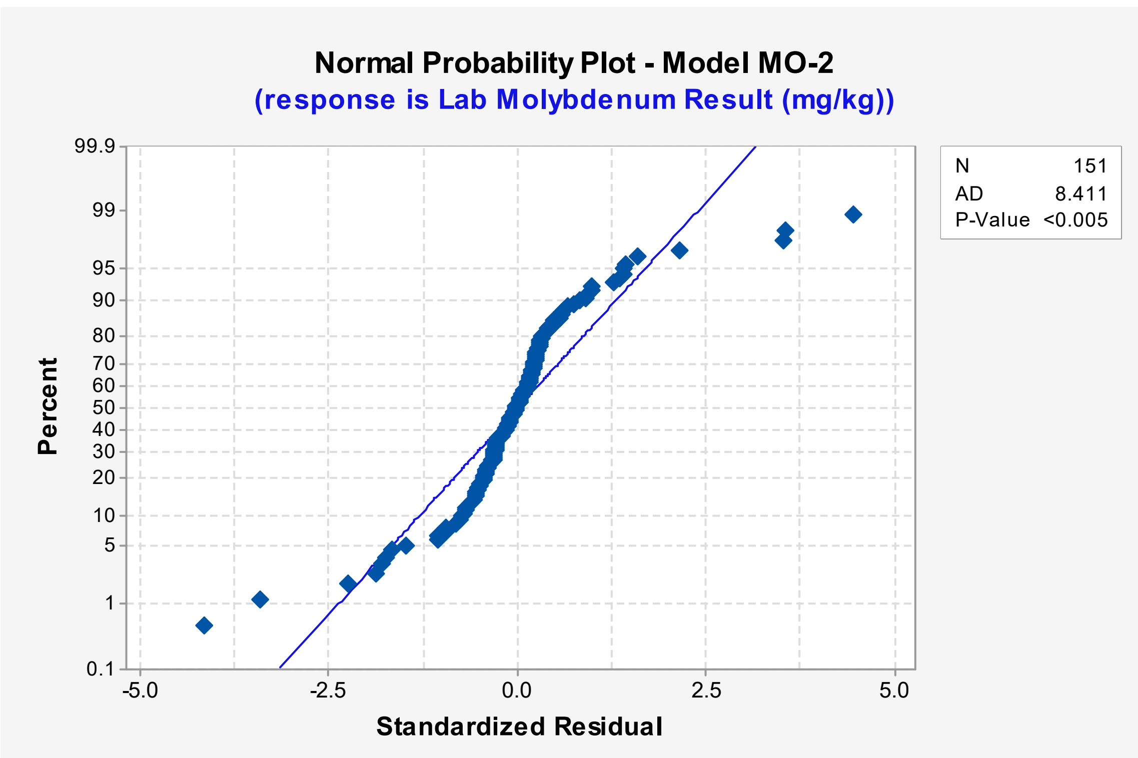


Figure B3-52. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-2

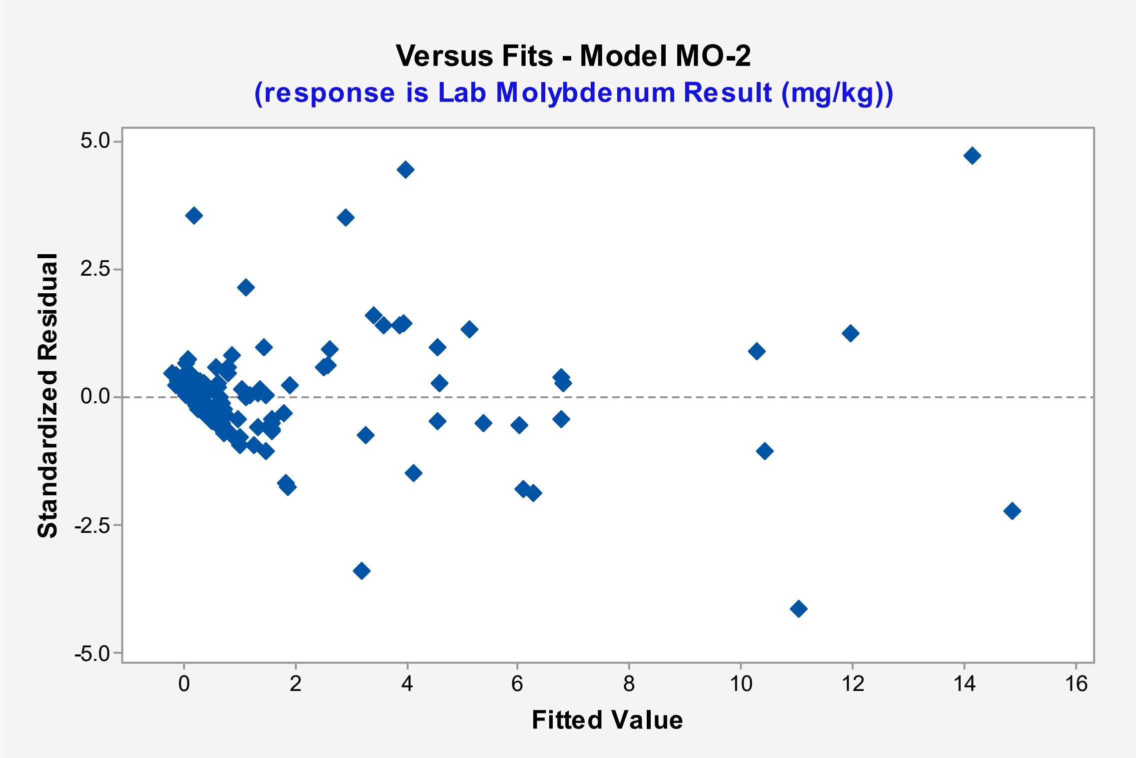


Figure B3-53. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-2

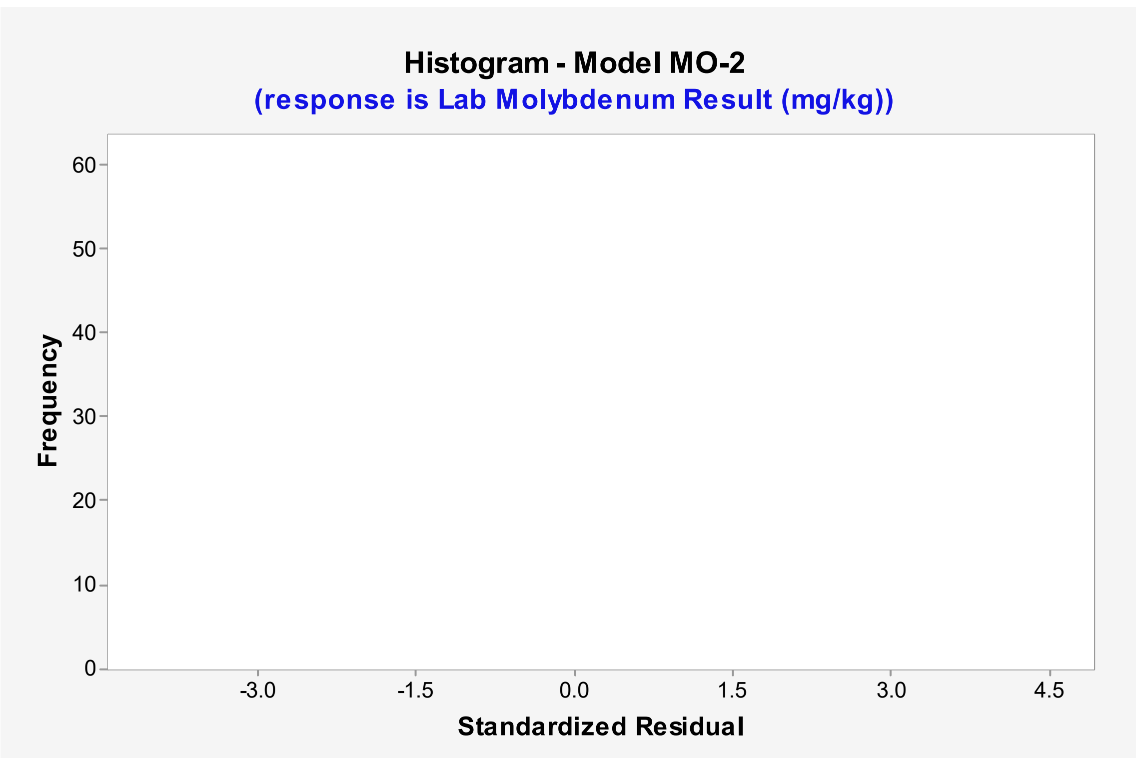


Figure B3-54. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-2

5.4 MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-2A)

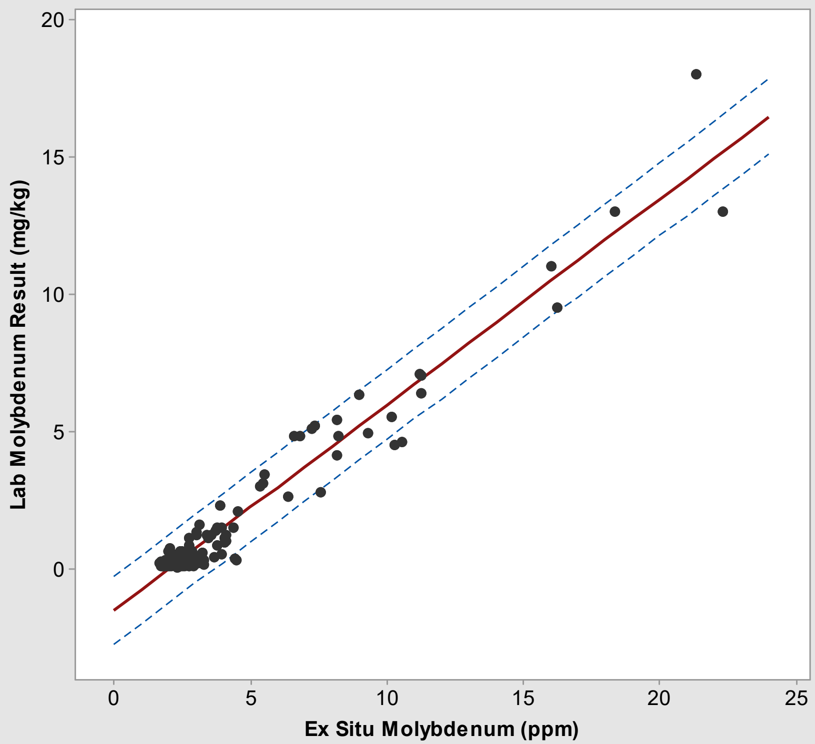
Regression for Lab Molybdenum Result (mg/kg) vs Ex Situ Molybdenum (ppm)

Prediction Report - Model MO-2A

Y: Lab Molybdenum Result (mg/kg)
X: Ex Situ Molybdenum (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	-1.5041	(-2.7557, -0.25250)
1	-0.75523	(-2.0046, 0.49410)
2	-0.00635	(-1.2541, 1.2414)
3	0.74253	(-0.50423, 1.9893)
4	1.4914	(0.24494, 2.7379)
5	2.2403	(0.99345, 3.4871)
6	2.9892	(1.7413, 4.2371)
7	3.7381	(2.4885, 4.9876)
8	4.4869	(3.2350, 5.7389)
9	5.2358	(3.9809, 6.4908)
10	5.9847	(4.7261, 7.2433)
11	6.7336	(5.4707, 7.9965)
12	7.4825	(6.2146, 8.7503)
13	8.2313	(6.9579, 9.5047)
14	8.9802	(7.7006, 10.260)
15	9.7291	(8.4427, 11.016)
16	10.478	(9.1842, 11.772)
17	11.227	(9.9251, 12.529)
18	11.976	(10.665, 13.286)
19	12.725	(11.405, 14.044)
20	13.474	(12.144, 14.803)
21	14.222	(12.883, 15.562)
22	14.971	(13.621, 16.322)
23	15.720	(14.359, 17.082)
24	16.469	(15.096, 17.842)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-55. Minitab Prediction Report for Model MO-2A

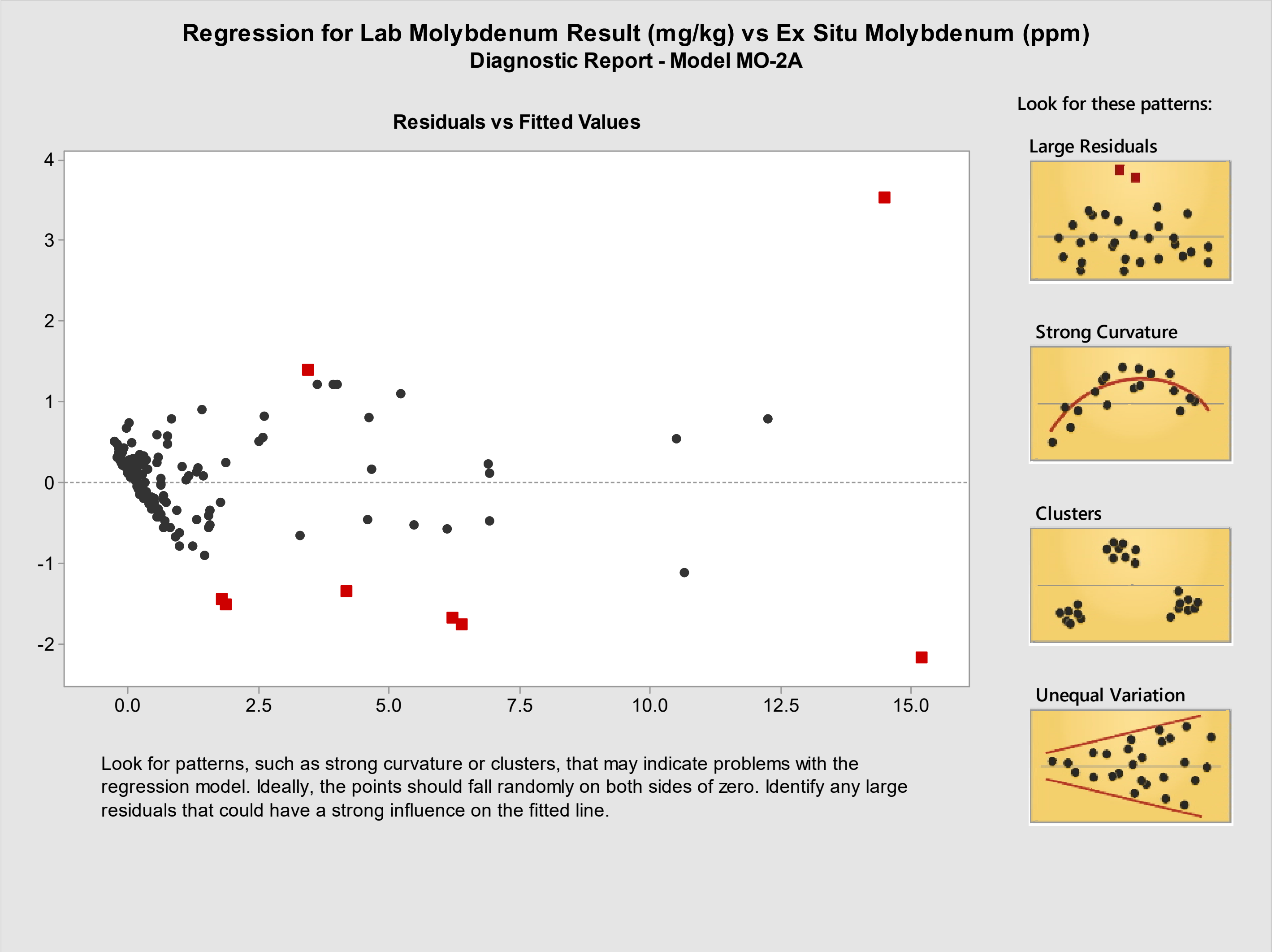


Figure B3-56. Minitab Residuals Report for Model MO-2A

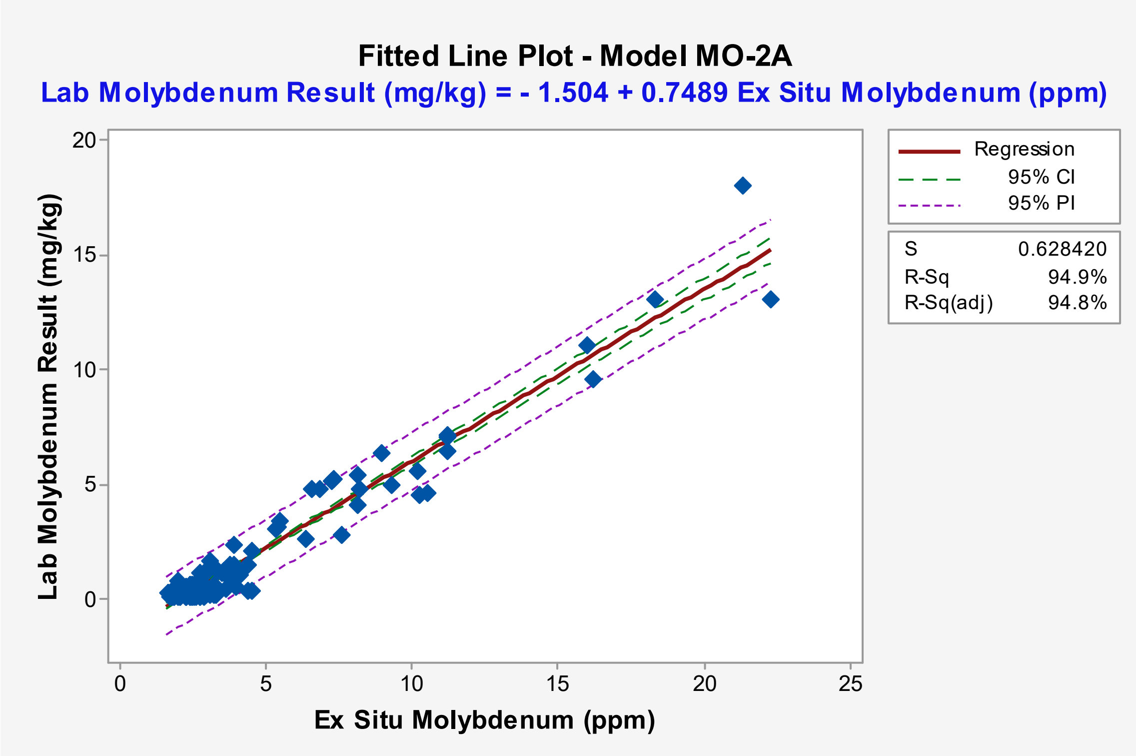


Figure B3-57. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-2A

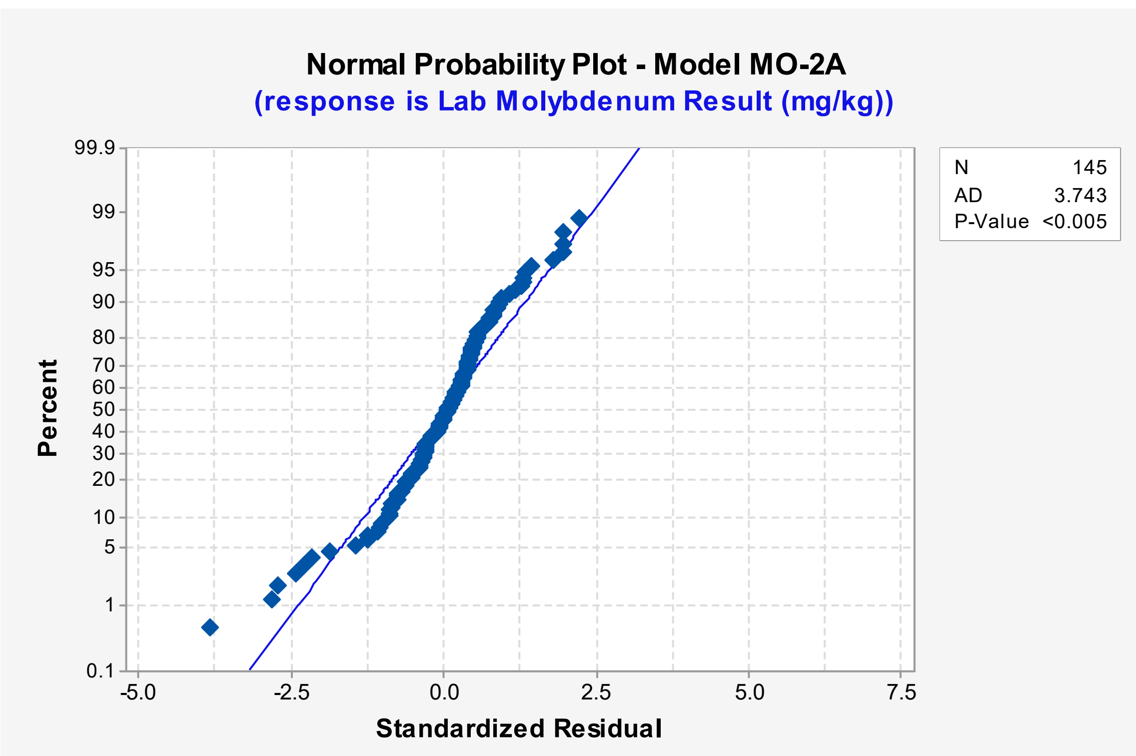


Figure B3-58. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-2A

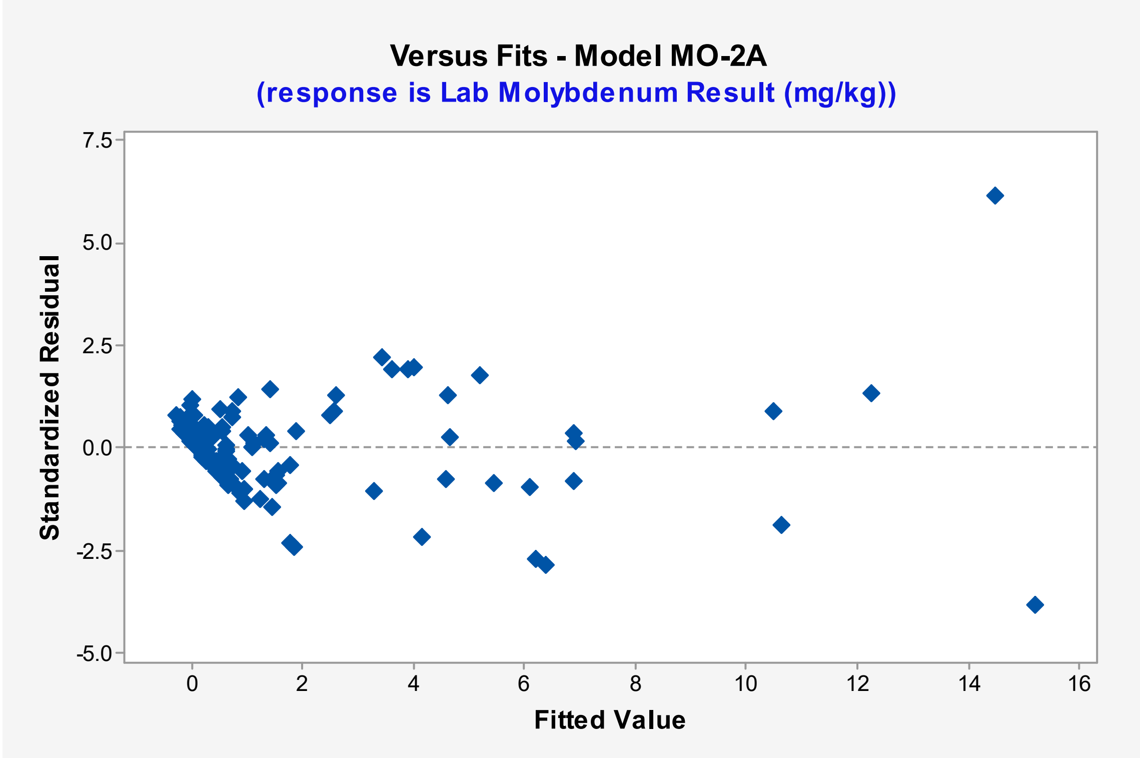


Figure B3-59. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-2A

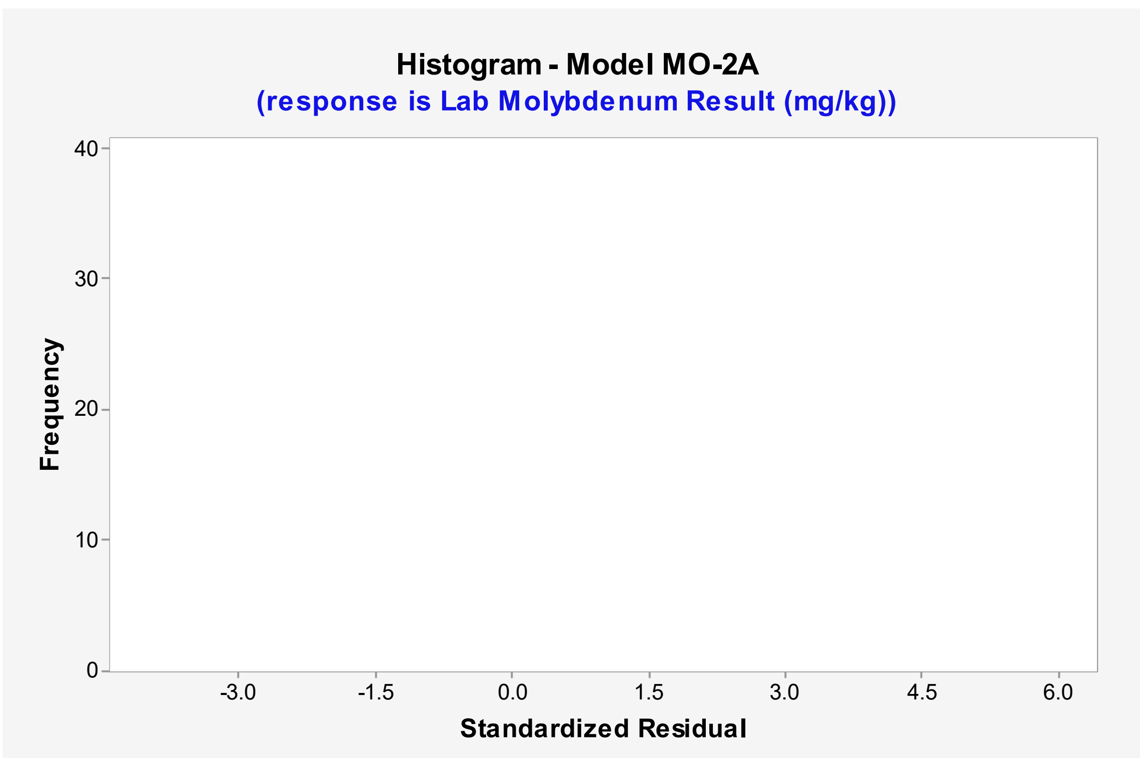


Figure B3-60. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-2A

5.5 MOLYBDENUM STATISTICAL OUTPUT (MODEL MO-1B)

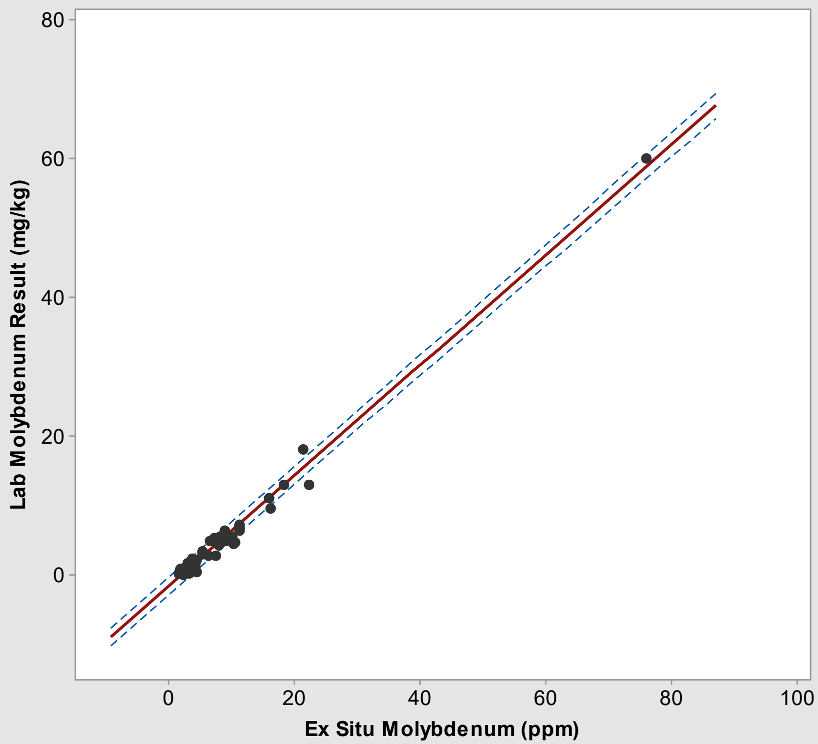
Regression for Lab Molybdenum Result (mg/kg) vs Ex Situ Molybdenum (ppm)

Prediction Report - Model MO-1B

Y: Lab Molybdenum Result (mg/kg)
X: Ex Situ Molybdenum (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-9	-8.8500	(-10.170, -7.5299)
-5	-5.6645	(-6.9763, -4.3528)
-1	-2.4791	(-3.7854, -1.1728)
3	0.70642	(-0.59735, 2.0102)
7	3.8919	(2.5877, 5.1961)
11	7.0774	(5.7698, 8.3849)
15	10.263	(8.9490, 11.577)
19	13.448	(12.125, 14.771)
23	16.634	(15.299, 17.969)
27	19.819	(18.470, 21.169)
31	23.005	(21.638, 24.372)
35	26.190	(24.803, 27.577)
39	29.376	(27.966, 30.785)
43	32.561	(31.127, 33.996)
47	35.747	(34.285, 37.208)
51	38.932	(37.442, 40.423)
55	42.118	(40.596, 43.639)
59	45.303	(43.749, 46.858)
63	48.489	(46.900, 50.078)
67	51.674	(50.049, 53.299)
71	54.860	(53.196, 56.523)
75	58.045	(56.343, 59.748)
79	61.231	(59.488, 62.974)
83	64.416	(62.631, 66.201)
87	67.602	(65.774, 69.429)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-61. Minitab Prediction Report for Model MO-1B

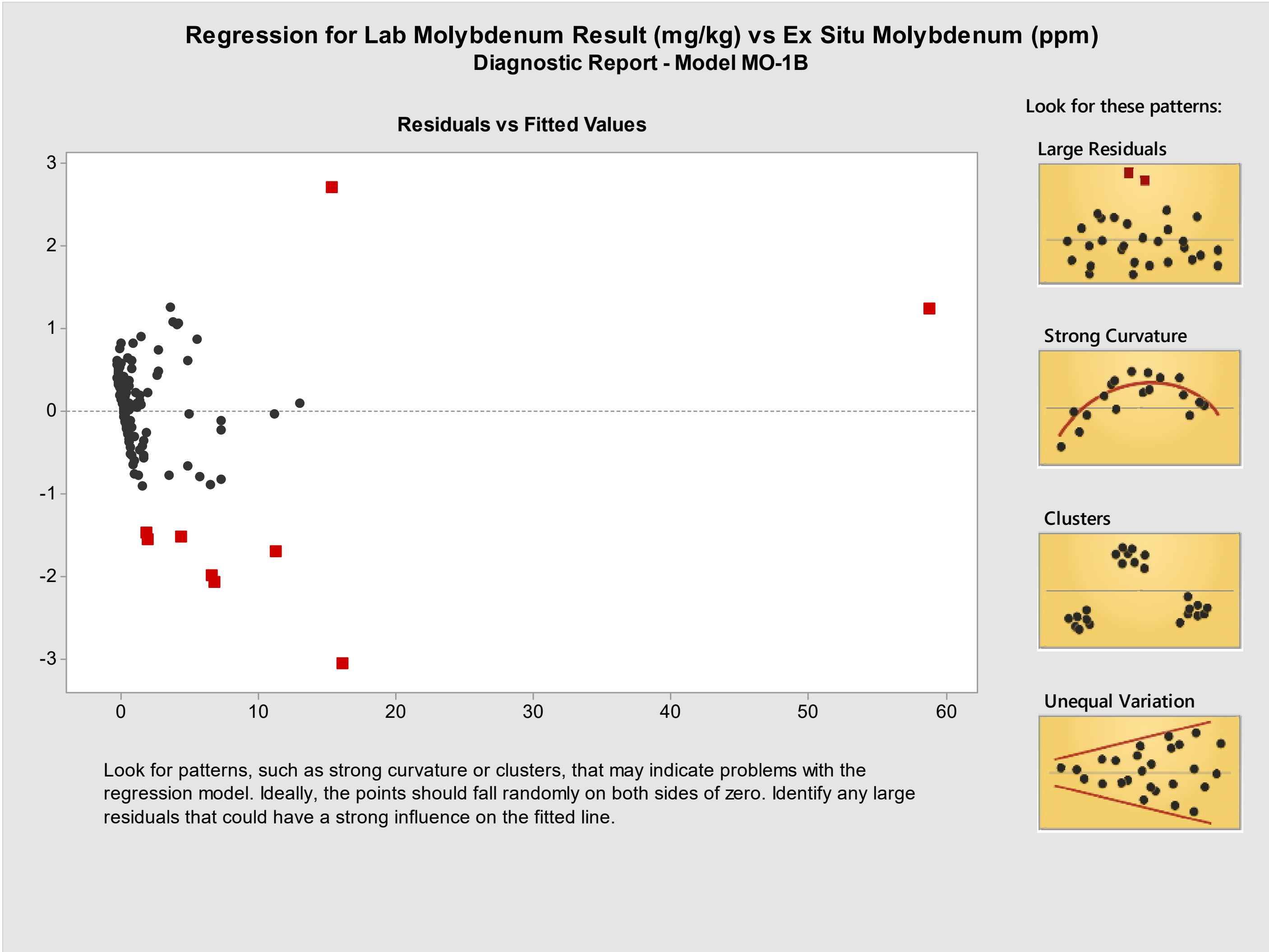


Figure B3-62. Minitab Residuals Report for Model MO-1B

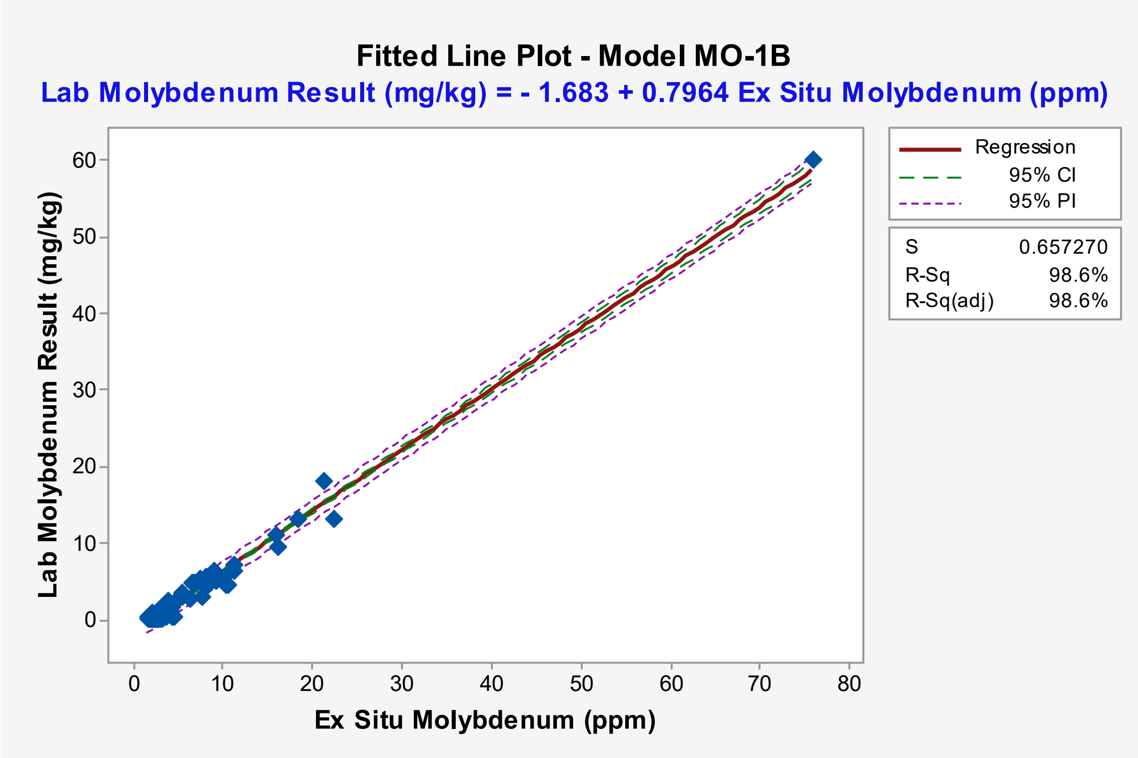


Figure B3-63. Ex Situ Bulk Sample Fitted Line Plot for Manganese Model MO-1B

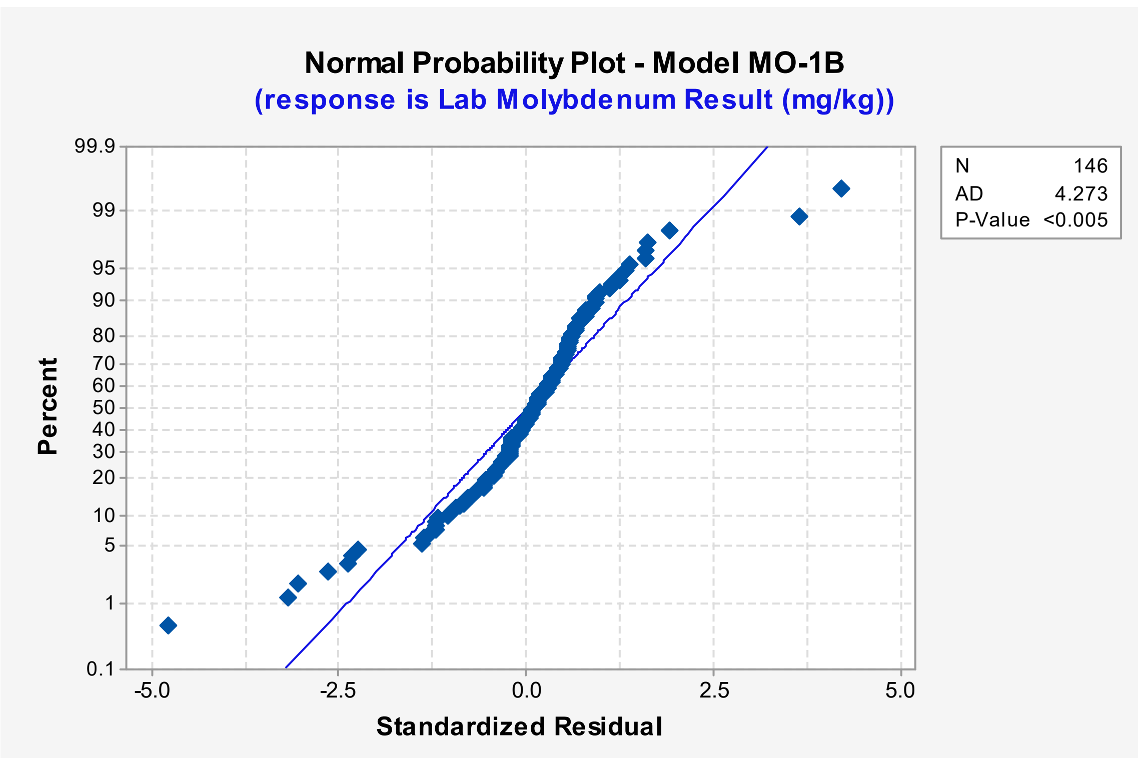


Figure B3-64. Ex Situ Bulk Sample Normal Probability Plot of Manganese Standardized Residuals for Model MO-1B

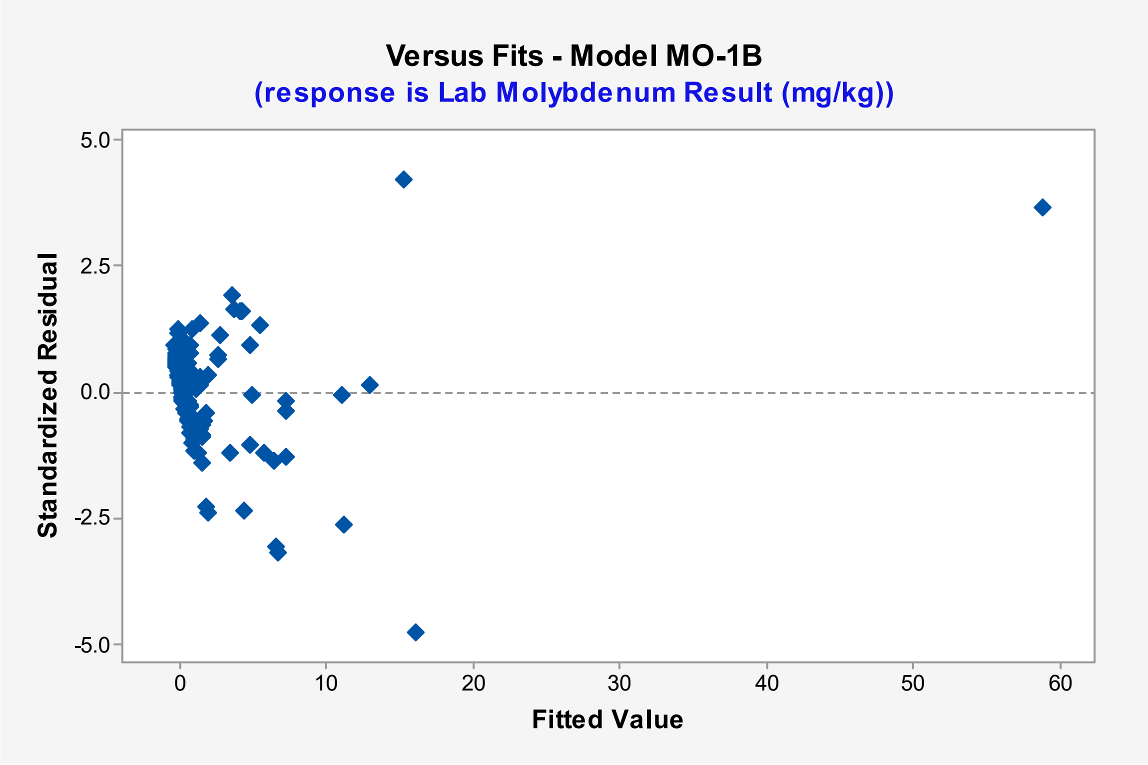


Figure B3-65. Ex Situ Bulk Sample Versus Fits Residuals Manganese for Model MO-1B

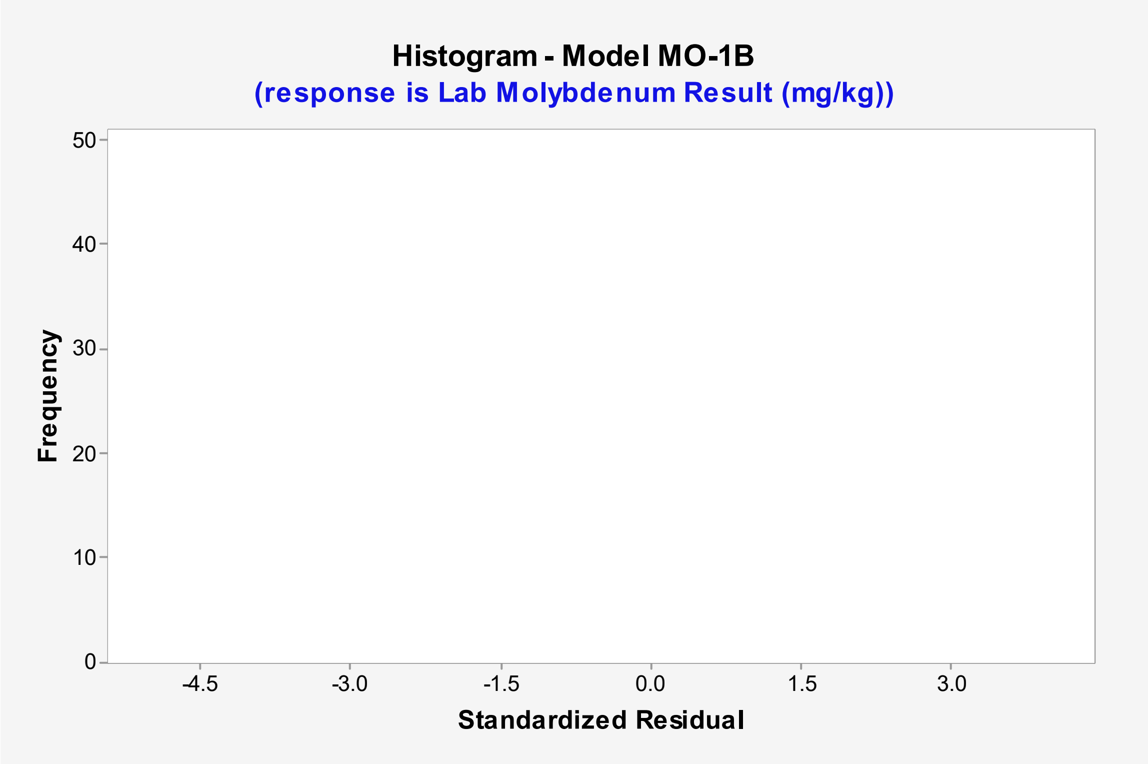


Figure B3-66. Ex Situ Bulk Sample Histogram of Standardized Manganese Residuals for Model MO-1B

6.0 LEAD EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

6.1 LEAD STATISTICAL OUTPUT (MODEL PB-1)

Regression for Lab Lead Result (mg/kg) vs Ex Situ XRF Lead (ppm)

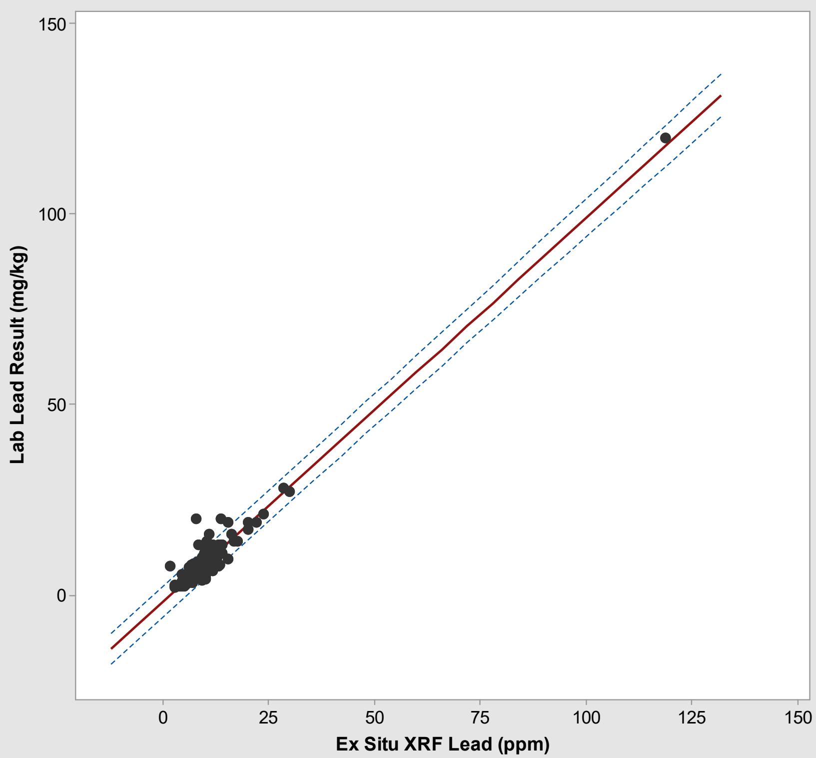
Prediction Report - Model PB-1

Y: Lab Lead Result (mg/kg)

X: Ex Situ XRF Lead (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-12	-13.950	(-18.001, -9.8994)
-6	-7.9071	(-11.930, -3.8843)
0	-1.8641	(-5.8682, 2.1399)
6	4.1788	(0.18429, 8.1734)
12	10.222	(6.2274, 14.216)
18	16.265	(12.261, 20.268)
24	22.308	(18.286, 26.330)
30	28.351	(24.301, 32.400)
36	34.394	(30.308, 38.479)
42	40.437	(36.306, 44.568)
48	46.480	(42.295, 50.664)
54	52.522	(48.276, 56.769)
60	58.565	(54.250, 62.881)
66	64.608	(60.216, 69.001)
72	70.651	(66.175, 75.128)
78	76.694	(72.128, 81.261)
84	82.737	(78.074, 87.401)
90	88.780	(84.014, 93.546)
96	94.823	(89.949, 99.697)
102	100.87	(95.879, 105.85)
108	106.91	(101.80, 112.01)
114	112.95	(107.72, 118.18)
120	118.99	(113.64, 124.35)
126	125.04	(119.55, 130.52)
132	131.08	(125.46, 136.70)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-67. Minitab Prediction Report for Model PB-1

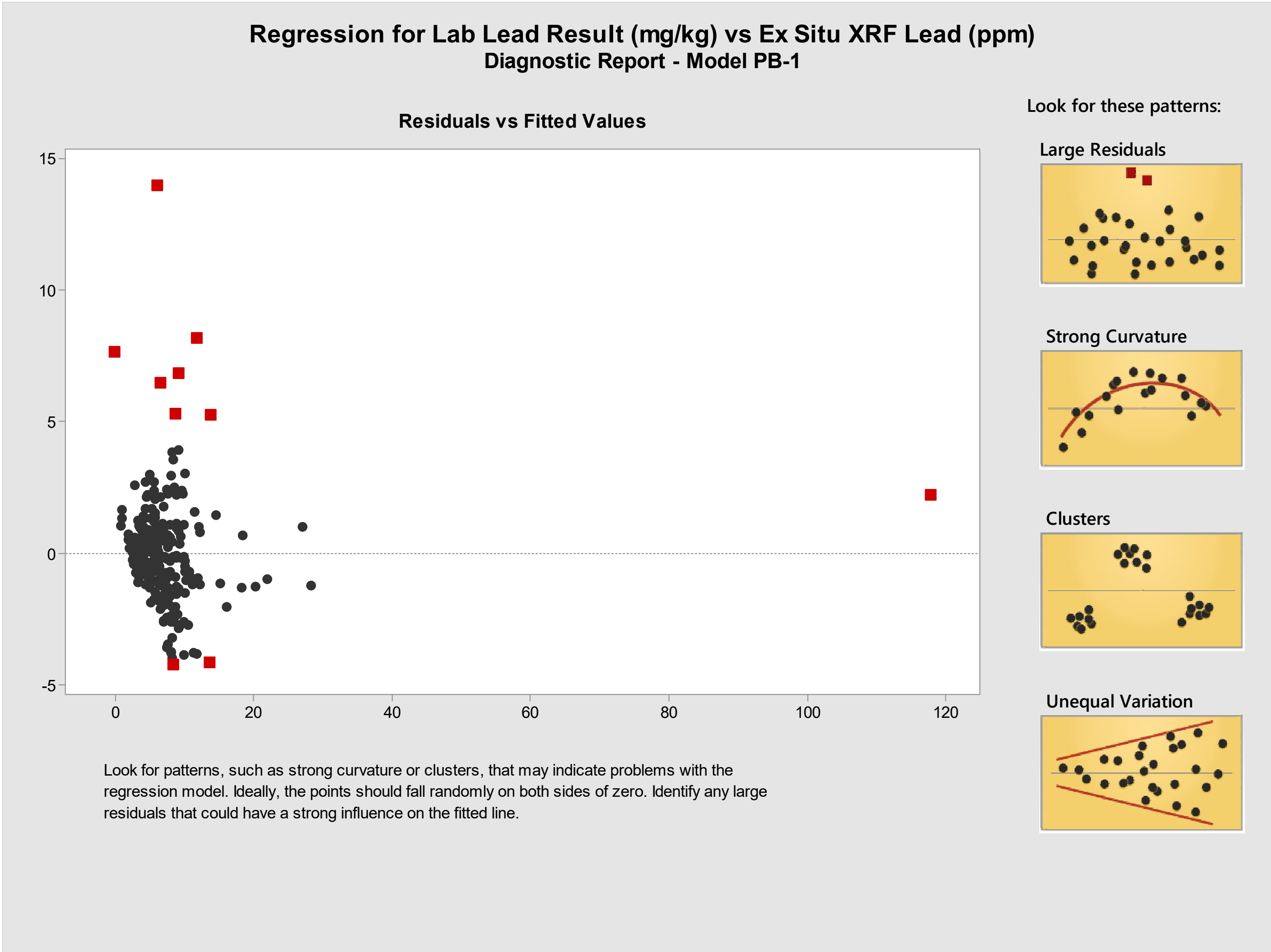


Figure B3-68. Minitab Residuals Report for Model PB-1

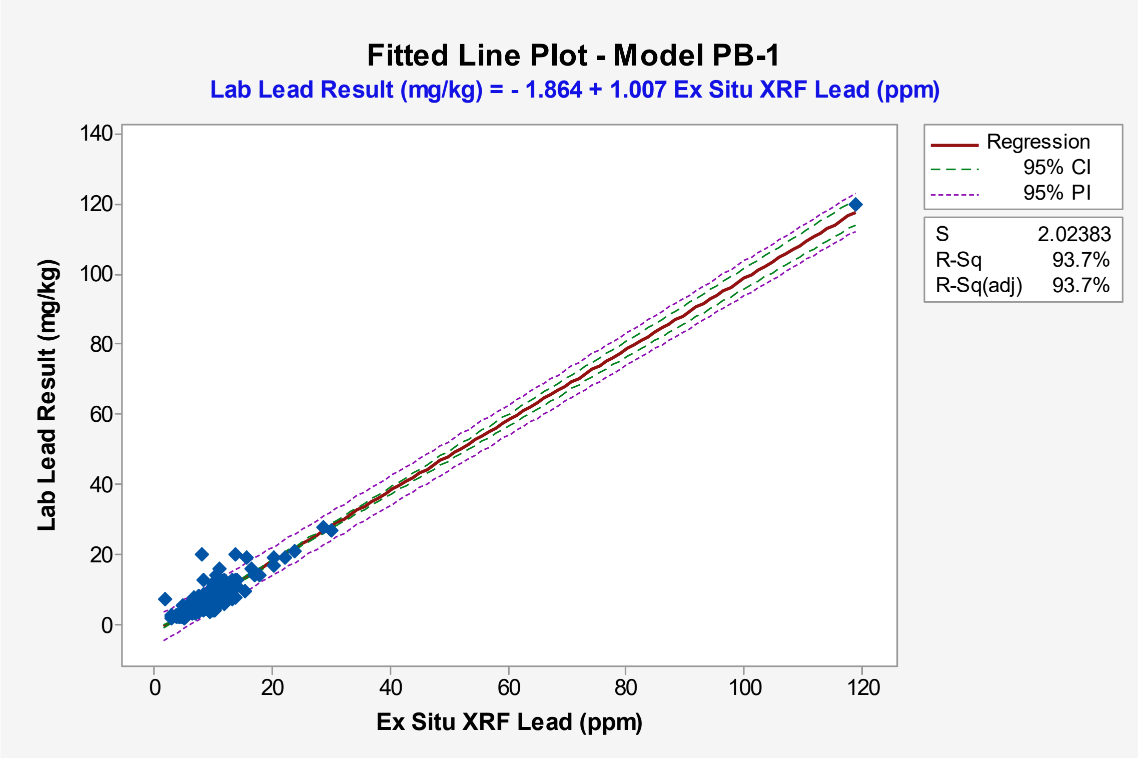


Figure B3-69. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-1

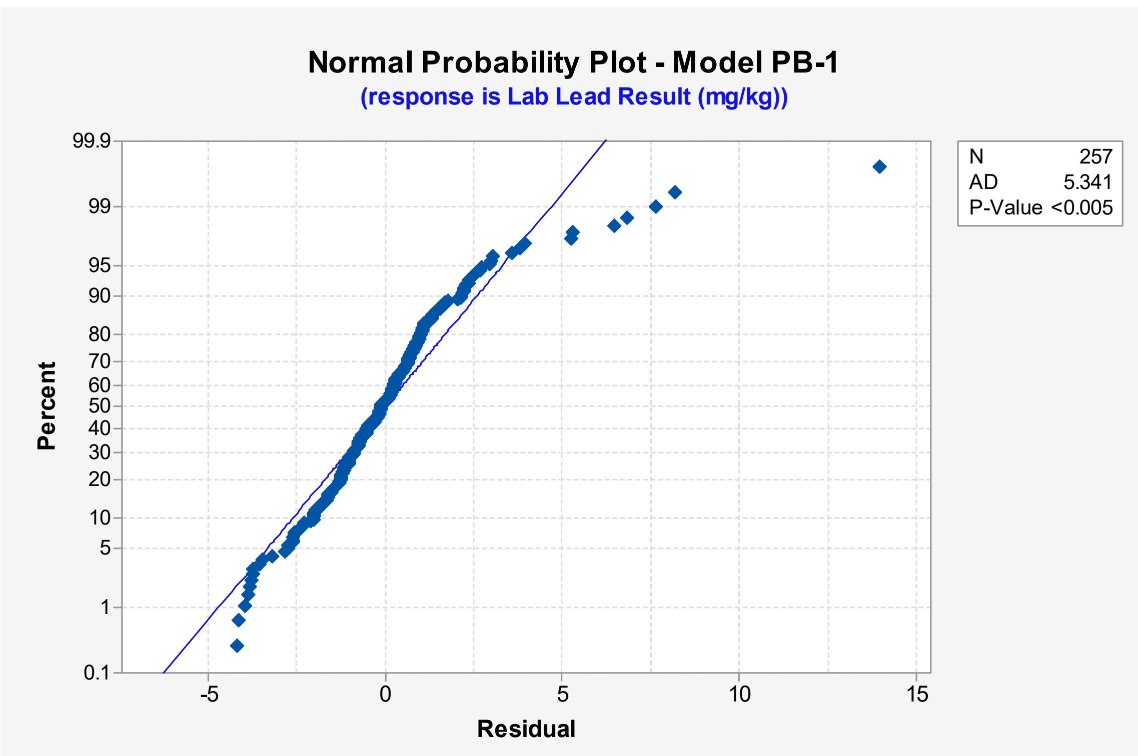


Figure B3-70. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-1

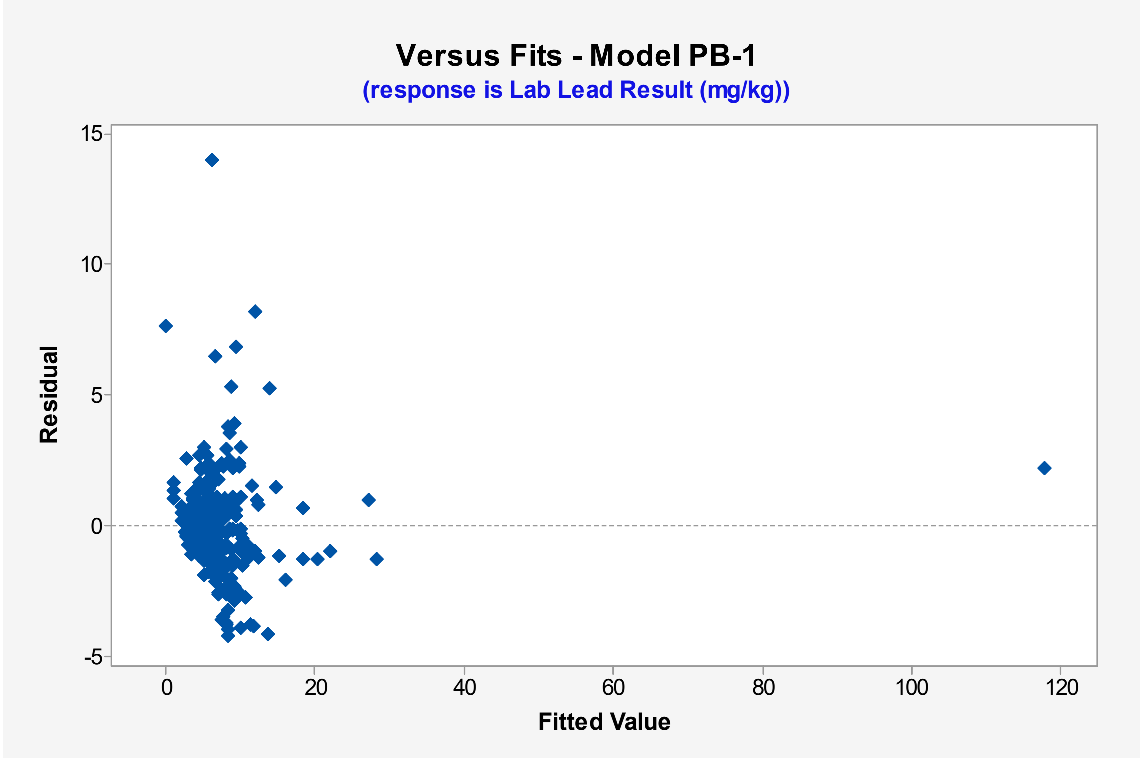


Figure B3-71. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-1

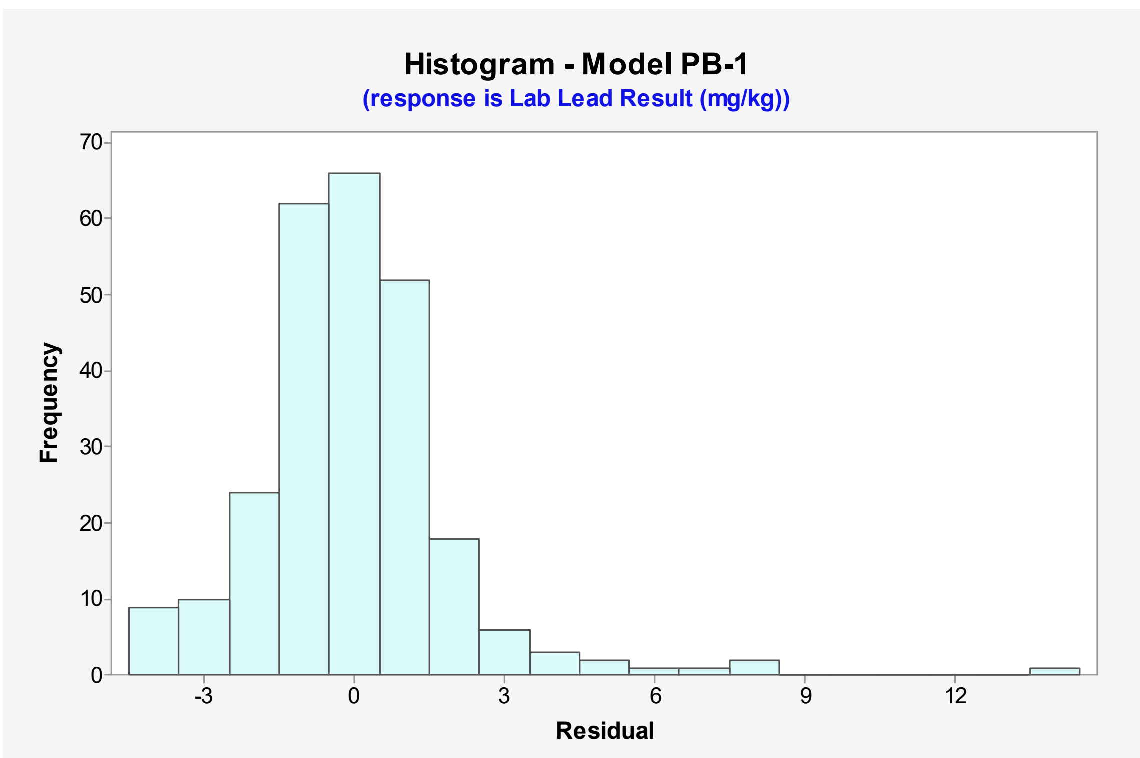


Figure B3-72. Ex Situ Bulk Sample Historgram of Lead Standardized Residuals for Model PB-1

6.2 LEAD STATISTICAL OUTPUT (MODEL PB-2)

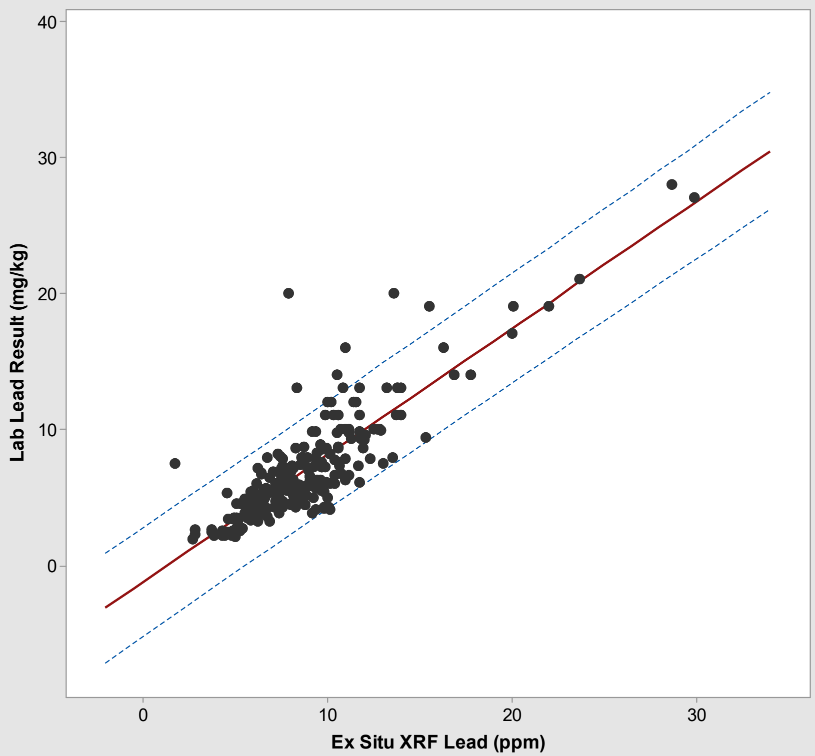
Regression for Lab Lead Result (mg/kg) vs Ex Situ XRF Lead (ppm)

Prediction Report - Model PB2

Y: Lab Lead Result (mg/kg)
X: Ex Situ XRF Lead (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-2	-3.0913	(-7.1162, 0.93354)
-0.5	-1.6923	(-5.6995, 2.3149)
1	-0.29322	(-4.2854, 3.6989)
2.5	1.1058	(-2.8739, 5.0856)
4	2.5049	(-1.4651, 6.4749)
5.5	3.9040	(-0.05890, 7.8669)
7	5.3030	(1.3446, 9.2615)
8.5	6.7021	(2.7453, 10.659)
10	8.1012	(4.1434, 12.059)
11.5	9.5002	(5.5387, 13.462)
13	10.899	(6.9314, 14.867)
14.5	12.298	(8.3213, 16.275)
16	13.697	(9.7086, 17.686)
17.5	15.096	(11.093, 19.100)
19	16.496	(12.475, 20.516)
20.5	17.895	(13.855, 21.934)
22	19.294	(15.232, 23.356)
23.5	20.693	(16.606, 24.779)
25	22.092	(17.978, 26.205)
26.5	23.491	(19.348, 27.634)
28	24.890	(20.715, 29.065)
29.5	26.289	(22.080, 30.498)
31	27.688	(23.442, 31.934)
32.5	29.087	(24.803, 33.371)
34	30.486	(26.161, 34.811)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-73. Minitab Prediction Report for Model PB-2

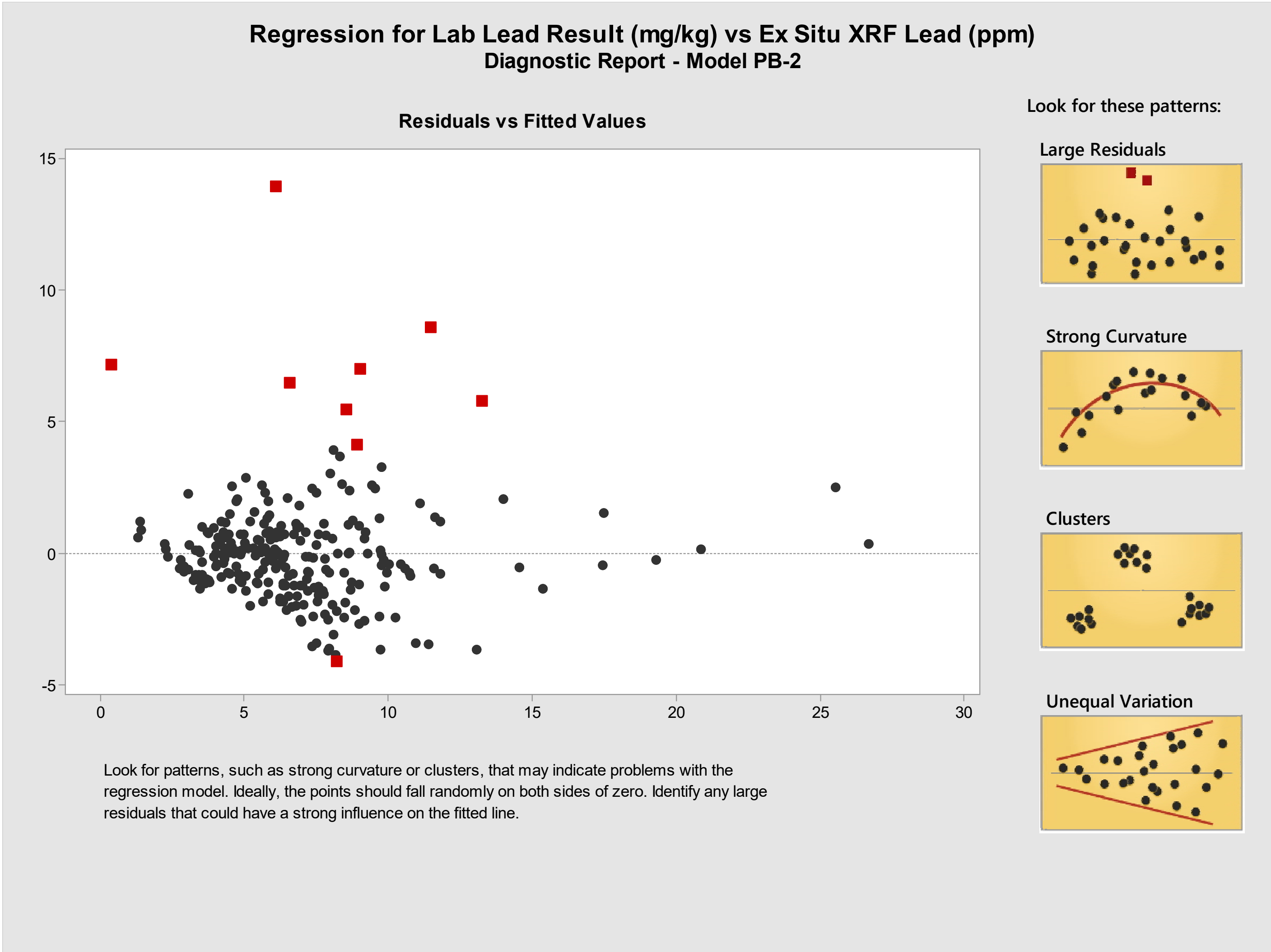


Figure B3-74. Minitab Residuals Report for Model PB-12

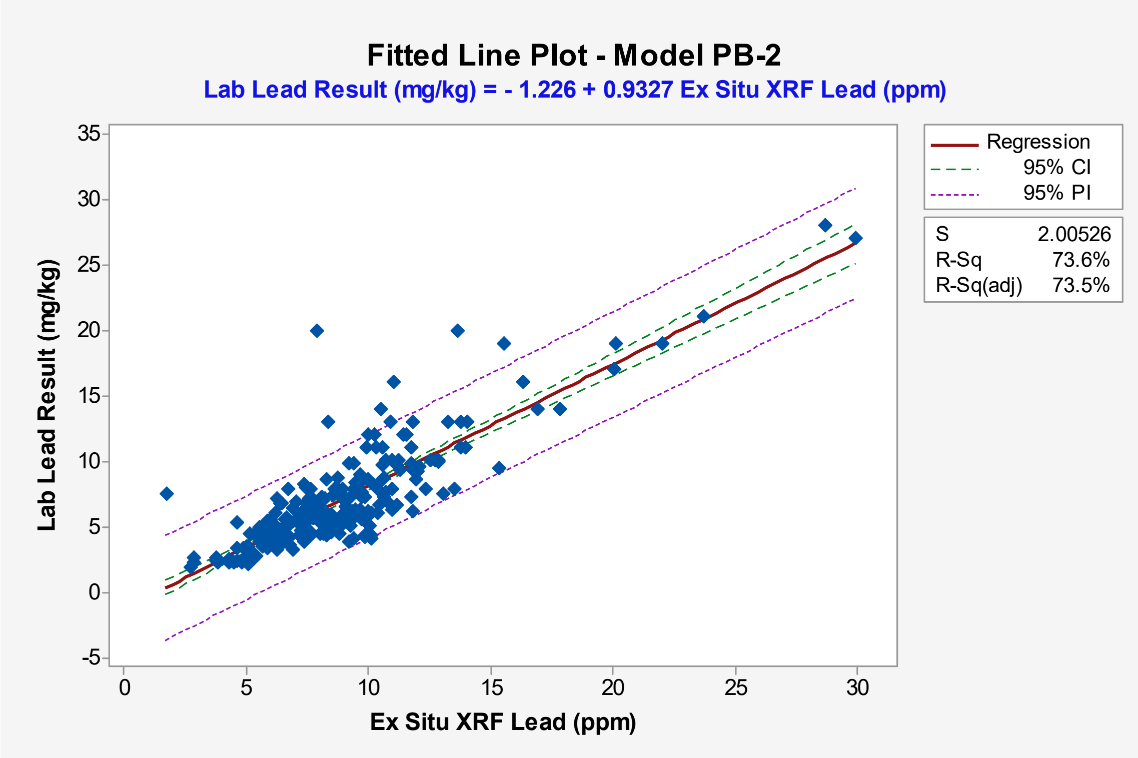


Figure B3-75. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-2

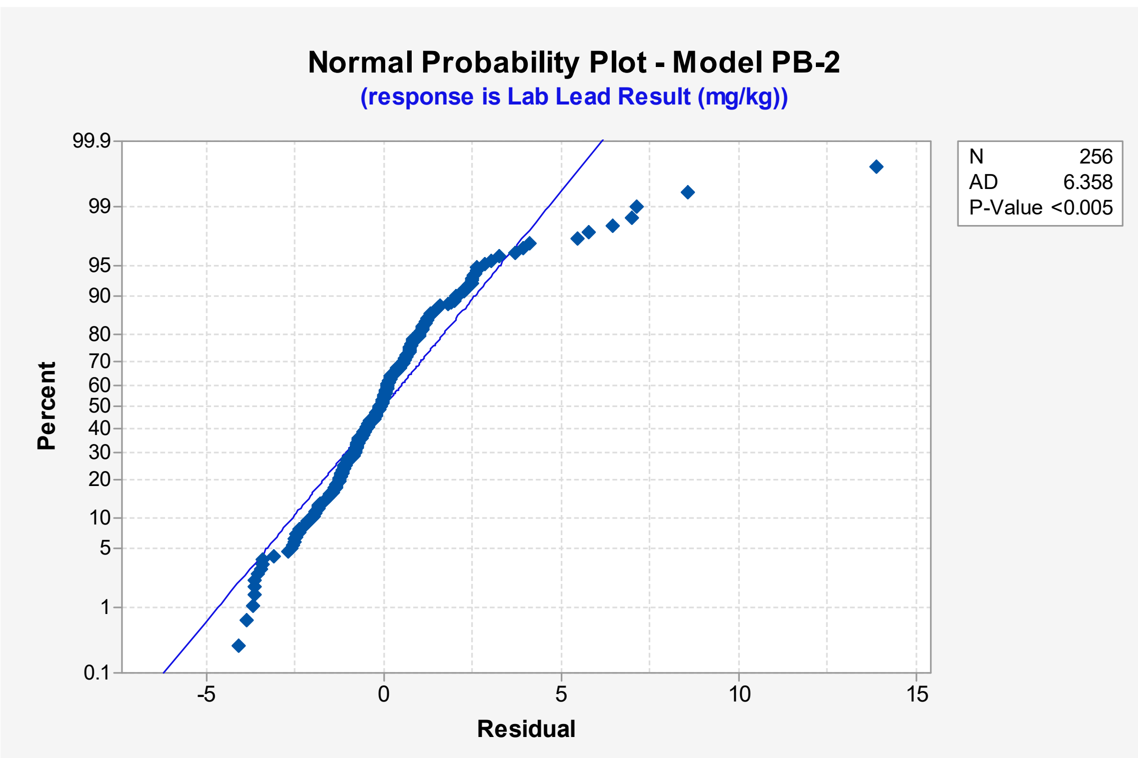


Figure B3-76. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-2

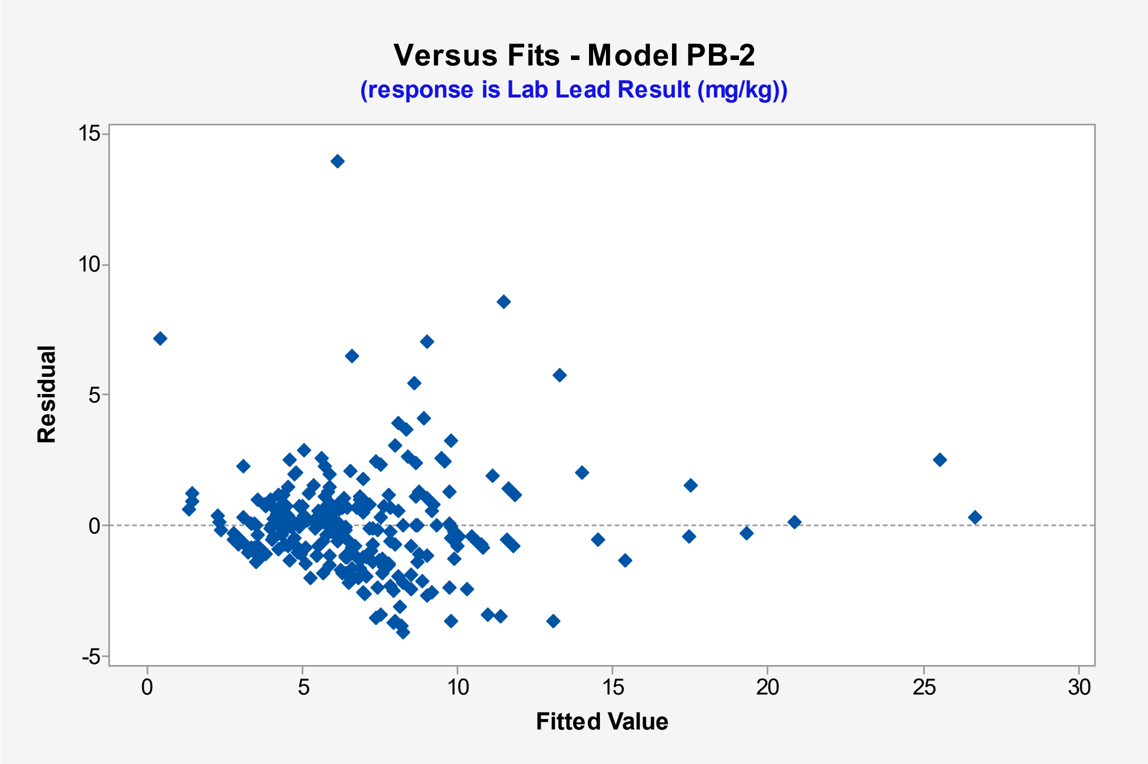


Figure B3-77. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-2

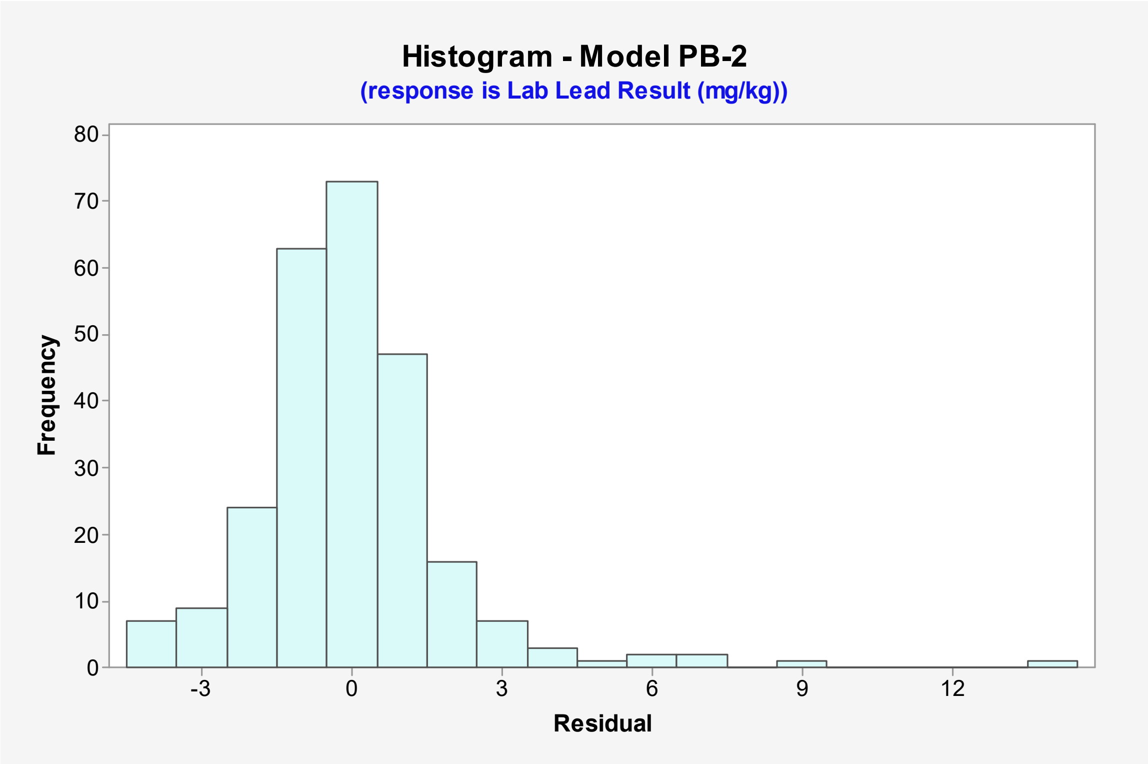


Figure B3-78. Ex Situ Bulk Sample Historgram of Lead Standardized Residuals for Model PB-2

6.3 LEAD STATISTICAL OUTPUT (MODEL PB-1A)

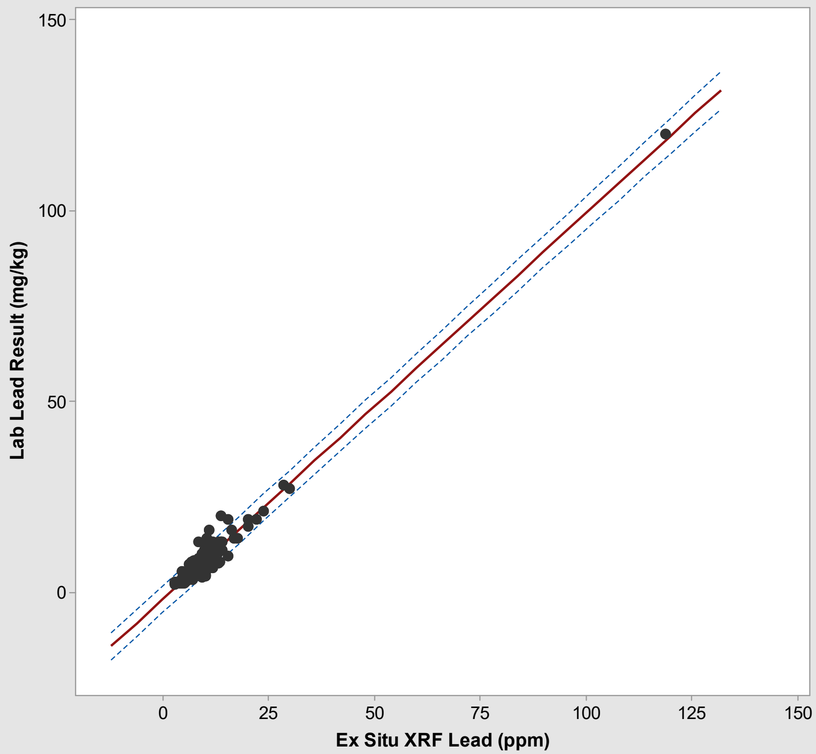
Regression for Lab Lead Result (mg/kg) vs Ex Situ XRF Lead (ppm)

Prediction Report - Model PB-1A

Y: Lab Lead Result (mg/kg)
X: Ex Situ XRF Lead (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-12	-14.138	(-17.674, -10.602)
-6	-8.0658	(-11.577, -4.5543)
0	-1.9935	(-5.4886, 1.5016)
6	4.0788	(0.59204, 7.5655)
12	10.151	(6.6645, 13.638)
18	16.223	(12.729, 19.718)
24	22.296	(18.785, 25.806)
30	28.368	(24.833, 31.903)
36	34.440	(30.874, 38.007)
42	40.513	(36.907, 44.119)
48	46.585	(42.932, 50.238)
54	52.657	(48.950, 56.364)
60	58.729	(54.962, 62.497)
66	64.802	(60.967, 68.637)
72	70.874	(66.966, 74.782)
78	76.946	(72.959, 80.934)
84	83.019	(78.947, 87.091)
90	89.091	(84.929, 93.253)
96	95.163	(90.907, 99.420)
102	101.24	(96.880, 105.59)
108	107.31	(102.85, 111.77)
114	113.38	(108.81, 117.95)
120	119.45	(114.78, 124.13)
126	125.52	(120.73, 130.32)
132	131.60	(126.69, 136.51)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-79. Minitab Prediction Report for Model PB-1A

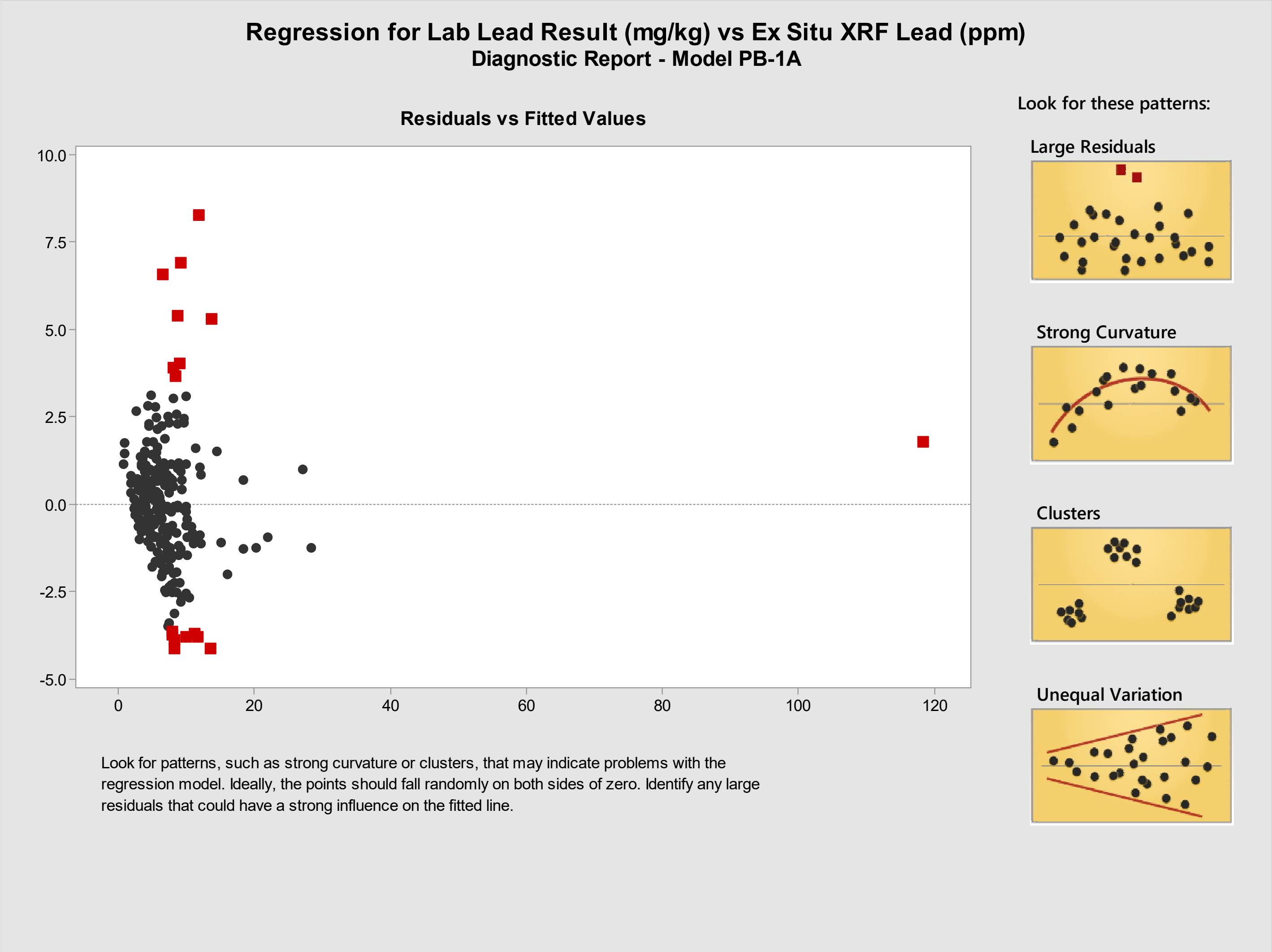


Figure B3-80. Minitab Residuals Report for Model PB-1A

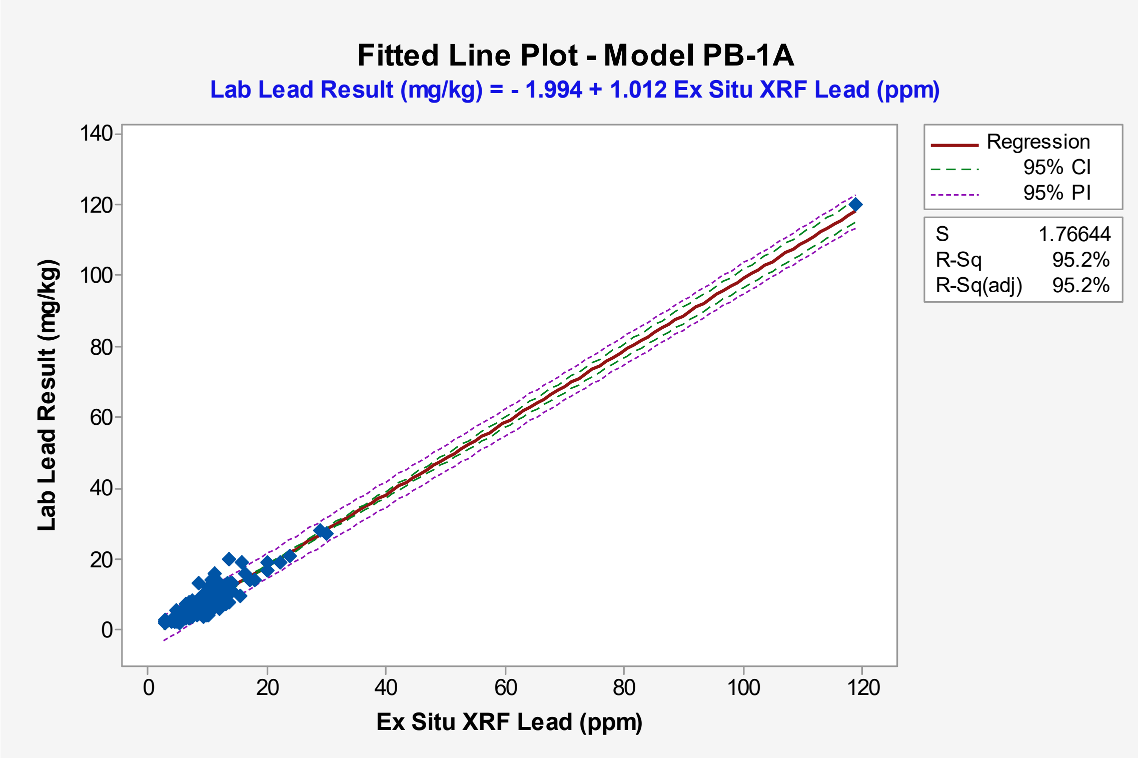


Figure B3-81. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-1A

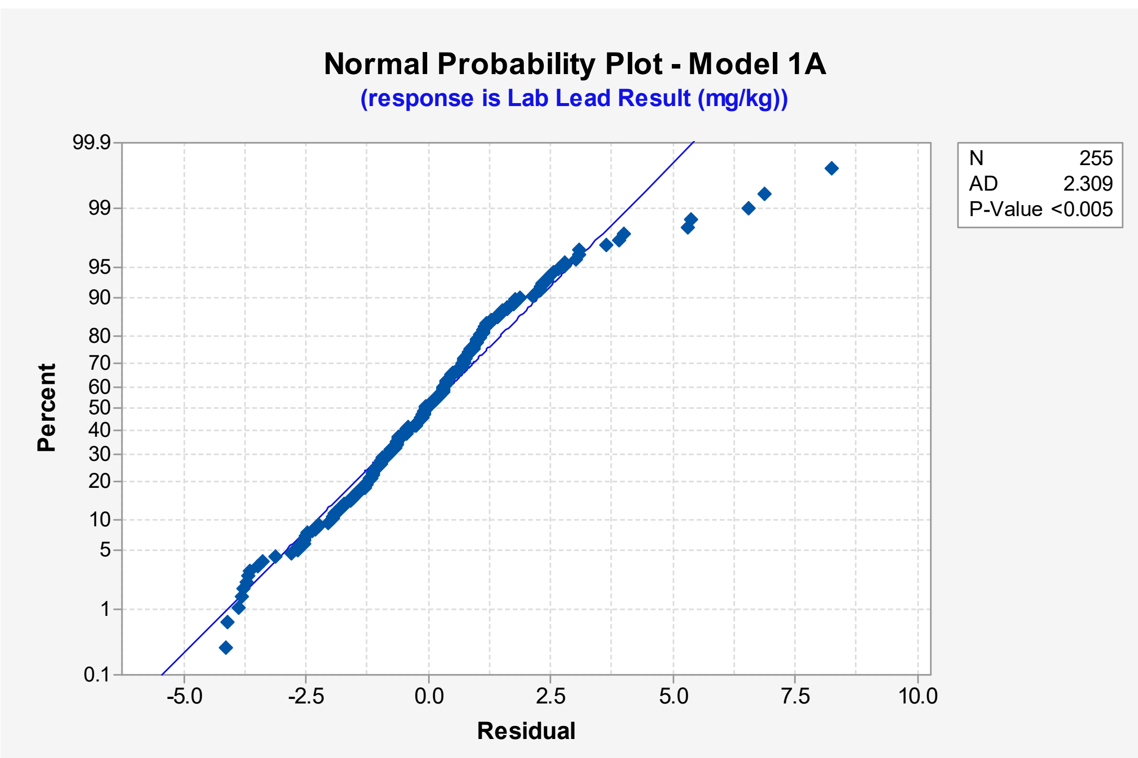


Figure B3-82. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-1A

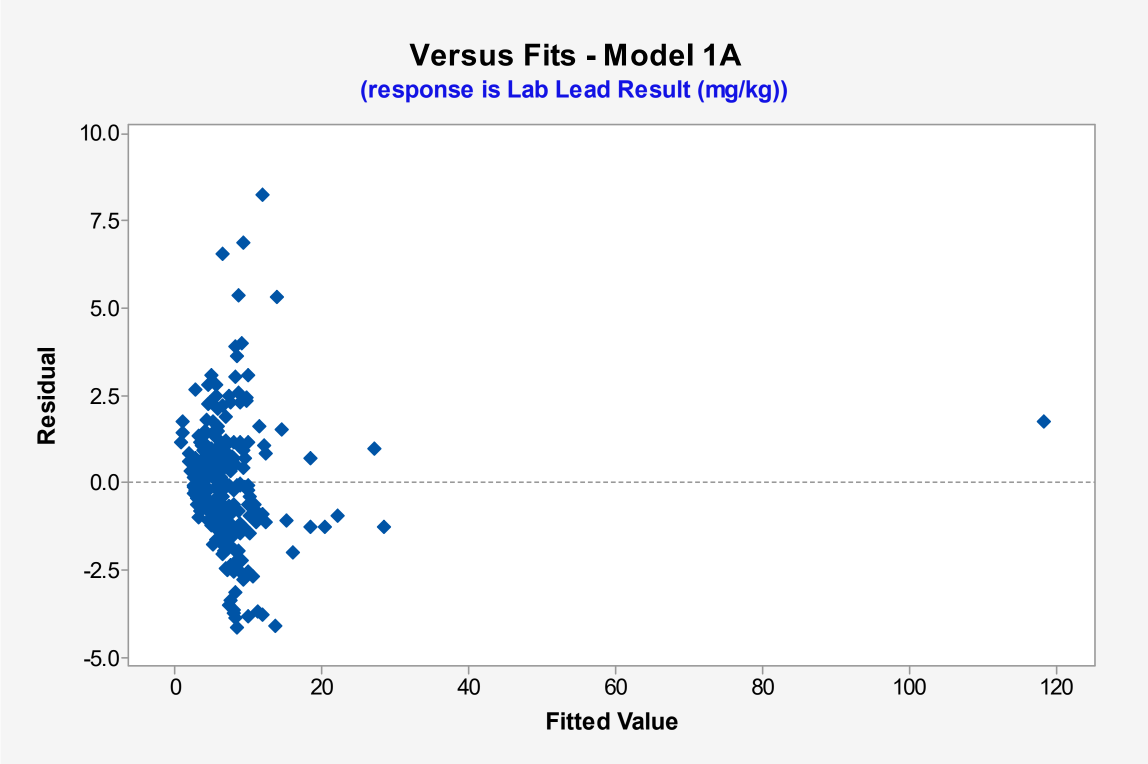


Figure B3-83. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-1A

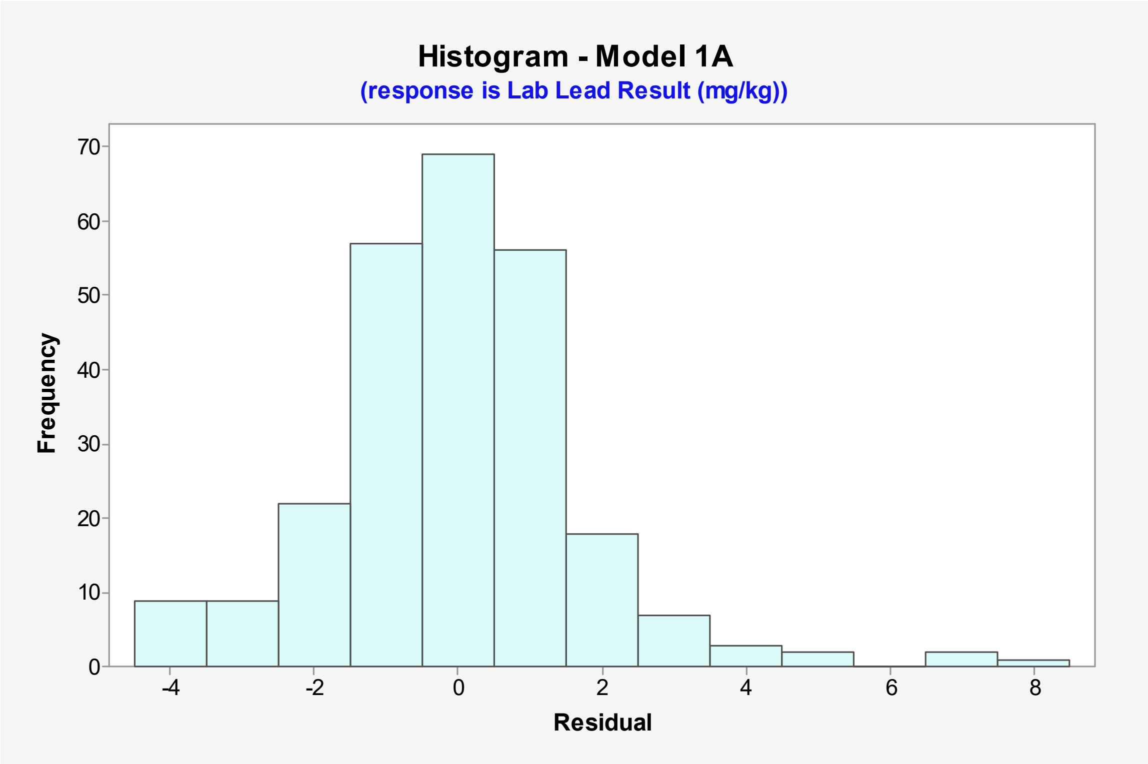


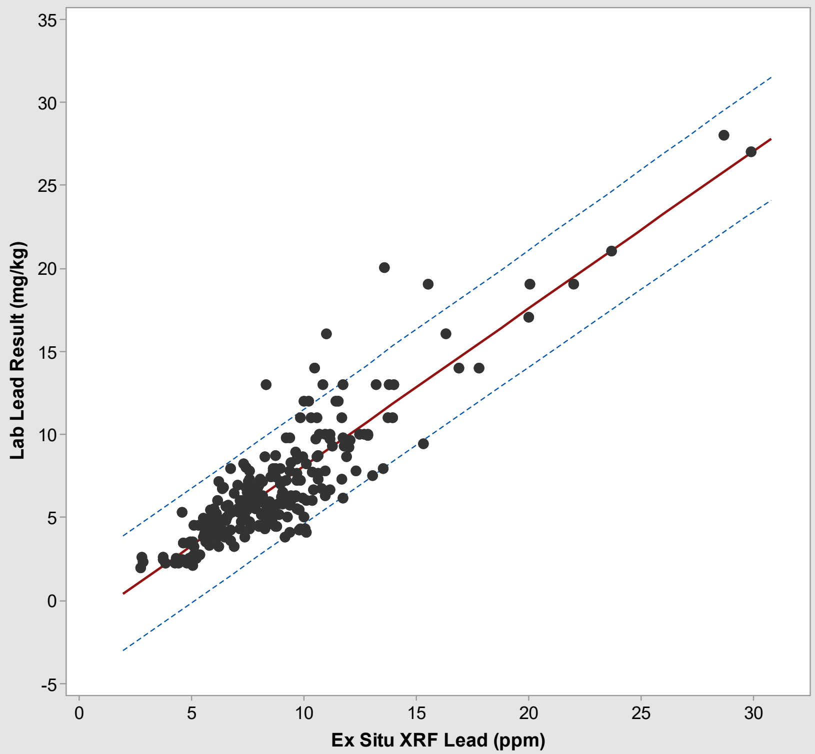
Figure B3-84. Ex Situ Bulk Sample Historgram of Lead Standardized Residuals for Model PB-1A

6.4 LEAD STATISTICAL OUTPUT (MODEL PB-2A)

Regression for Lab Lead Result (mg/kg) vs Ex Situ XRF Lead (ppm)
Prediction Report - Model PB-2A

Y: Lab Lead Result (mg/kg)
X: Ex Situ XRF Lead (ppm)

Prediction Plot
The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
2	0.42793	(-3.0558, 3.9116)
3.2	1.5702	(-1.9057, 5.0461)
4.4	2.7124	(-0.75720, 6.1821)
5.6	3.8547	(0.38981, 7.3196)
6.8	4.9969	(1.5353, 8.4586)
8	6.1392	(2.6792, 9.5992)
9.2	7.2815	(3.8216, 10.741)
10.4	8.4237	(4.9625, 11.885)
11.6	9.5660	(6.1018, 13.030)
12.8	10.708	(7.2396, 14.177)
14	11.850	(8.3759, 15.325)
15.2	12.993	(9.5107, 16.475)
16.4	14.135	(10.644, 17.626)
17.6	15.277	(11.776, 18.779)
18.8	16.419	(12.906, 19.933)
20	17.562	(14.035, 21.089)
21.2	18.704	(15.162, 22.246)
22.4	19.846	(16.288, 23.404)
23.6	20.988	(17.413, 24.564)
24.8	22.131	(18.536, 25.726)
26	23.273	(19.657, 26.889)
27.2	24.415	(20.778, 28.053)
28.4	25.558	(21.897, 29.218)
29.6	26.700	(23.015, 30.385)
30.8	27.842	(24.131, 31.553)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-85. Minitab Prediction Report for Model PB-2A

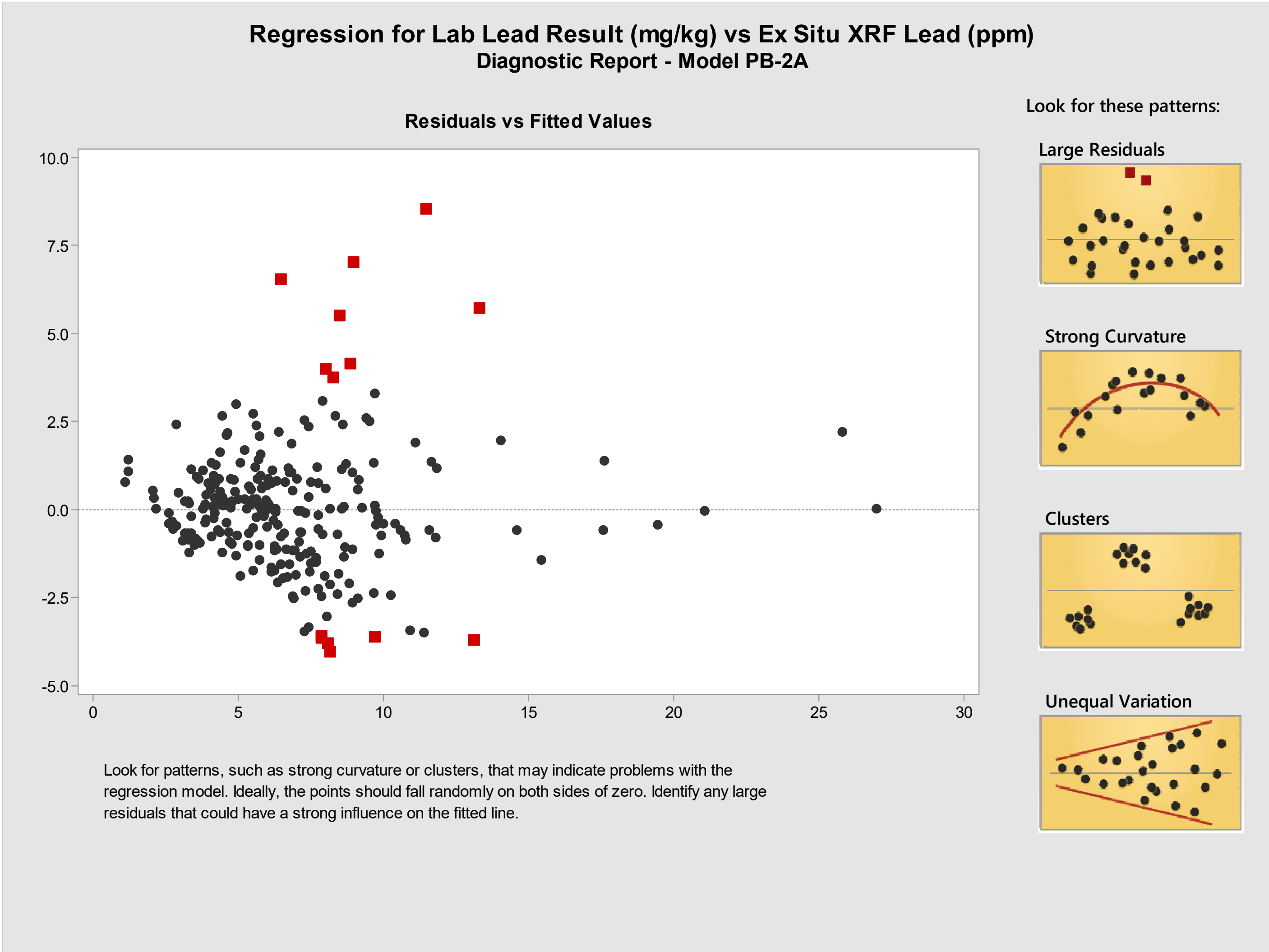


Figure B3-86. Minitab Residuals Report for Model PB-2A

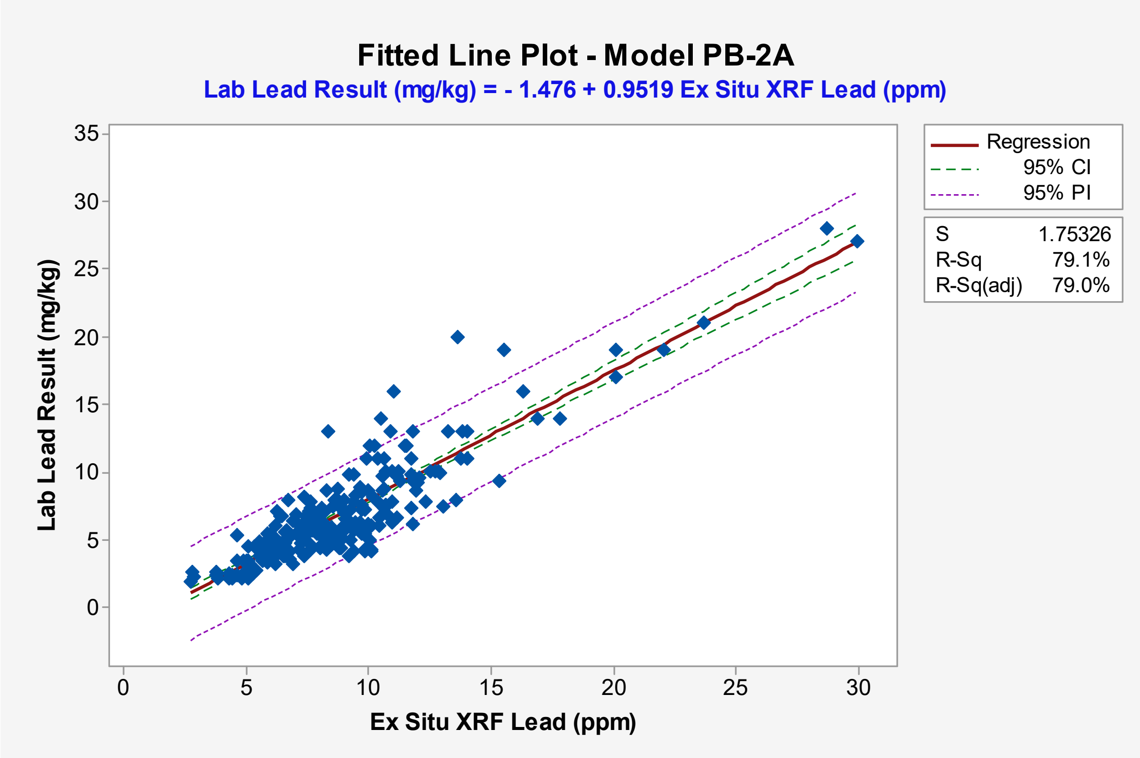


Figure B3-87. Ex Situ Bulk Sample Fitted Line Plot for Lead Model PB-2A

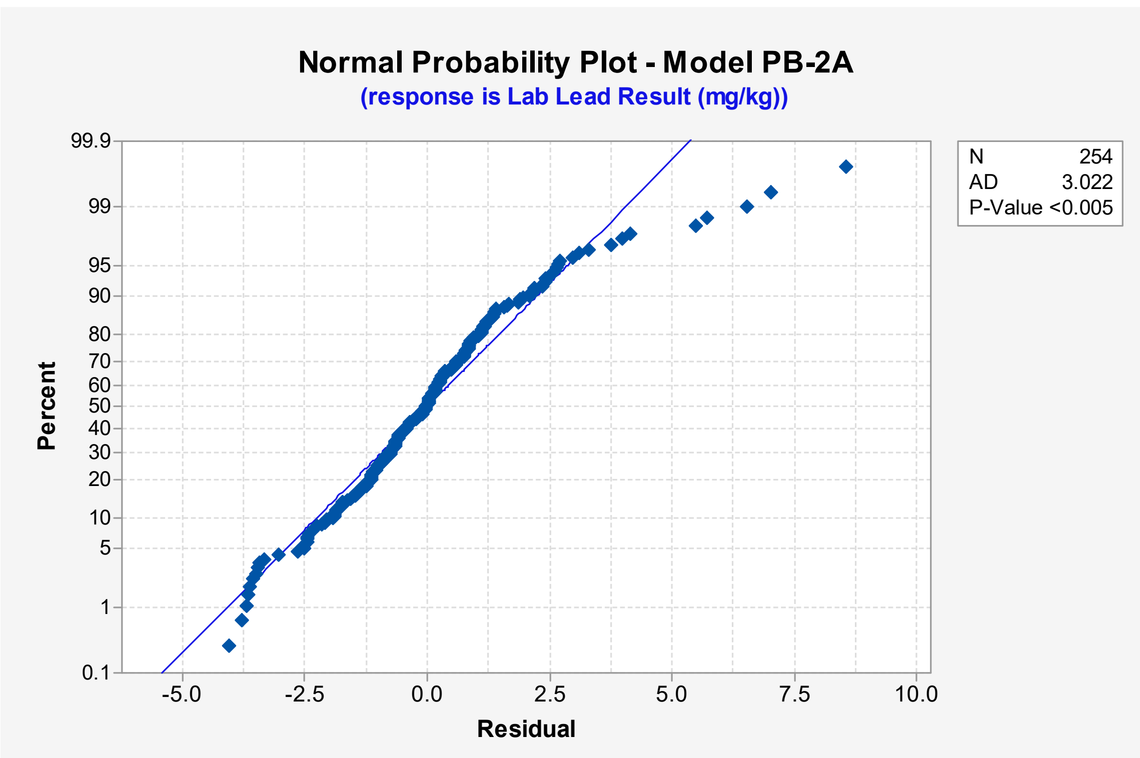


Figure B3-88. Ex Situ Bulk Sample Normal Probability Plot of Lead Standardized Residuals for Model PB-2A

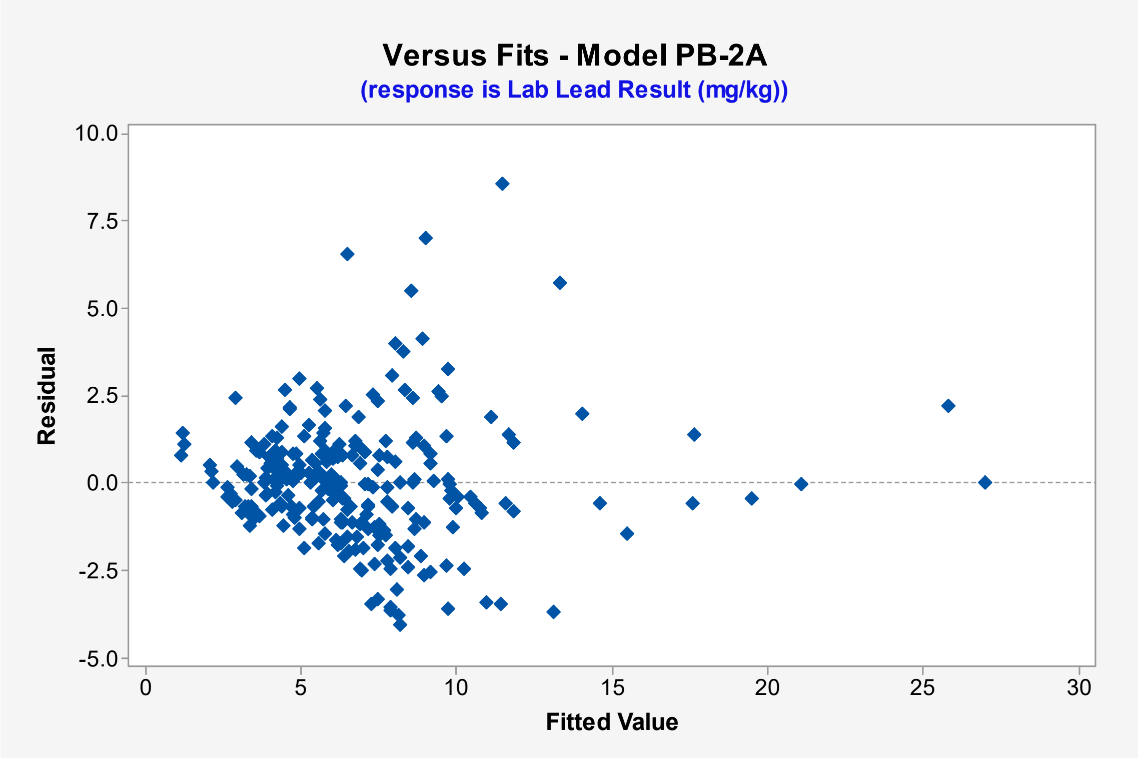


Figure B3-89. Ex Situ Bulk Sample Versus Fits Residuals Lead for Model PB-2A

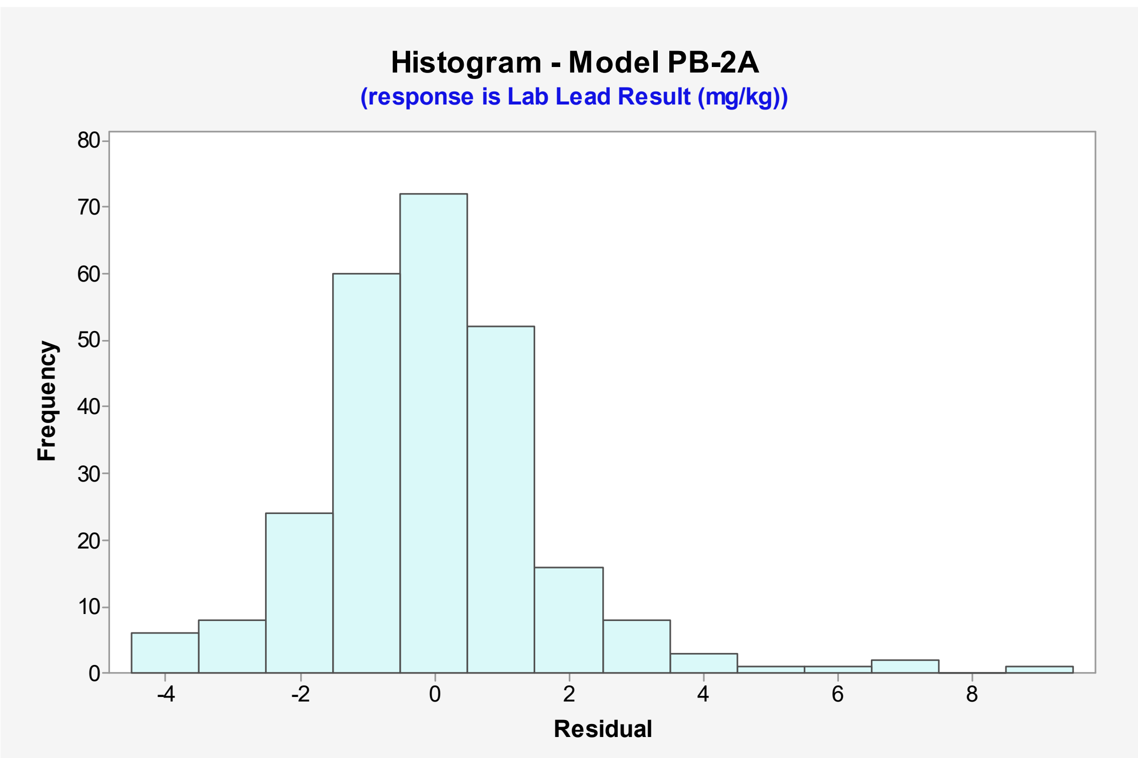


Figure B3-90. Ex Situ Bulk Sample Historgram of Lead Standardized Residals for Model PB-2A

7.0 THORIUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

7.1 THORIUM STATISTICAL OUTPUT (MODEL TH-1)

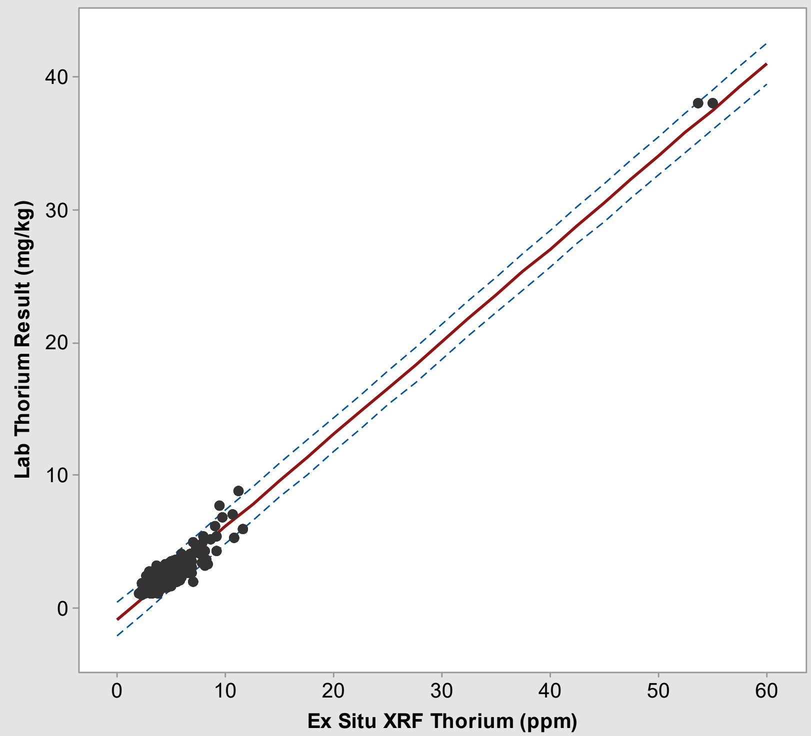
Regression for Lab Thorium Result (mg/kg) vs Ex Situ XRF Thorium (ppm)

Prediction Report - Model TH-1

Y: Lab Thorium Result (mg/kg)
X: Ex Situ XRF Thorium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	-0.85220	(-2.1081, 0.40366)
2.5	0.89375	(-0.35997, 2.1475)
5	2.6397	(1.3867, 3.8927)
7.5	4.3856	(3.1320, 5.6393)
10	6.1316	(4.8759, 7.3873)
12.5	7.8775	(6.6184, 9.1367)
15	9.6235	(8.3595, 10.887)
17.5	11.369	(10.099, 12.640)
20	13.115	(11.838, 14.393)
22.5	14.861	(13.575, 16.148)
25	16.607	(15.311, 17.904)
27.5	18.353	(17.045, 19.661)
30	20.099	(18.778, 21.420)
32.5	21.845	(20.510, 23.180)
35	23.591	(22.241, 24.941)
37.5	25.337	(23.971, 26.703)
40	27.083	(25.700, 28.466)
42.5	28.829	(27.428, 30.230)
45	30.575	(29.154, 31.995)
47.5	32.321	(30.880, 33.761)
50	34.067	(32.605, 35.529)
52.5	35.813	(34.329, 37.297)
55	37.559	(36.052, 39.065)
57.5	39.305	(37.774, 40.835)
60	41.050	(39.496, 42.605)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-91. Minitab Prediction Report for Model TH-1

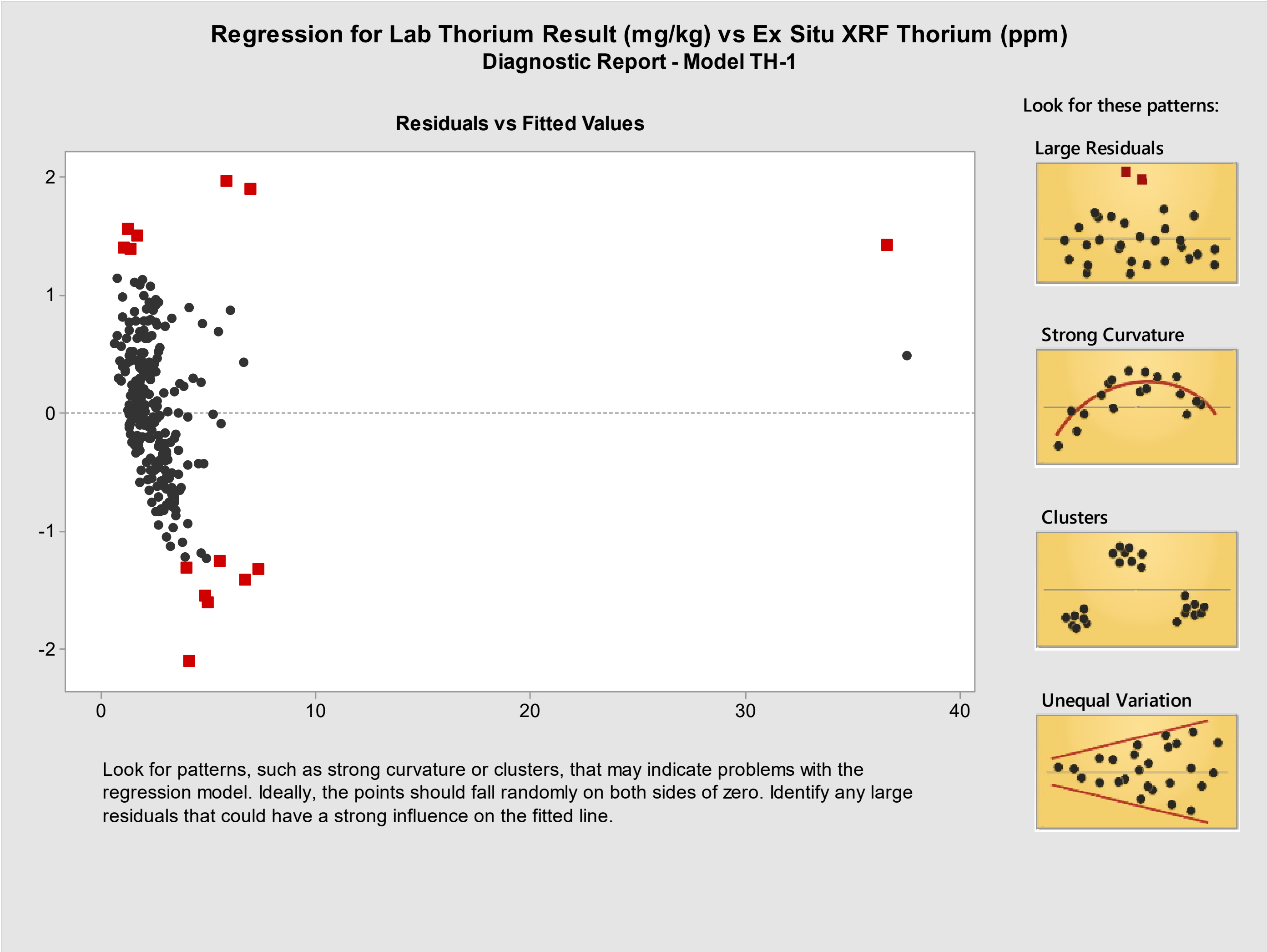


Figure B3-92. Minitab Residuals Report for Model TH-1

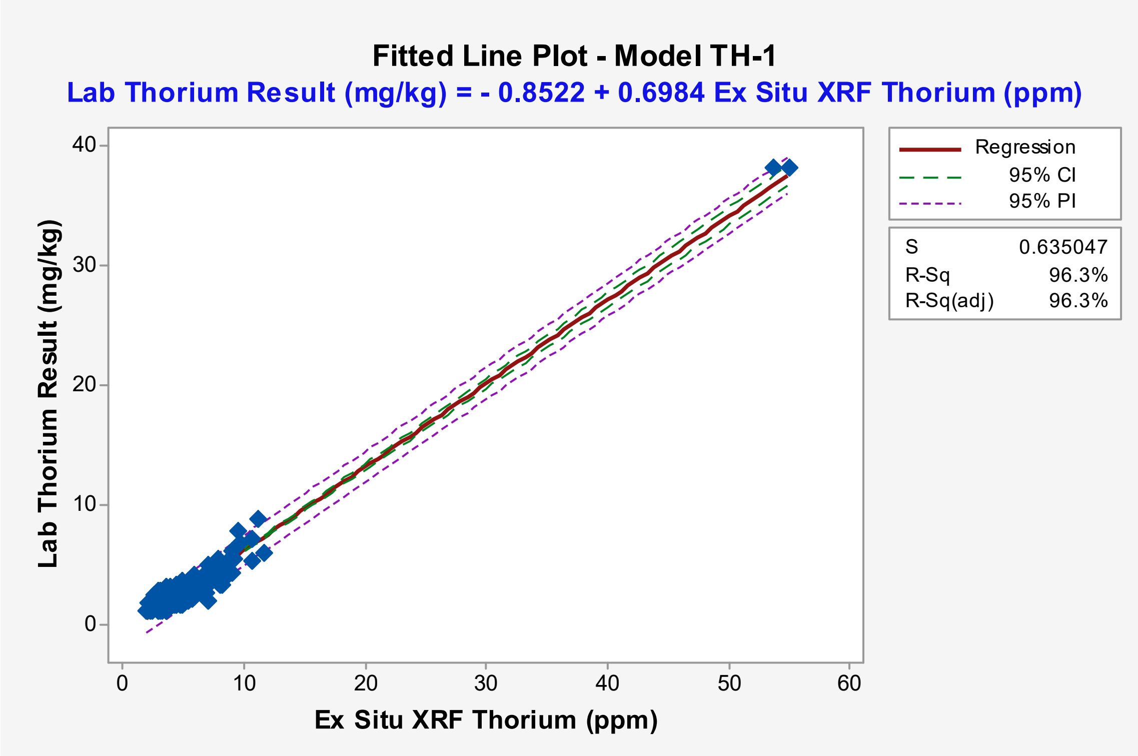


Figure B3-93. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-1

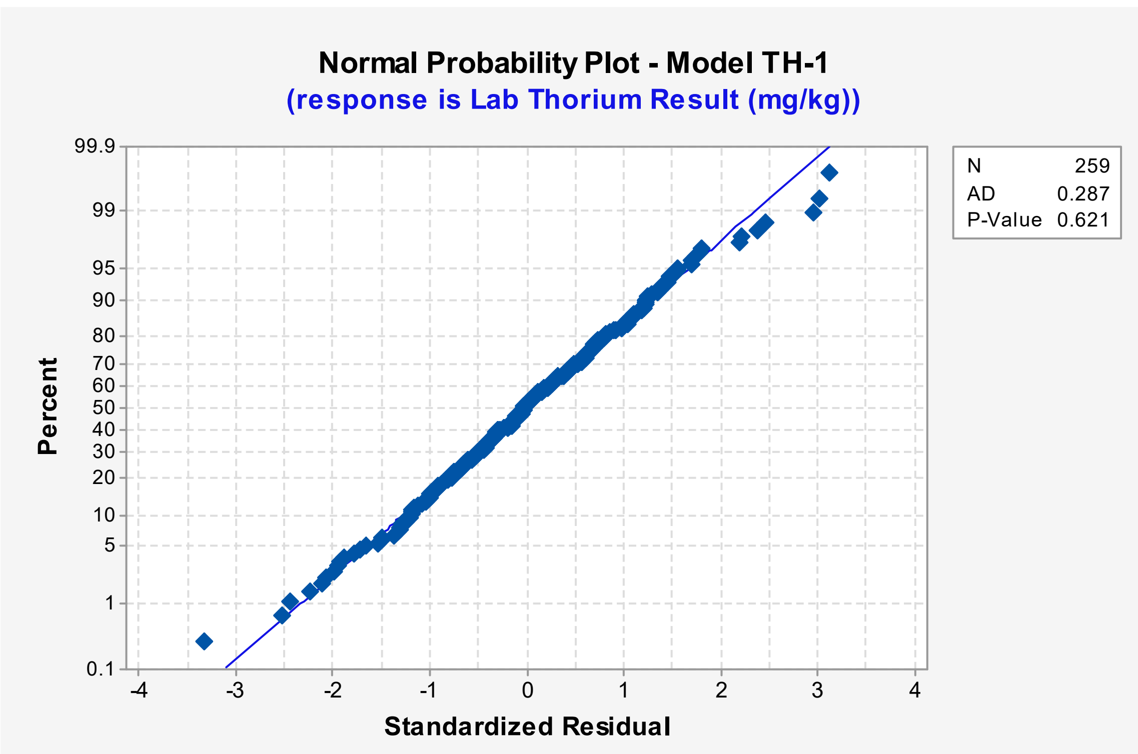


Figure B3-94. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-1

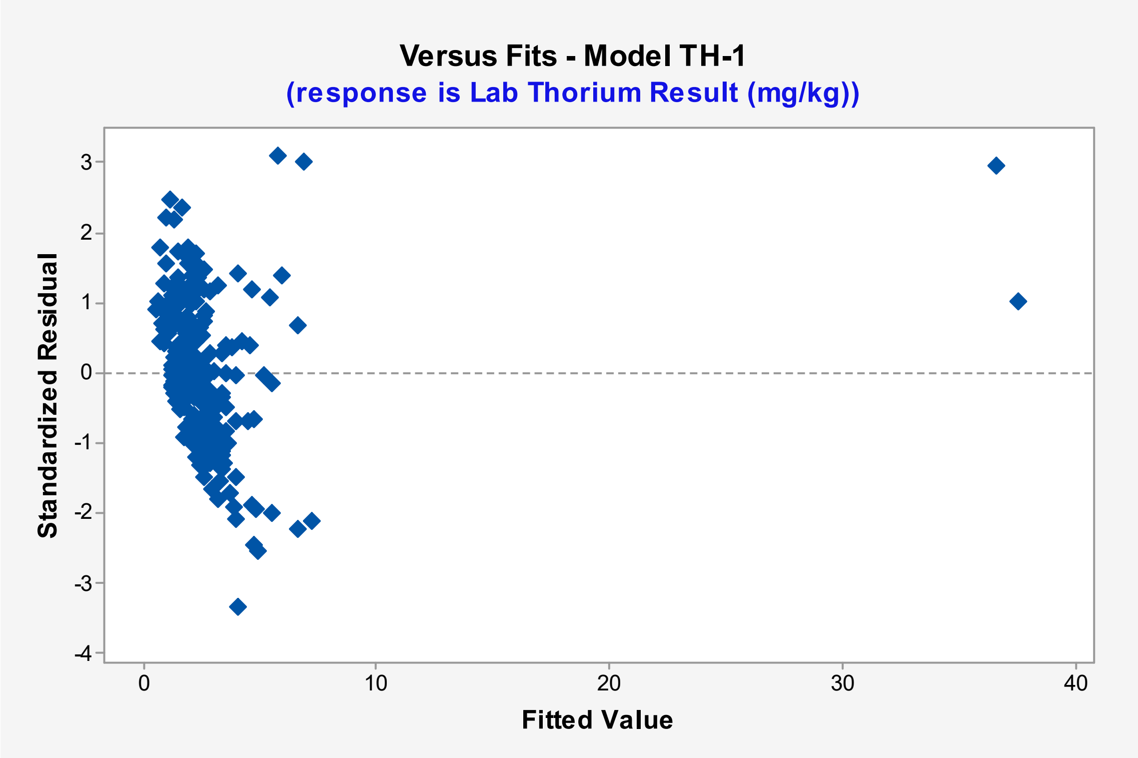


Figure B3-95. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-1

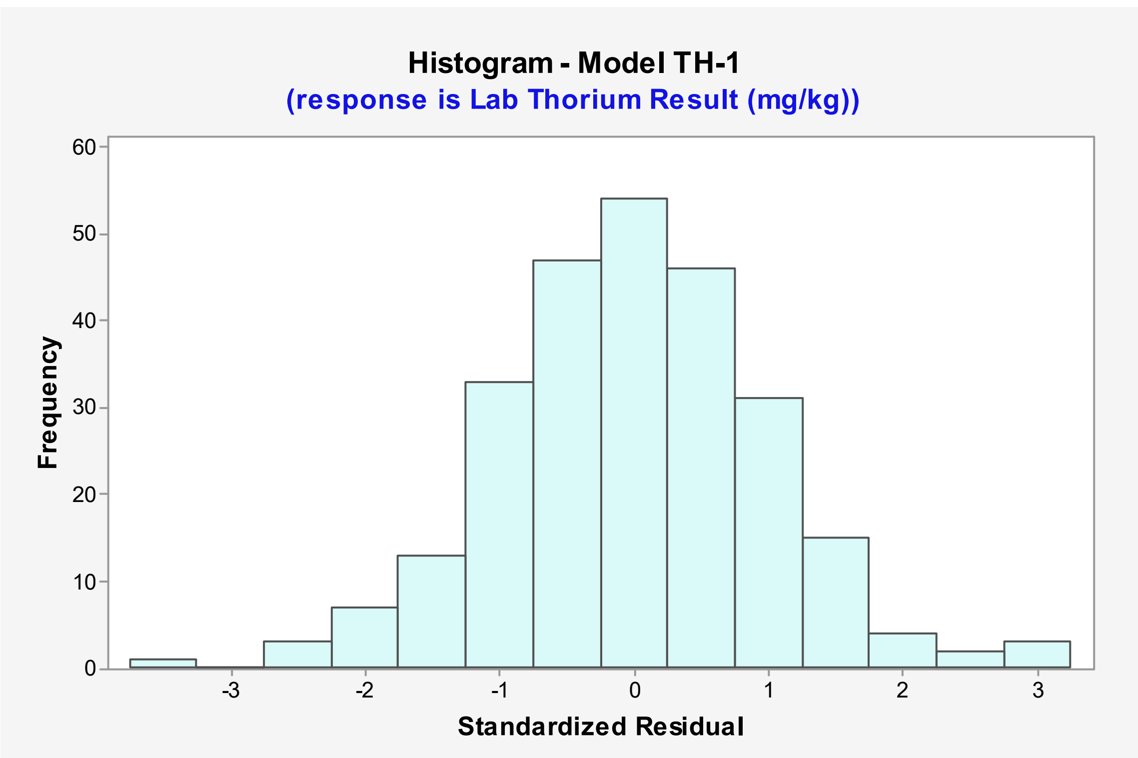


Figure B3-96. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-1

7.2 THORIUM STATISTICAL OUTPUT (MODEL TH-2)

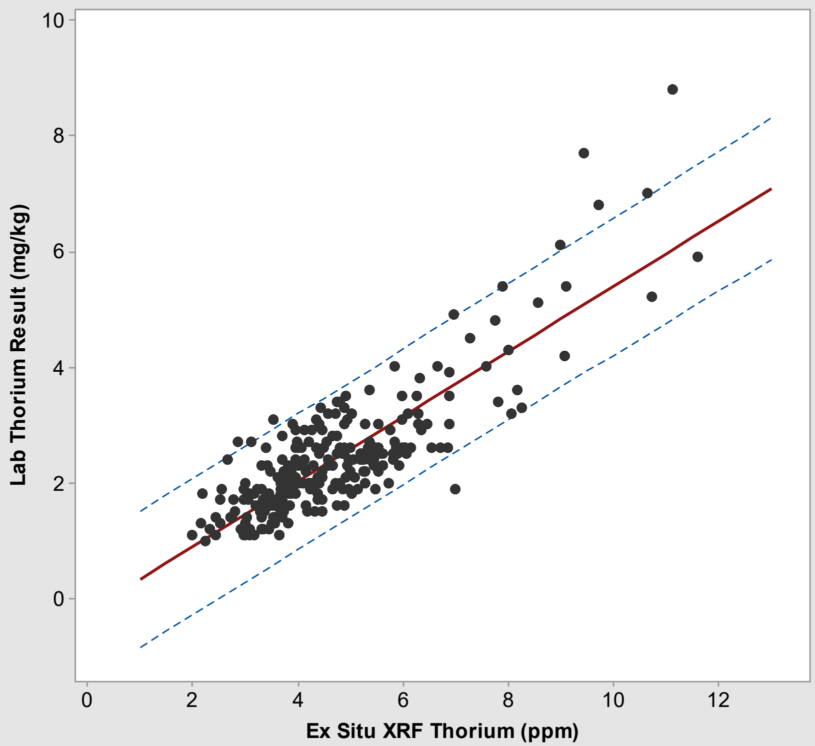
Regression for Lab Thorium Result (mg/kg) vs Ex Situ XRF Thorium (ppm)

Prediction Report - Model TH-2

Y: Lab Thorium Result (mg/kg)
X: Ex Situ XRF Thorium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
1	0.34428	(-0.82980, 1.5184)
1.5	0.62507	(-0.54613, 1.7963)
2	0.90586	(-0.26287, 2.0746)
2.5	1.1866	(0.019974, 2.3533)
3	1.4674	(0.30240, 2.6325)
3.5	1.7482	(0.58440, 2.9120)
4	2.0290	(0.86599, 3.1920)
4.5	2.3098	(1.1472, 3.4724)
5	2.5906	(1.4279, 3.7533)
5.5	2.8714	(1.7082, 4.0345)
6	3.1522	(1.9881, 4.3162)
6.5	3.4330	(2.2676, 4.5983)
7	3.7137	(2.5467, 4.8808)
7.5	3.9945	(2.8253, 5.1638)
8	4.2753	(3.1035, 5.4471)
8.5	4.5561	(3.3813, 5.7309)
9	4.8369	(3.6587, 6.0150)
9.5	5.1177	(3.9357, 6.2996)
10	5.3985	(4.2123, 6.5846)
10.5	5.6793	(4.4885, 6.8700)
11	5.9600	(4.7644, 7.1557)
11.5	6.2408	(5.0398, 7.4419)
12	6.5216	(5.3148, 7.7284)
12.5	6.8024	(5.5895, 8.0153)
13	7.0832	(5.8638, 8.3026)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-97. Minitab Prediction Report for Model TH-2

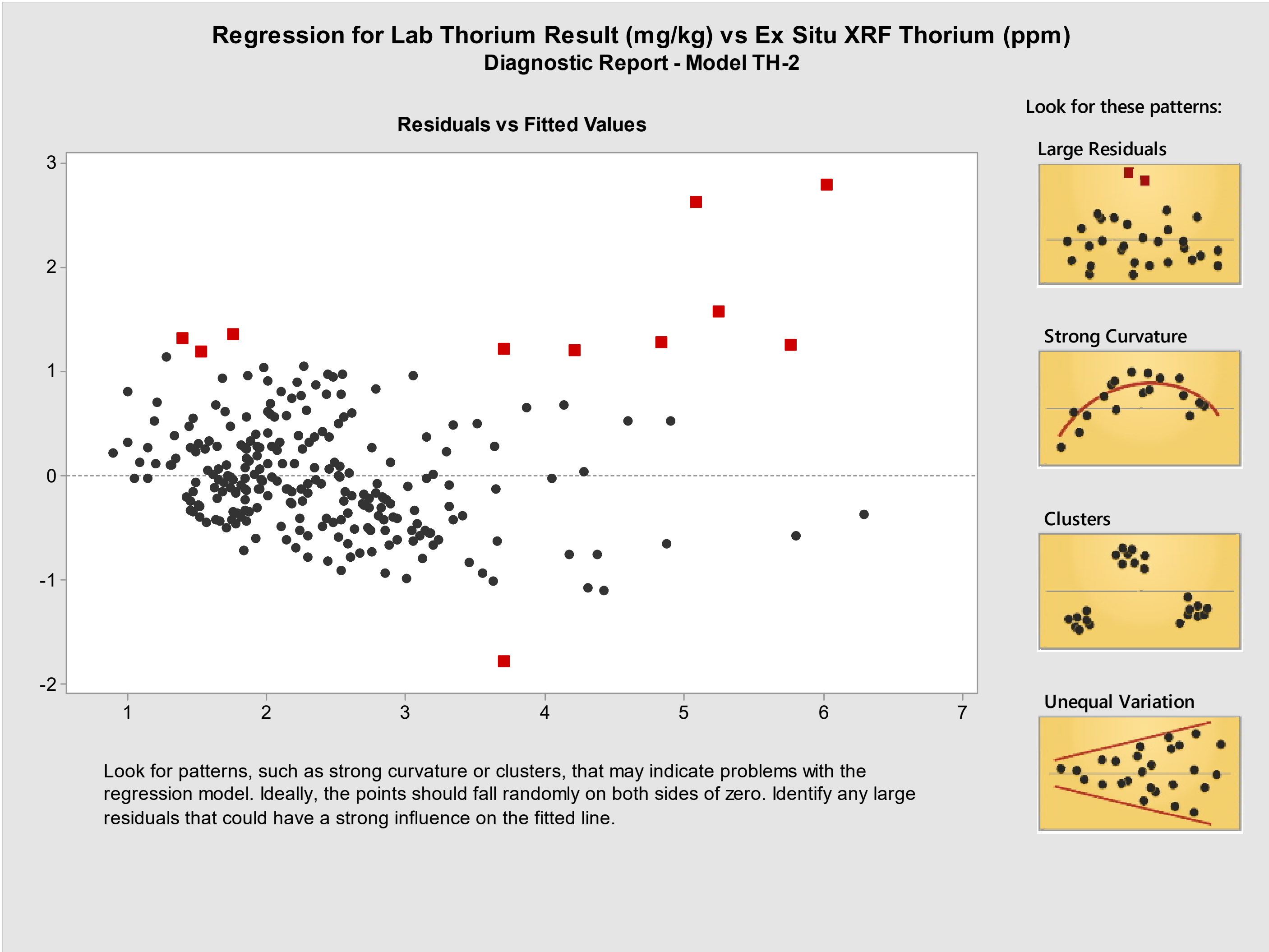


Figure B3-98. Minitab Residuals Report for Model TH-2

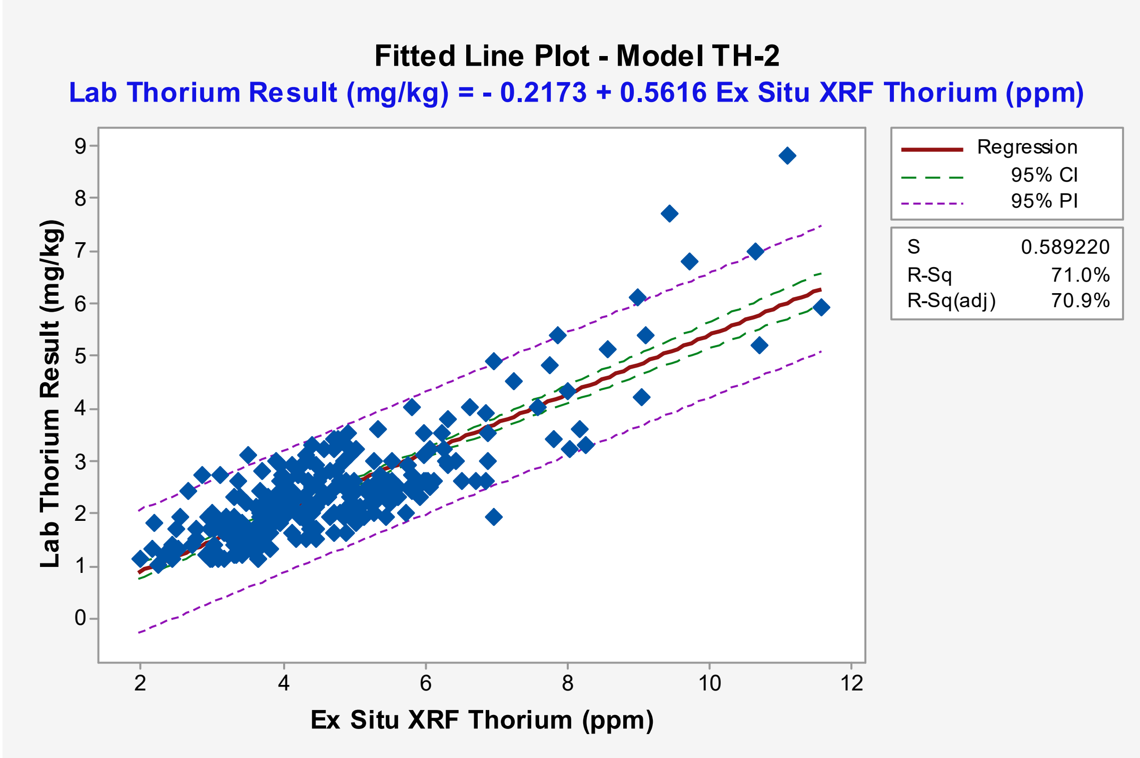


Figure B3-99. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-2

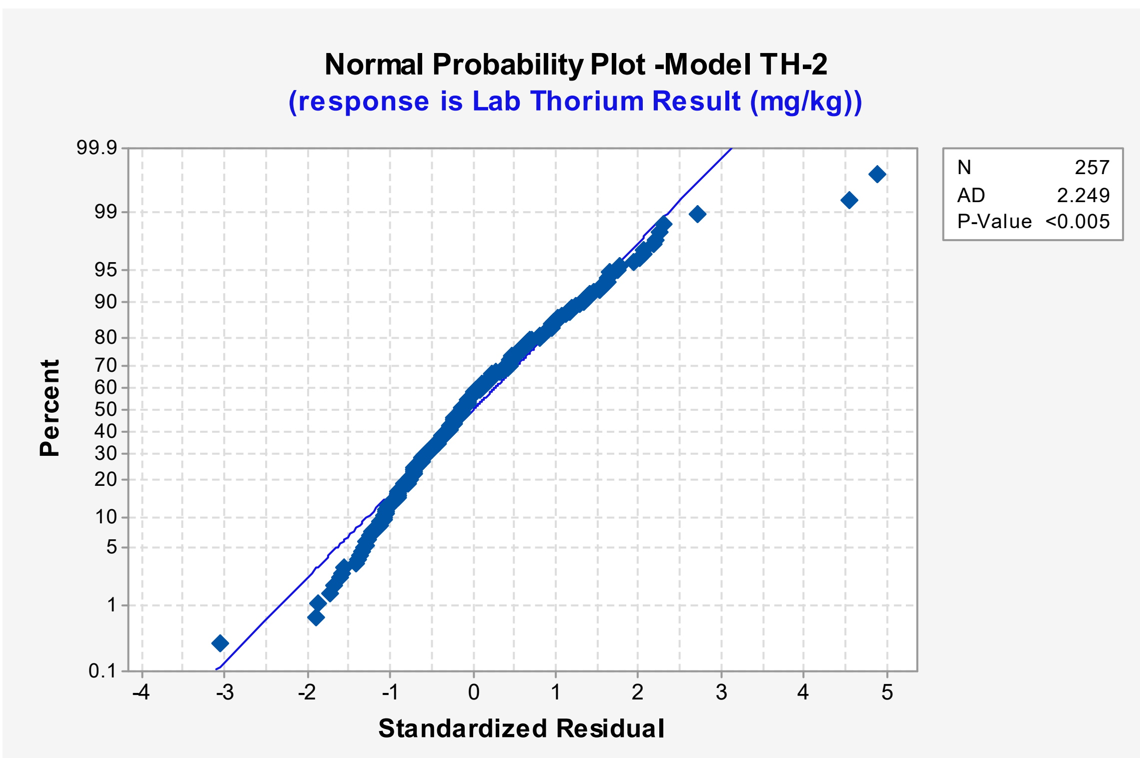


Figure B3-100. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-2

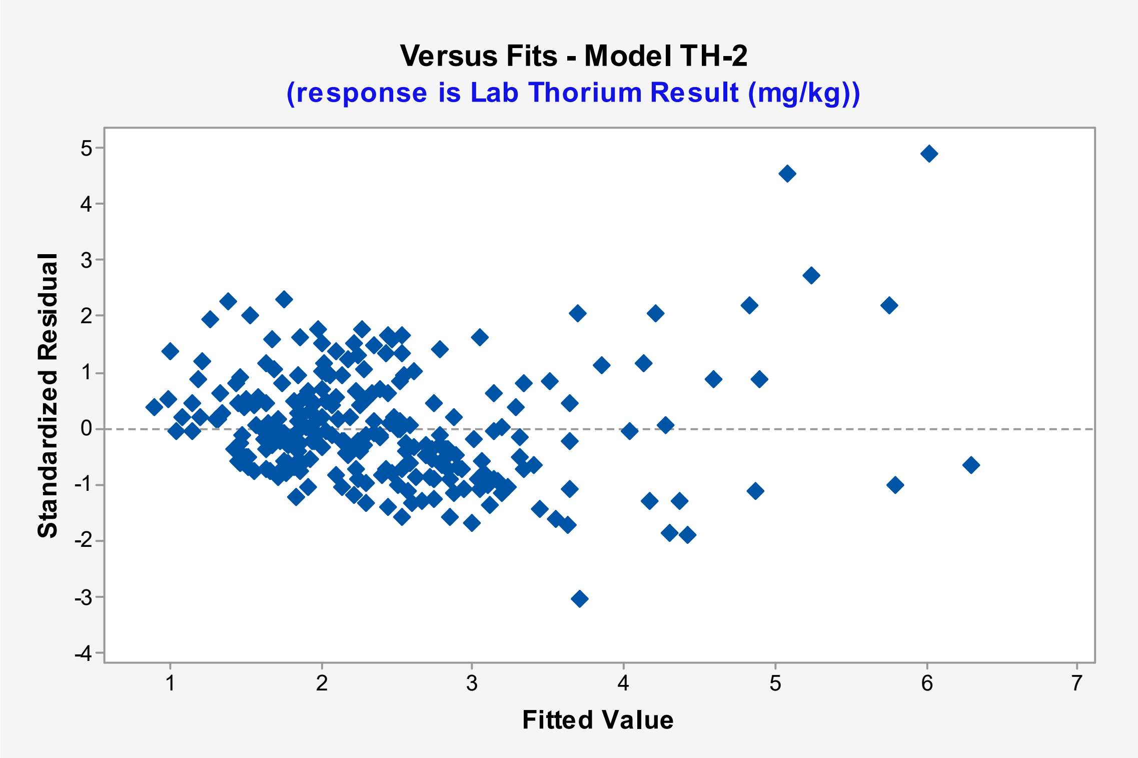


Figure B3-101. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-2

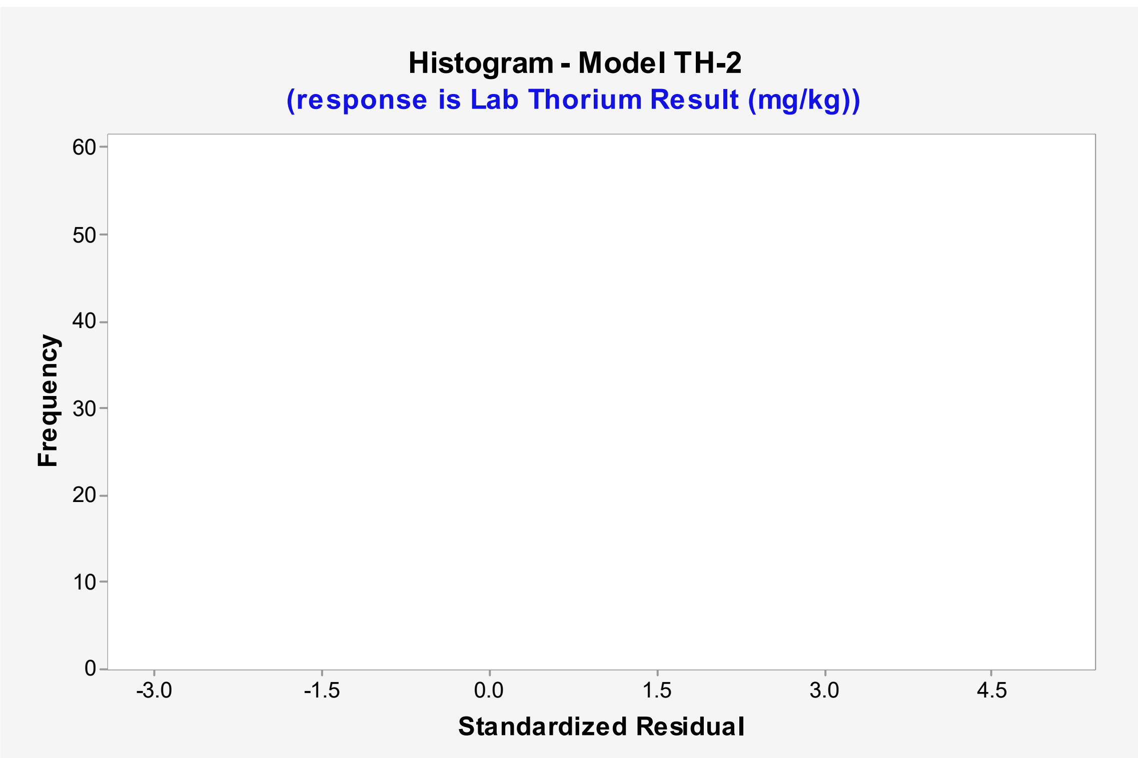


Figure B3-102. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-2

7.3 THORIUM STATISTICAL OUTPUT (MODEL TH-1A)

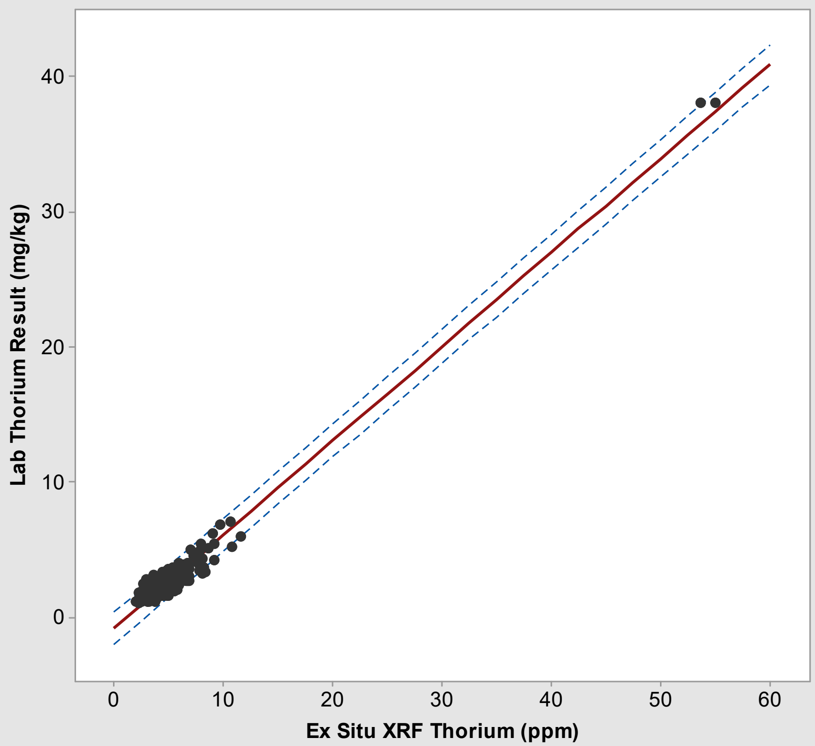
Regression for Lab Thorium Result (mg/kg) vs Ex Situ XRF Thorium (ppm)

Prediction Report - Model TH-1A

Y: Lab Thorium Result (mg/kg)
X: Ex Situ XRF Thorium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
0	-0.84434	(-2.0321, 0.34346)
2.5	0.89431	(-0.29147, 2.0801)
5	2.6330	(1.4479, 3.8180)
7.5	4.3716	(3.1859, 5.5574)
10	6.1103	(4.9225, 7.2980)
12.5	7.8489	(6.6578, 9.0400)
15	9.5876	(8.3918, 10.783)
17.5	11.326	(10.125, 12.528)
20	13.065	(11.856, 14.274)
22.5	14.804	(13.586, 16.021)
25	16.542	(15.315, 17.769)
27.5	18.281	(17.043, 19.519)
30	20.019	(18.769, 21.270)
32.5	21.758	(20.495, 23.022)
35	23.497	(22.219, 24.775)
37.5	25.235	(23.942, 26.529)
40	26.974	(25.664, 28.284)
42.5	28.713	(27.386, 30.040)
45	30.451	(29.106, 31.797)
47.5	32.190	(30.825, 33.555)
50	33.929	(32.544, 35.314)
52.5	35.667	(34.261, 37.073)
55	37.406	(35.978, 38.834)
57.5	39.145	(37.694, 40.595)
60	40.883	(39.409, 42.357)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-103. Minitab Prediction Report for Model TH-1A

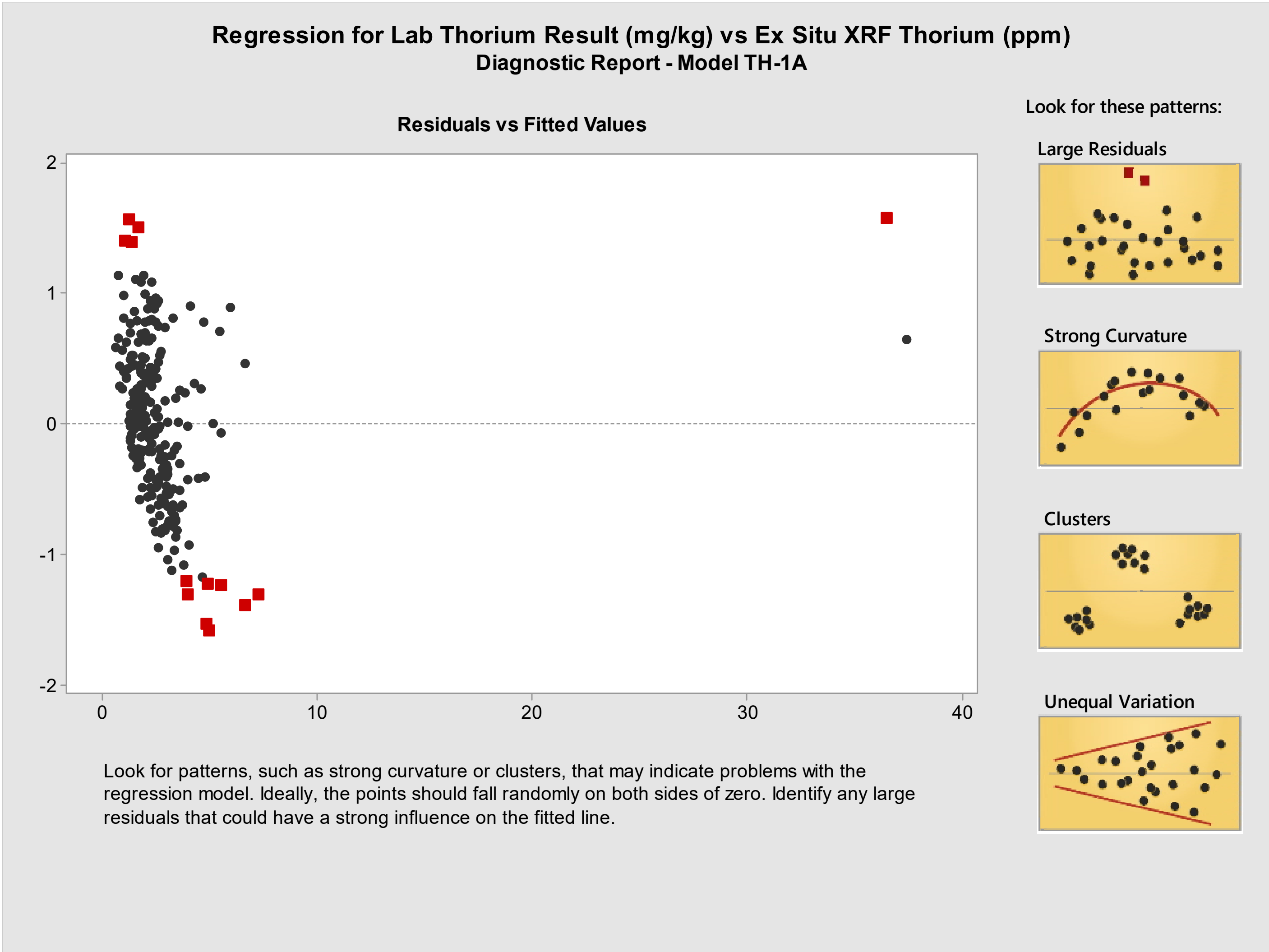


Figure B3-104. Minitab Residuals Report for Model TH-1A

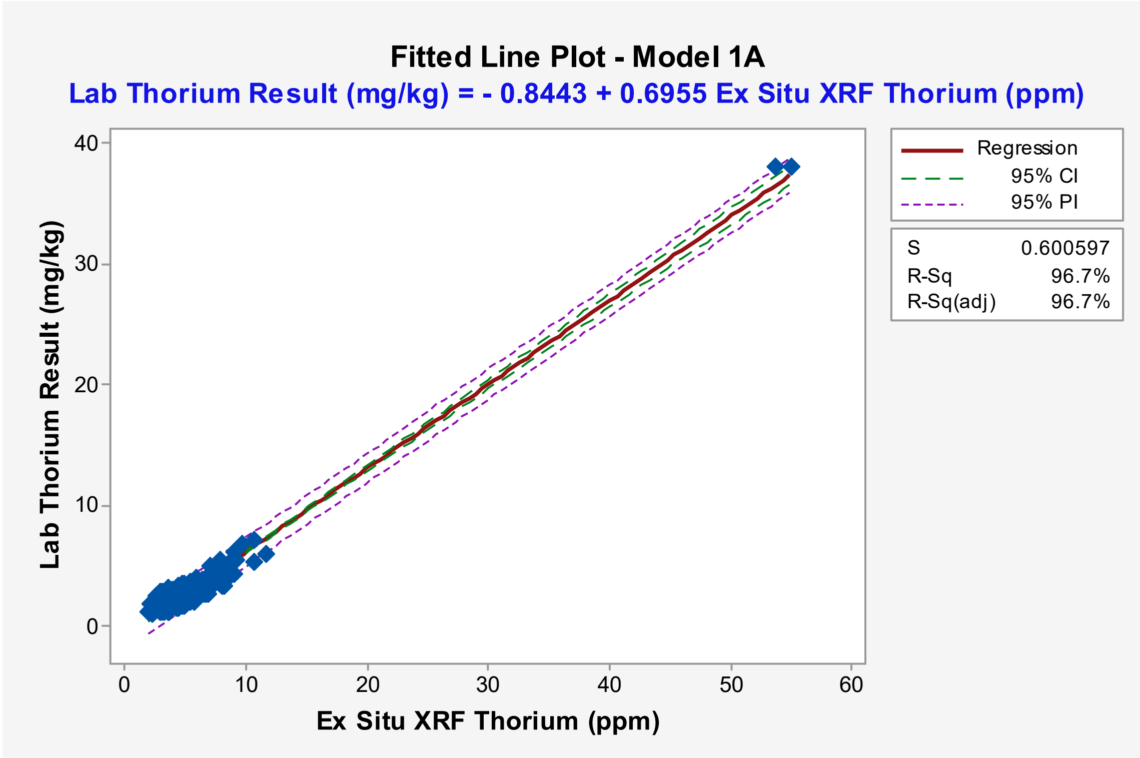


Figure B3-105. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-1A

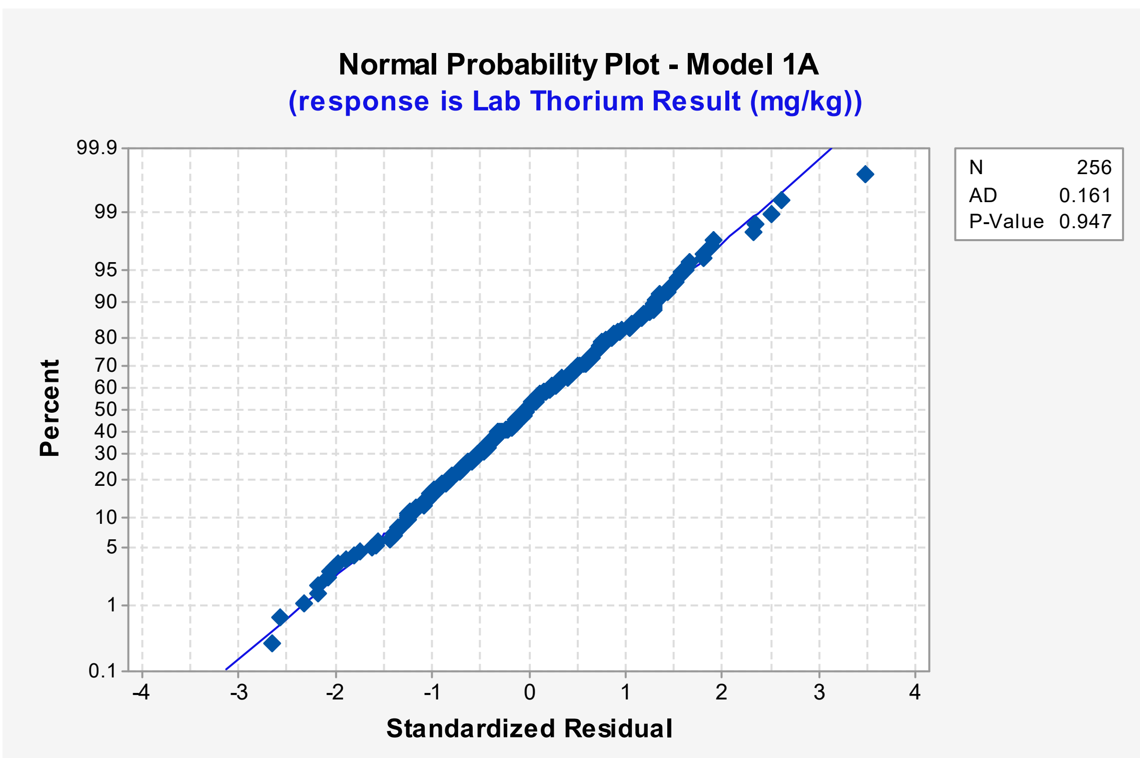


Figure B3-106. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-1A

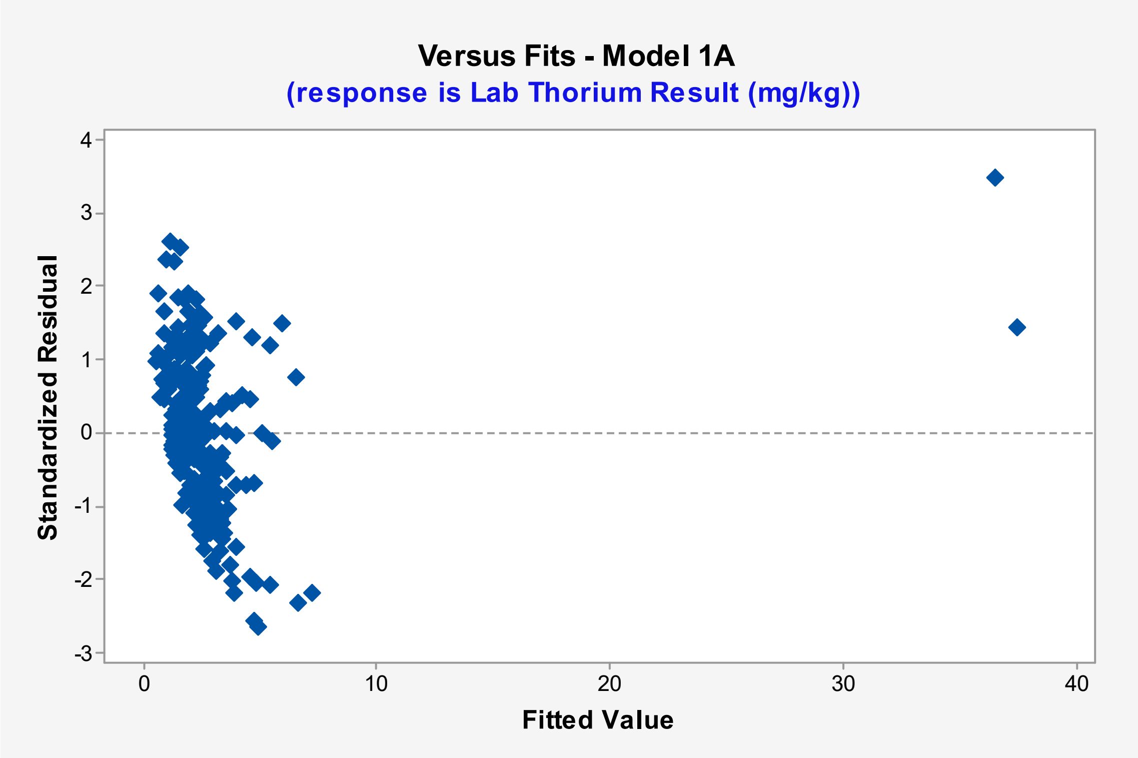


Figure B3-107. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-1A

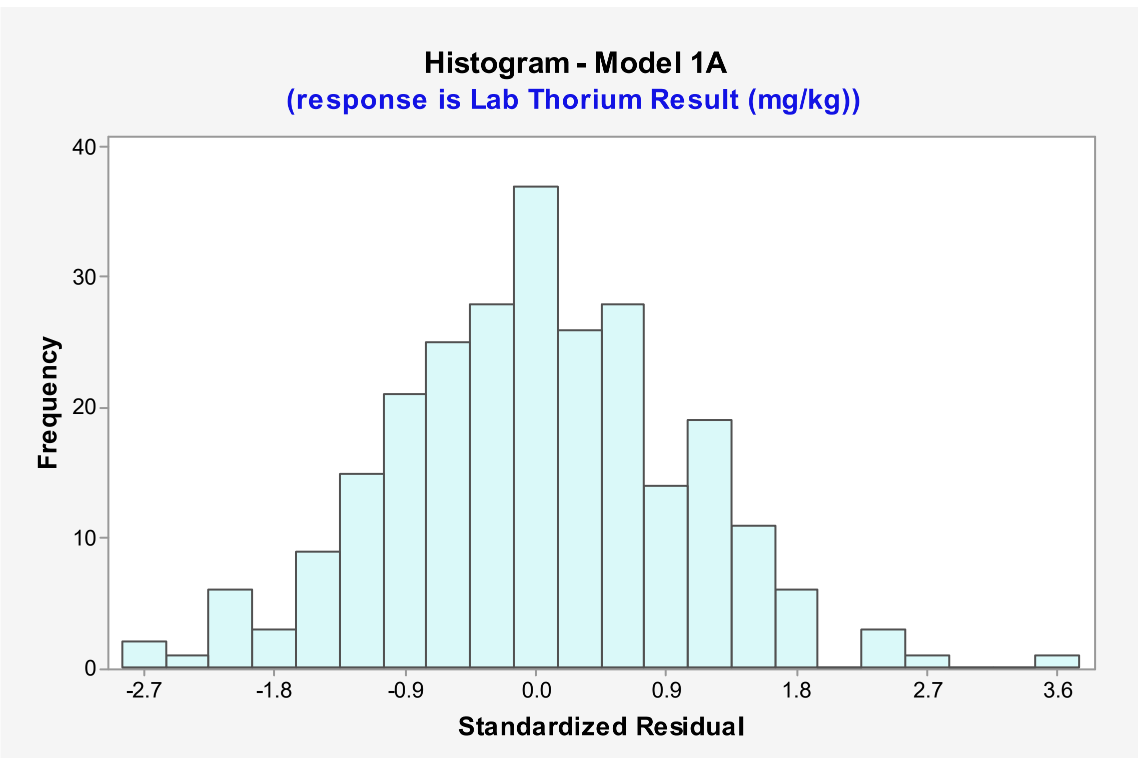


Figure B3-108. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-1A

7.4 THORIUM STATISTICAL OUTPUT (MODEL TH-2A)

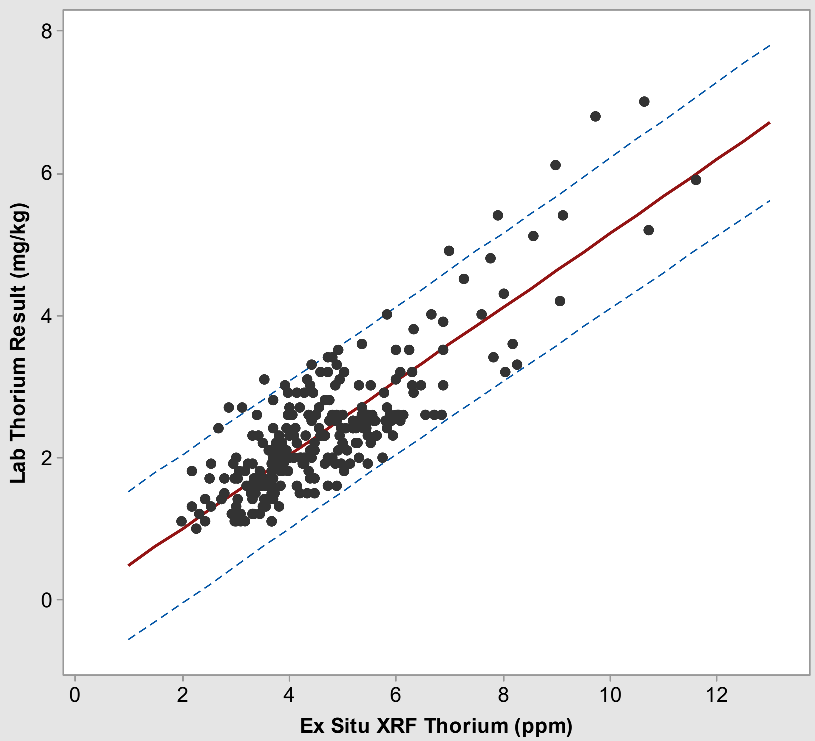
Regression for Lab Thorium Result (mg/kg) vs Ex Situ XRF Thorium (ppm)

Prediction Report - Model TH-2A

Y: Lab Thorium Result (mg/kg)
X: Ex Situ XRF Thorium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
1	0.48559	(-0.56176, 1.5329)
1.5	0.74503	(-0.29950, 1.7896)
2	1.0045	(-0.03765, 2.0466)
2.5	1.2639	(0.22378, 2.3040)
3	1.5234	(0.48480, 2.5619)
3.5	1.7828	(0.74541, 2.8202)
4	2.0422	(1.0056, 3.0789)
4.5	2.3017	(1.2654, 3.3380)
5	2.5611	(1.5247, 3.5975)
5.5	2.8206	(1.7837, 3.8575)
6	3.0800	(2.0422, 4.1179)
6.5	3.3395	(2.3003, 4.3786)
7	3.5989	(2.5580, 4.6398)
7.5	3.8583	(2.8152, 4.9015)
8	4.1178	(3.0721, 5.1635)
8.5	4.3772	(3.3286, 5.4259)
9	4.6367	(3.5846, 5.6887)
9.5	4.8961	(3.8403, 5.9520)
10	5.1556	(4.0955, 6.2156)
10.5	5.4150	(4.3504, 6.4796)
11	5.6744	(4.6049, 6.7440)
11.5	5.9339	(4.8590, 7.0088)
12	6.1933	(5.1127, 7.2740)
12.5	6.4528	(5.3660, 7.5395)
13	6.7122	(5.6190, 7.8054)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-109. Minitab Prediction Report for Model TH-2A

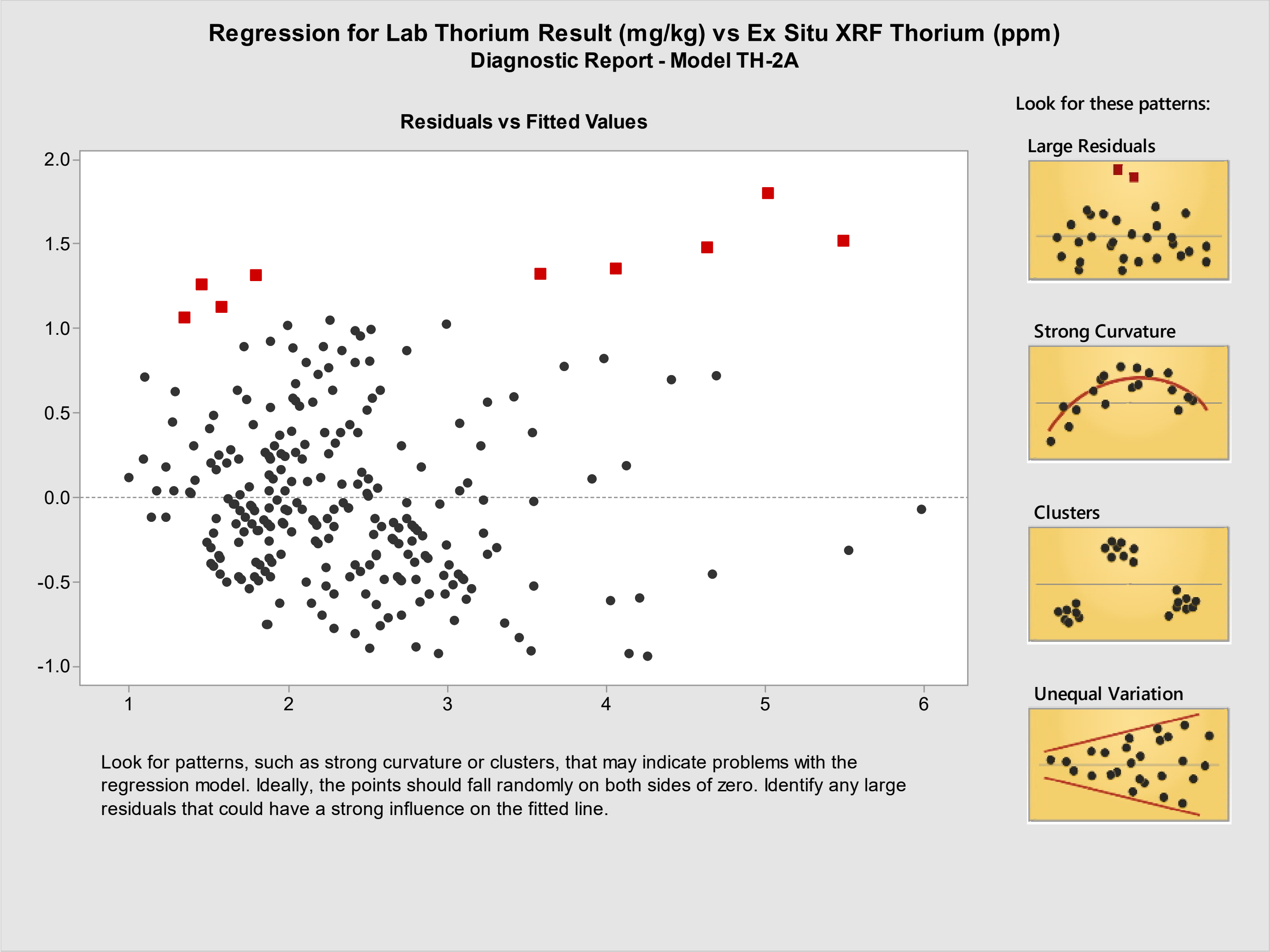


Figure B3-110. Minitab Residuals Report for Model TH-2A

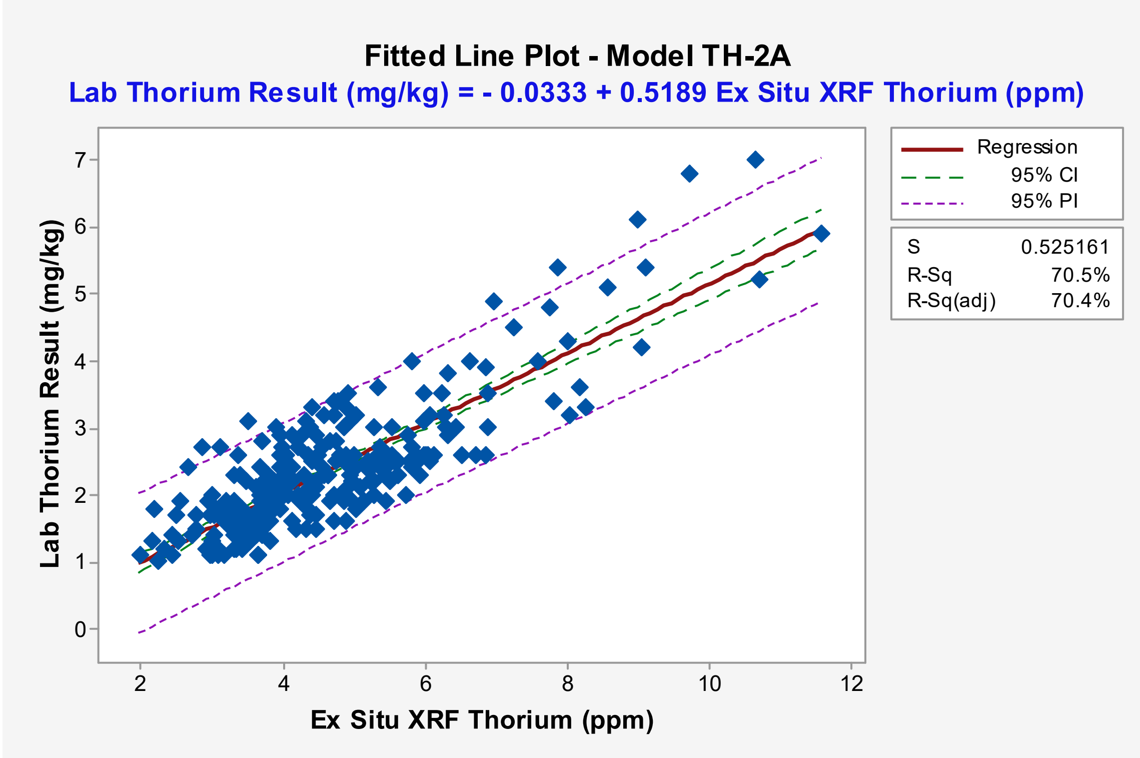


Figure B3-111. Ex Situ Bulk Sample Fitted Line Plot for Thorium Model TH-2A

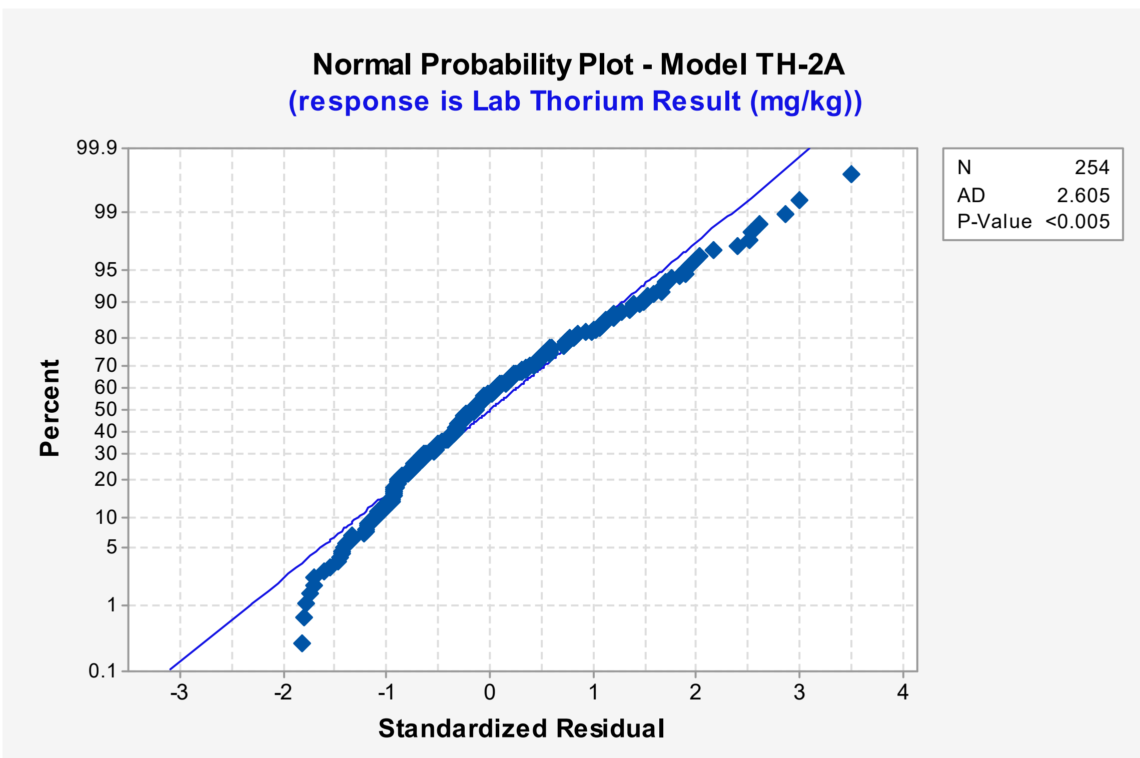


Figure B3-112. Ex Situ Bulk Sample Normal Probability Plot of Thorium Standardized Residuals for Model TH-2A

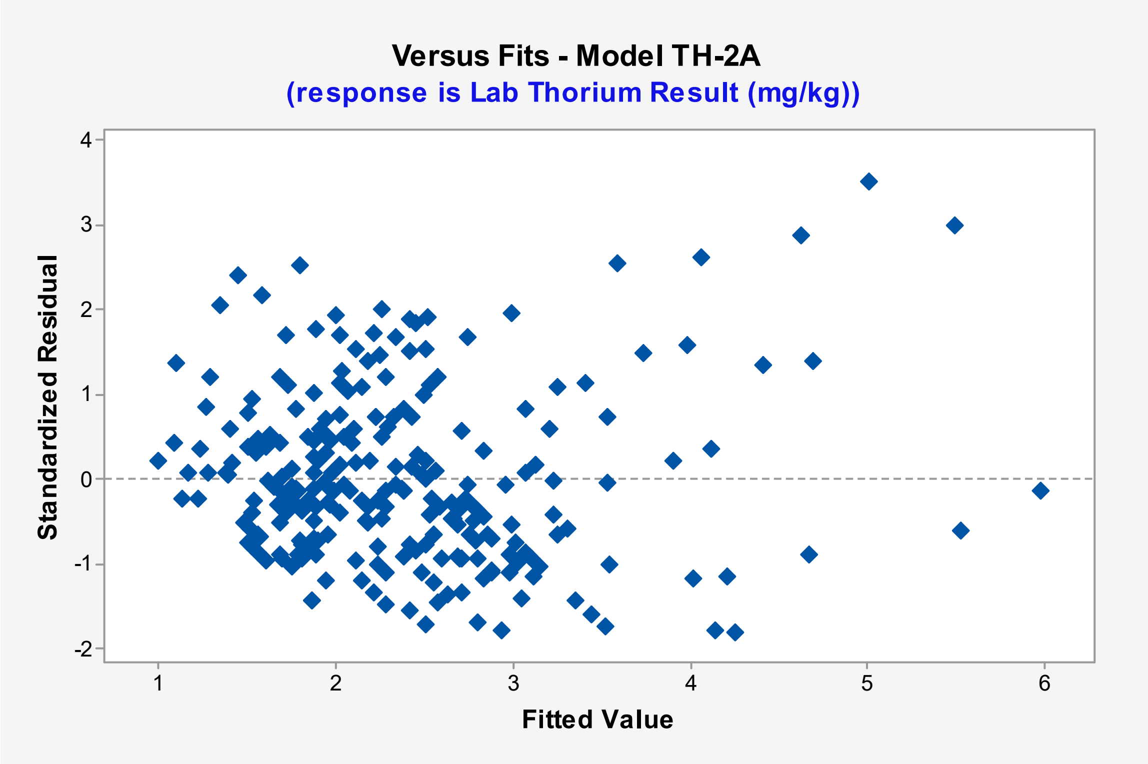


Figure B3-113. Ex Situ Bulk Sample Versus Fits Residuals Thorium for Model TH-2A

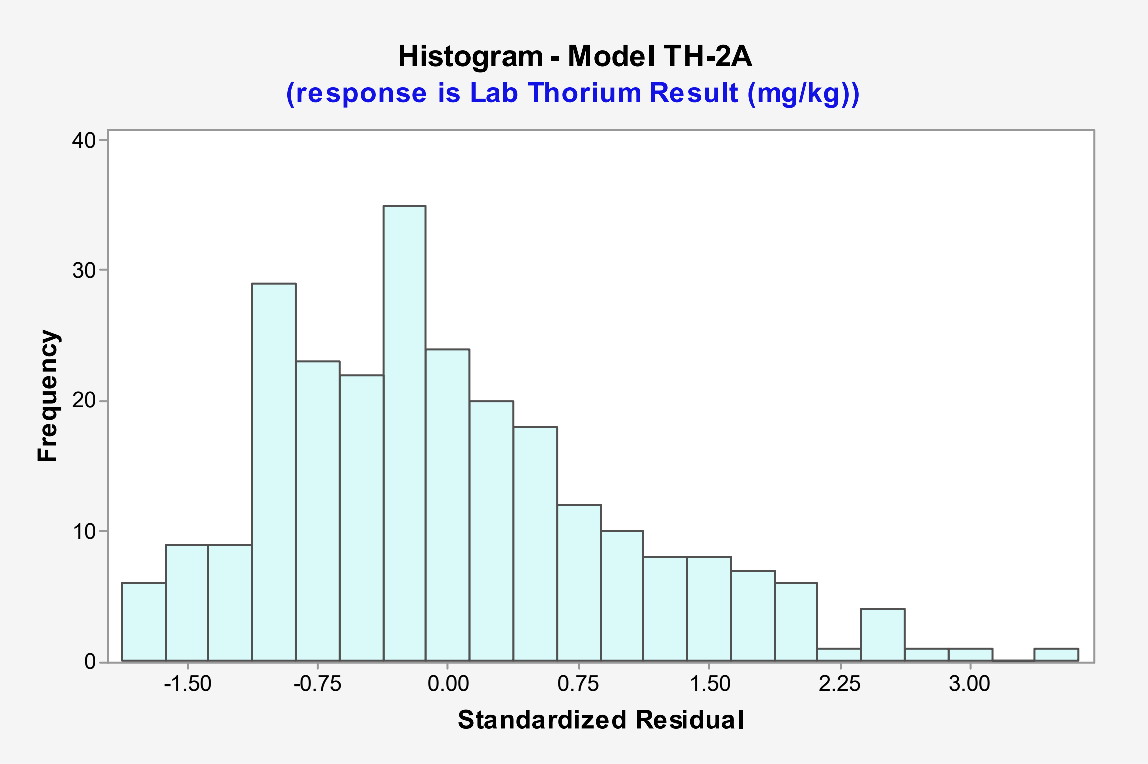


Figure B3-114. Ex Situ Bulk Sample Historgram of Thorium Standardized Residuals for Model TH-2A

8.0 URANIUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

8.1 URANIUM STATISTICAL OUTPUT (MODEL U-1)

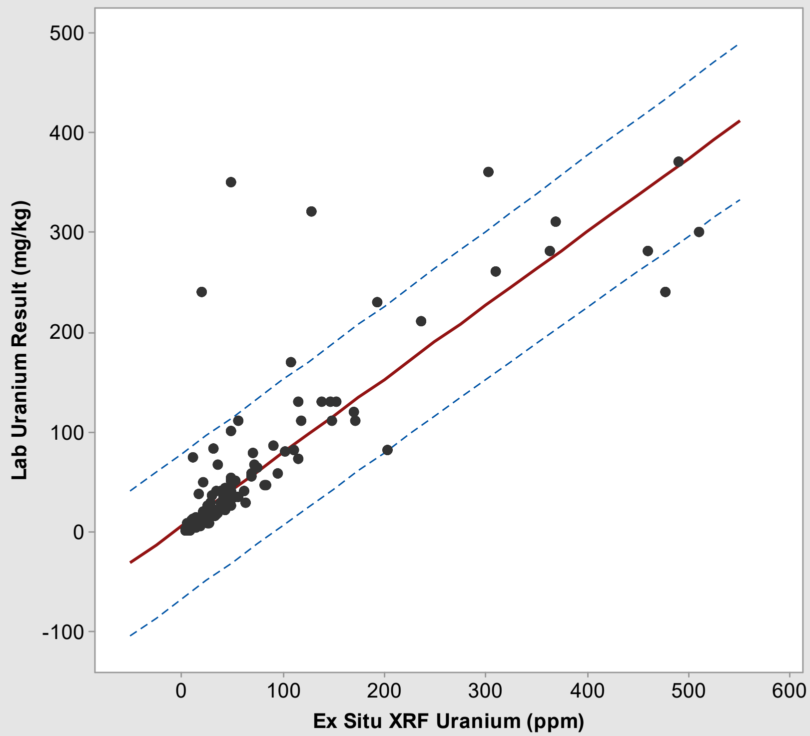
Regression for Lab Uranium Result (mg/kg) vs Ex Situ XRF Uranium (ppm)

Prediction Report - Model U-1

Y: Lab Uranium Result (mg/kg)
X: Ex Situ XRF Uranium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-50	-31.434	(-104.29, 41.420)
-25	-12.989	(-85.744, 59.766)
0	5.4561	(-67.231, 78.143)
25	23.901	(-48.748, 96.550)
50	42.346	(-30.296, 114.99)
75	60.791	(-11.874, 133.45)
100	79.236	(6.5182, 151.95)
125	97.680	(24.880, 170.48)
150	116.13	(43.211, 189.04)
175	134.57	(61.512, 207.63)
200	153.02	(79.784, 226.25)
225	171.46	(98.026, 244.89)
250	189.90	(116.24, 263.57)
275	208.35	(134.42, 282.28)
300	226.79	(152.58, 301.01)
325	245.24	(170.70, 319.78)
350	263.68	(188.80, 338.57)
375	282.13	(206.87, 357.39)
400	300.57	(224.91, 376.23)
425	319.02	(242.93, 395.11)
450	337.46	(260.92, 414.01)
475	355.91	(278.89, 432.93)
500	374.35	(296.82, 451.88)
525	392.80	(314.74, 470.86)
550	411.24	(332.63, 489.86)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-115. Minitab Prediction Report for Model U-1

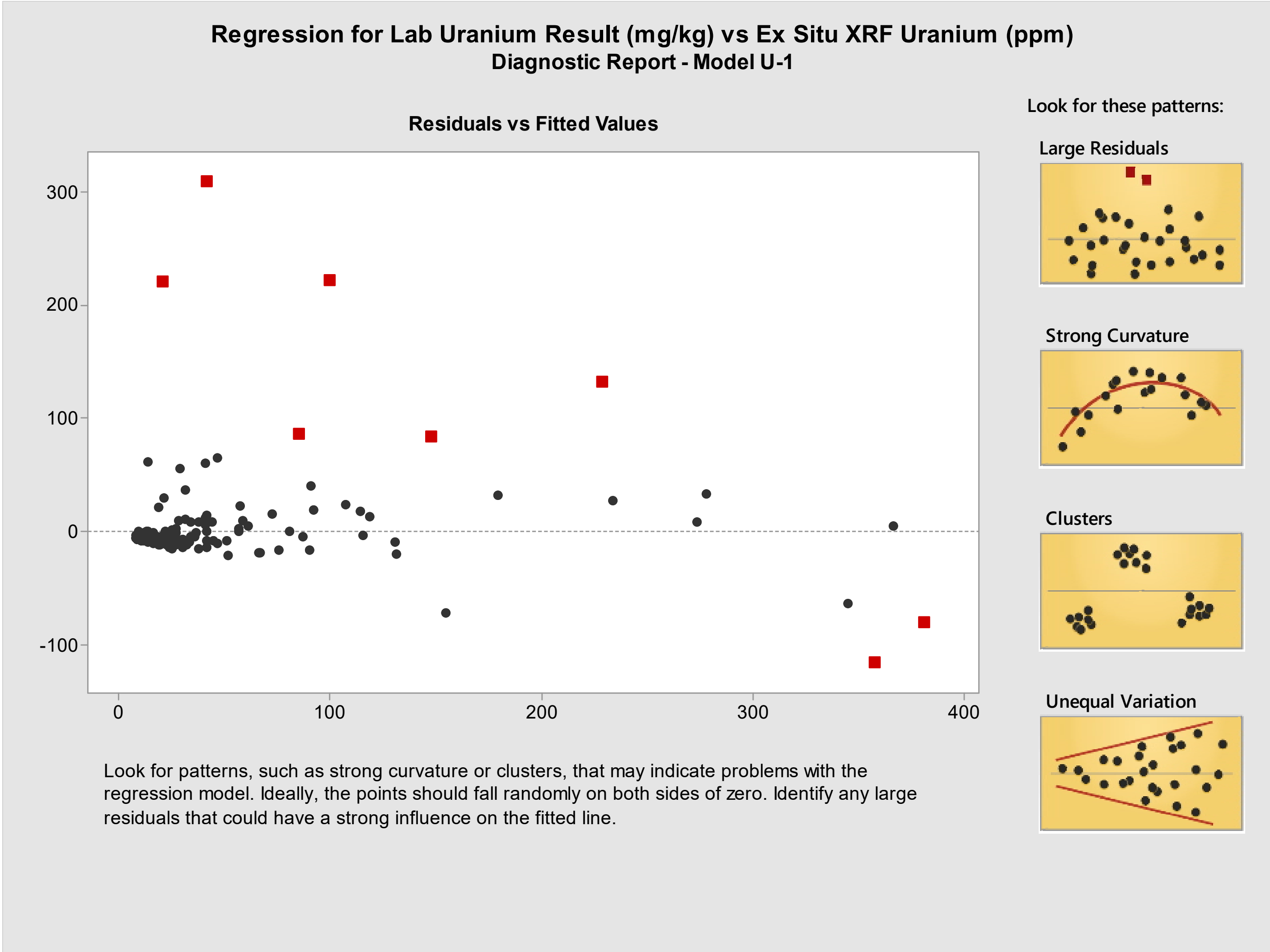


Figure B3-116. Minitab Residuals Report for Model U-1

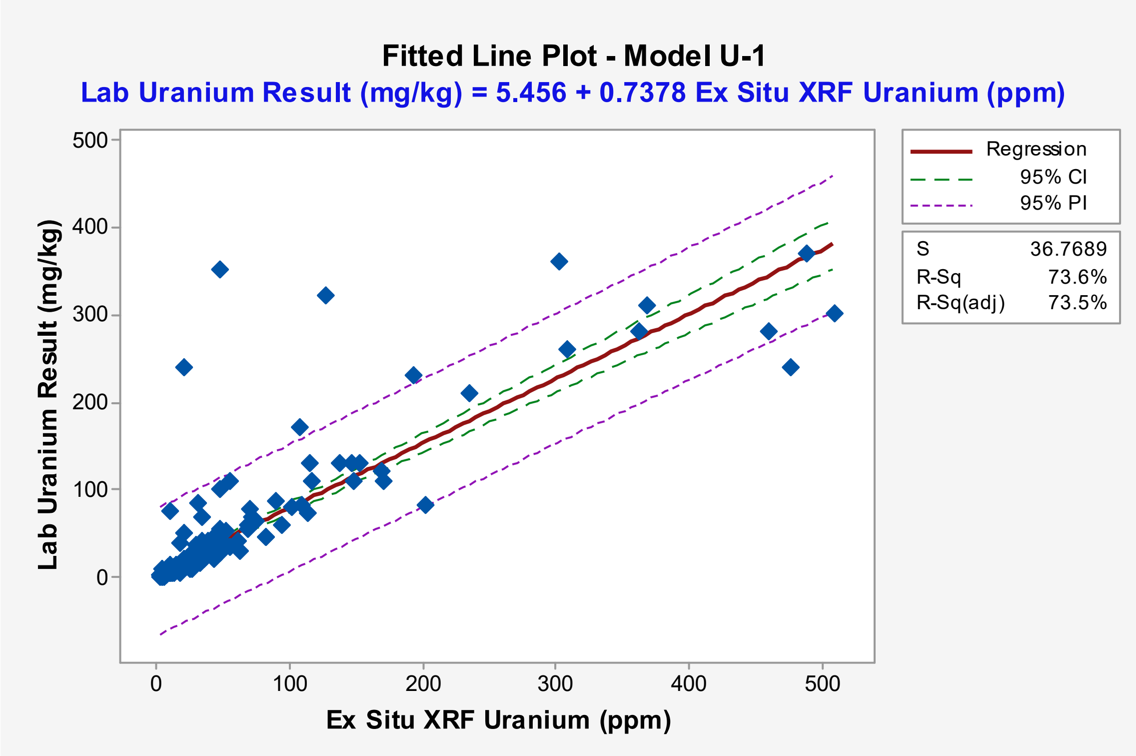


Figure B3-117. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-1

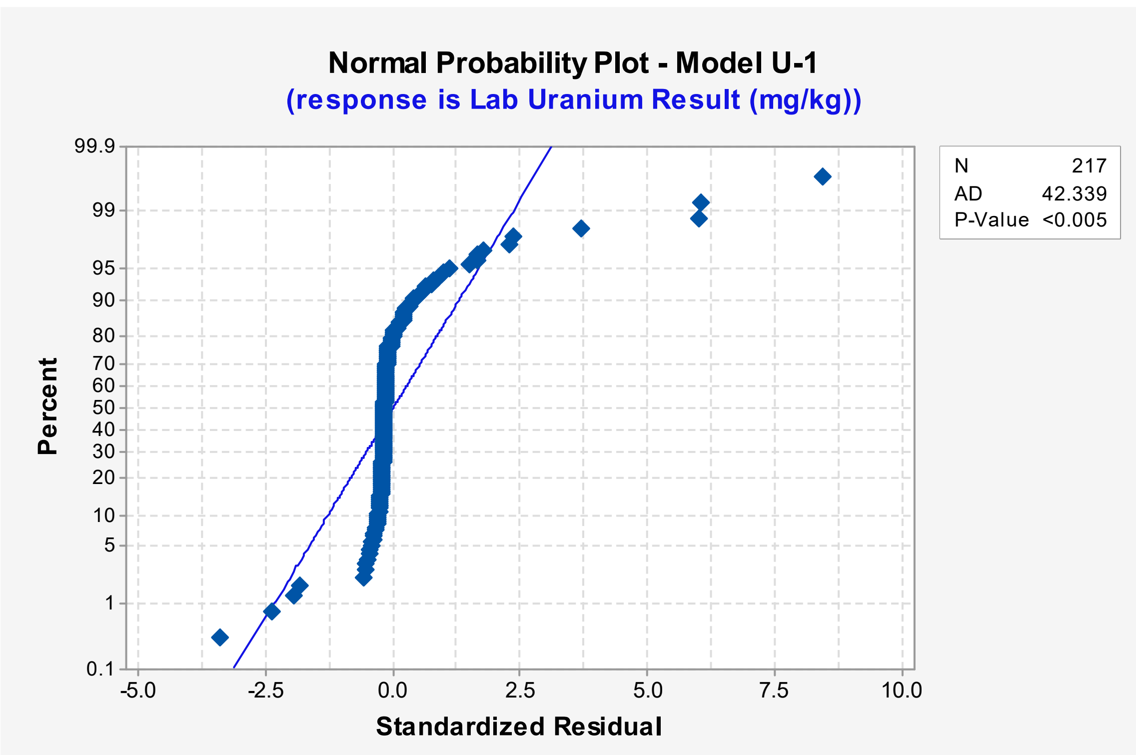


Figure B3-118. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-1

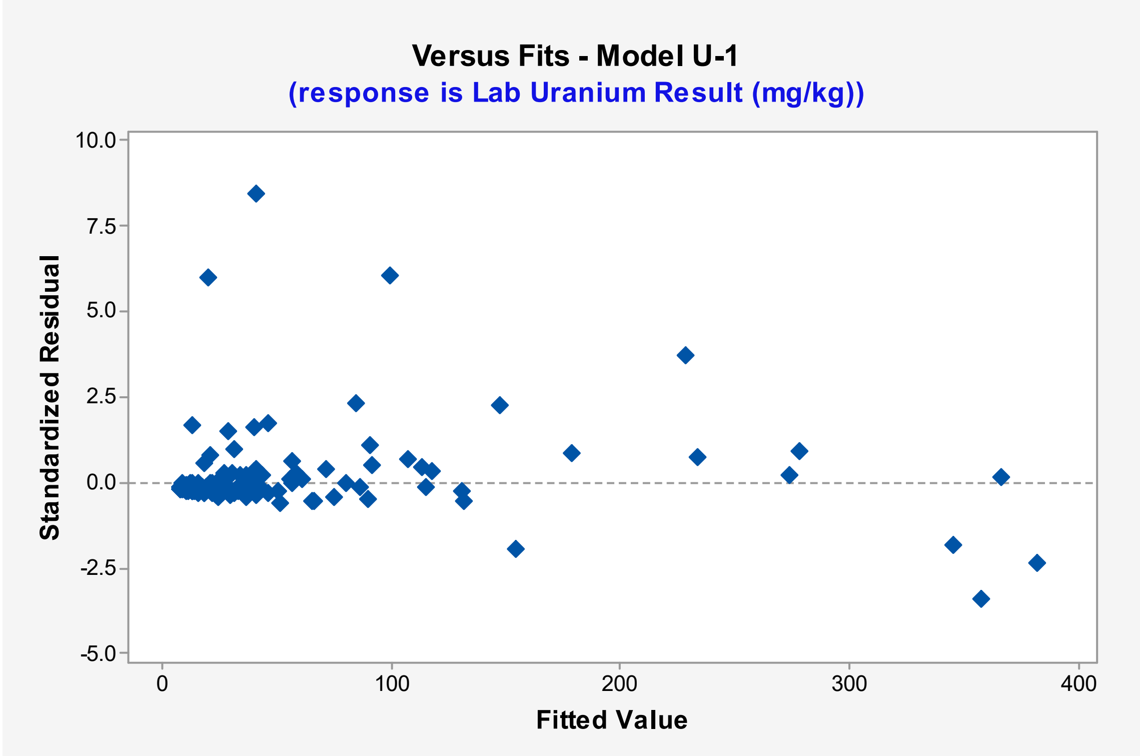


Figure B3-119. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-1

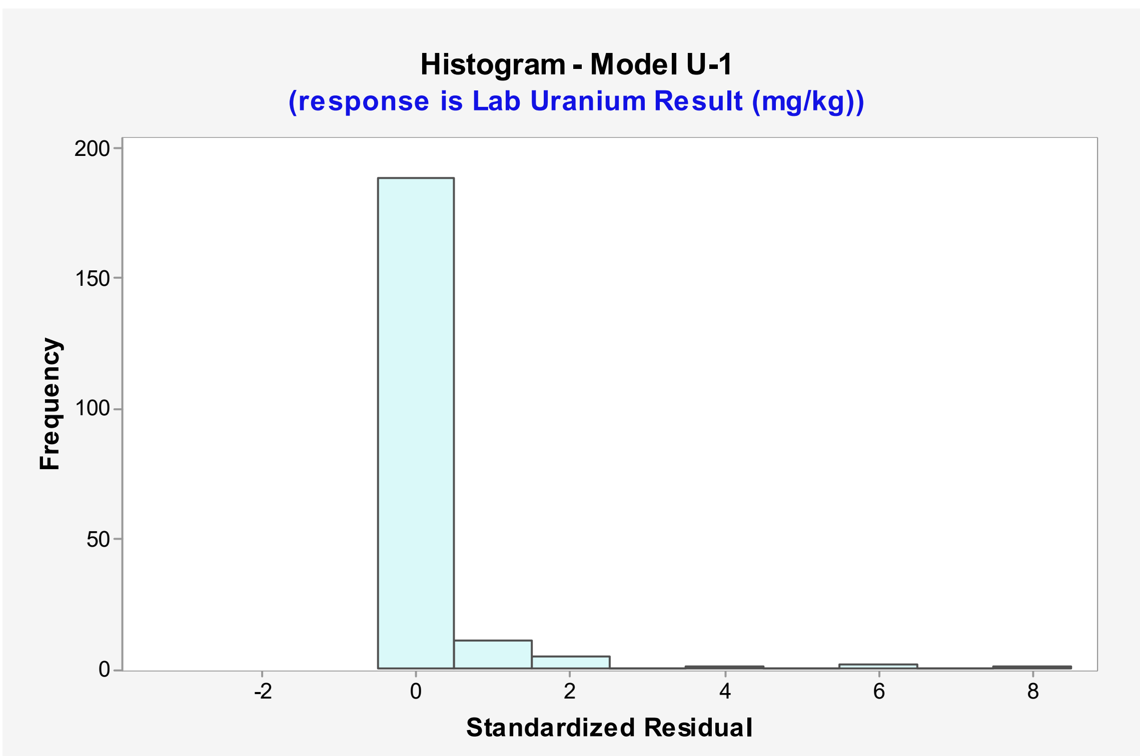


Figure B3-120. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-1

8.2 URANIUM STATISTICAL OUTPUT (MODEL U-2)

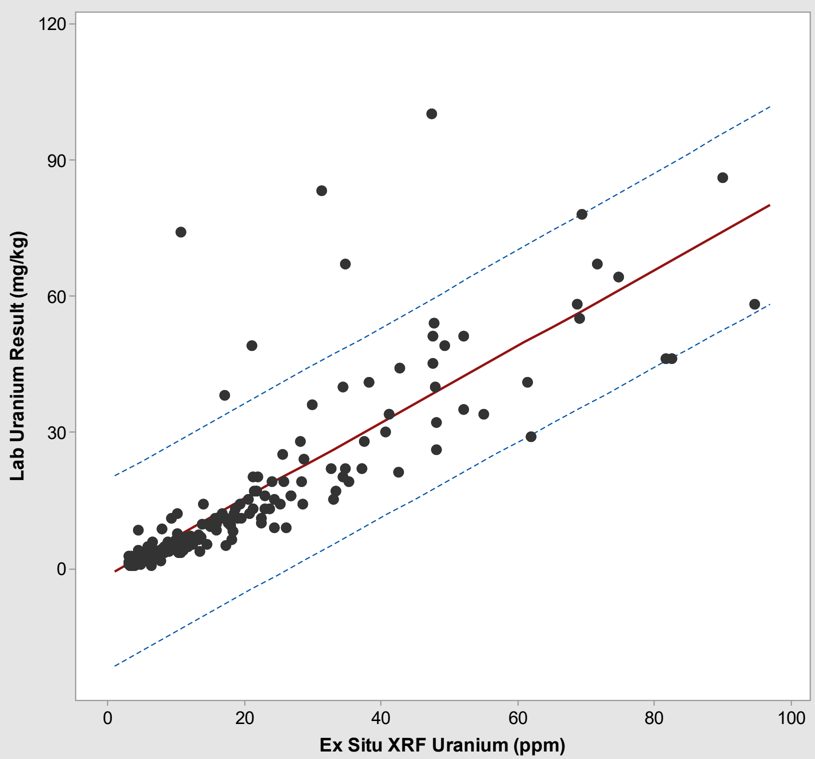
Regression for Lab Uranium Result (mg/kg) vs Ex Situ XRF Uranium (ppm)

Prediction Report - Model U-2

Y: Lab Uranium Result (mg/kg)
X: Ex Situ XRF Uranium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
1	-0.59583	(-21.522, 20.330)
5	2.7626	(-18.143, 23.668)
9	6.1210	(-14.769, 27.011)
13	9.4794	(-11.400, 30.358)
17	12.838	(-8.0355, 33.711)
21	16.196	(-4.6762, 37.069)
25	19.555	(-1.3219, 40.431)
29	22.913	(2.0275, 43.798)
33	26.271	(5.3719, 47.171)
37	29.630	(8.7115, 50.548)
41	32.988	(12.046, 53.930)
45	36.347	(15.376, 57.317)
49	39.705	(18.701, 60.709)
53	43.063	(22.021, 64.106)
57	46.422	(25.336, 67.507)
61	49.780	(28.647, 70.914)
65	53.139	(31.952, 74.325)
69	56.497	(35.253, 77.741)
73	59.855	(38.550, 81.161)
77	63.214	(41.841, 84.586)
81	66.572	(45.129, 88.016)
85	69.931	(48.411, 91.450)
89	73.289	(51.689, 94.889)
93	76.647	(54.963, 98.332)
97	80.006	(58.232, 101.78)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-121. Minitab Prediction Report for Model U-2

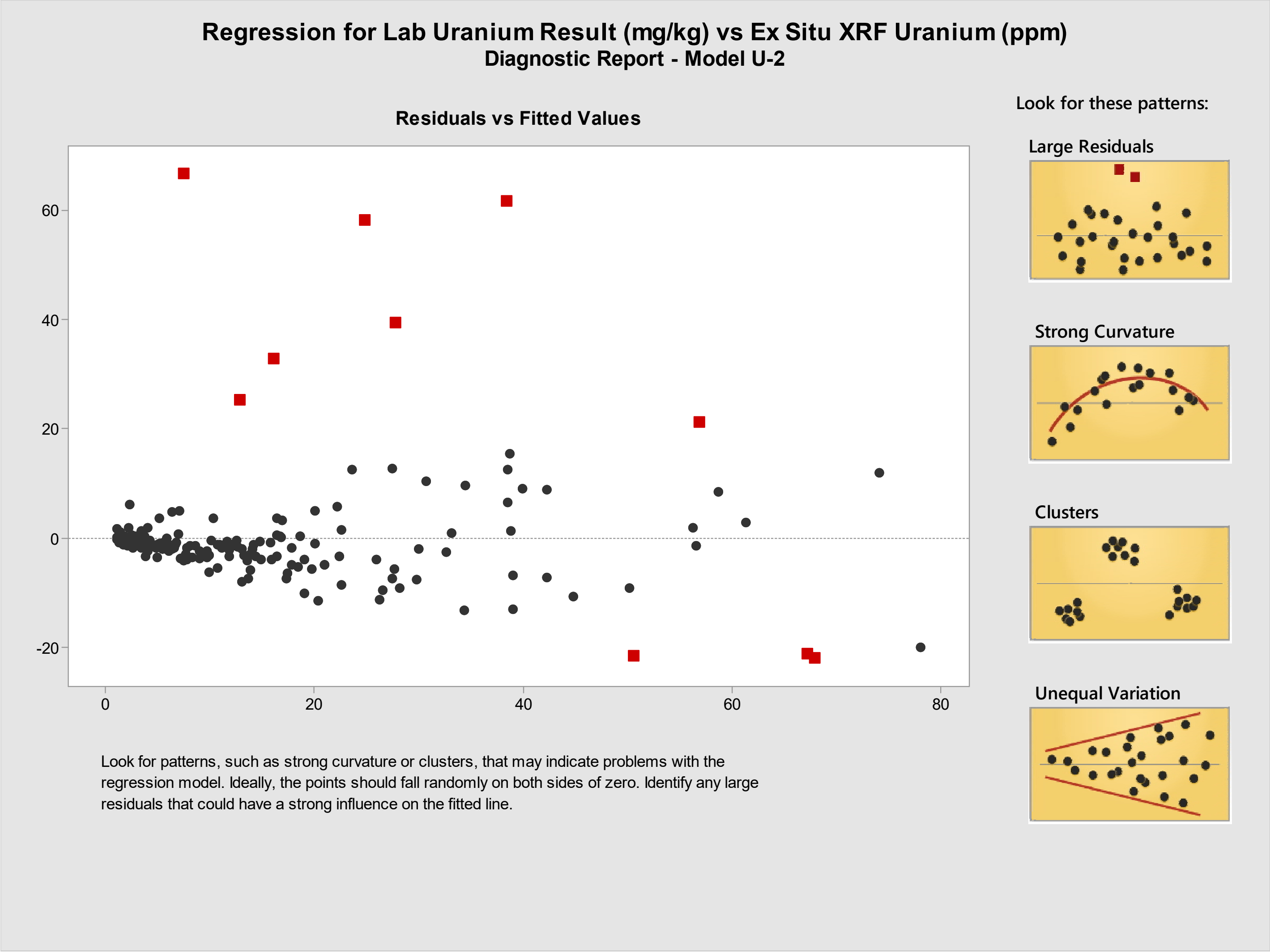


Figure B3-122. Minitab Residuals Report for Model U-2

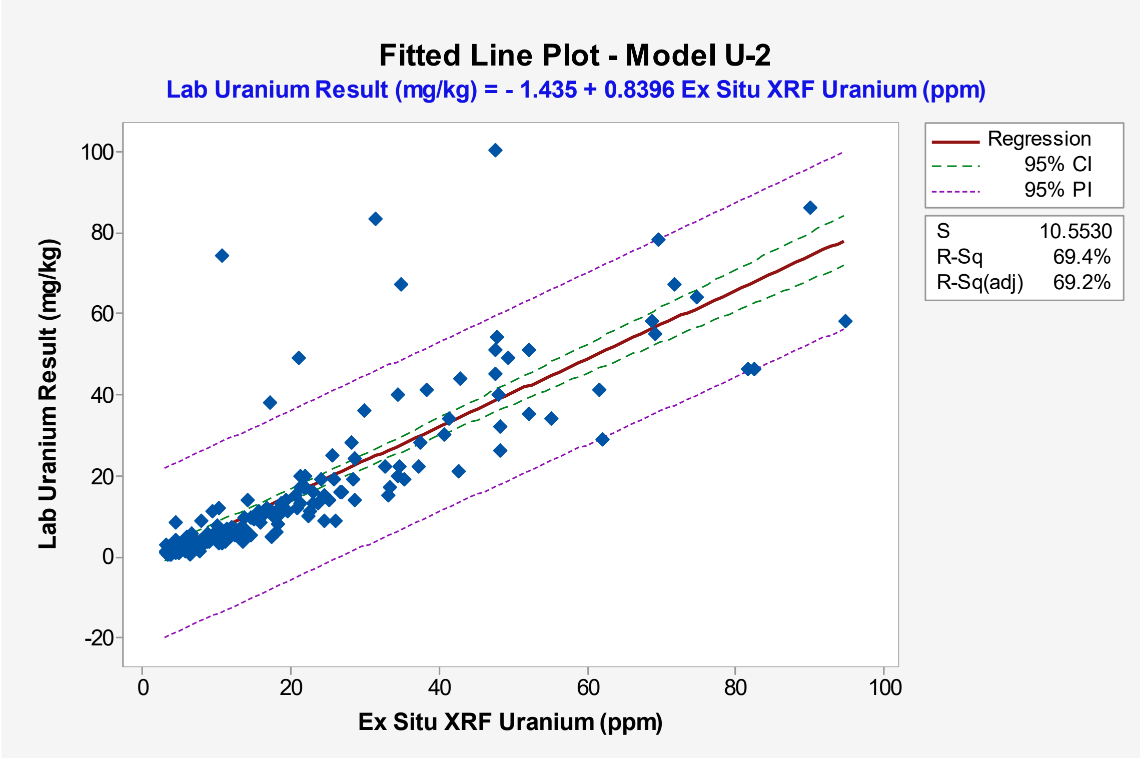


Figure B3-123. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-2

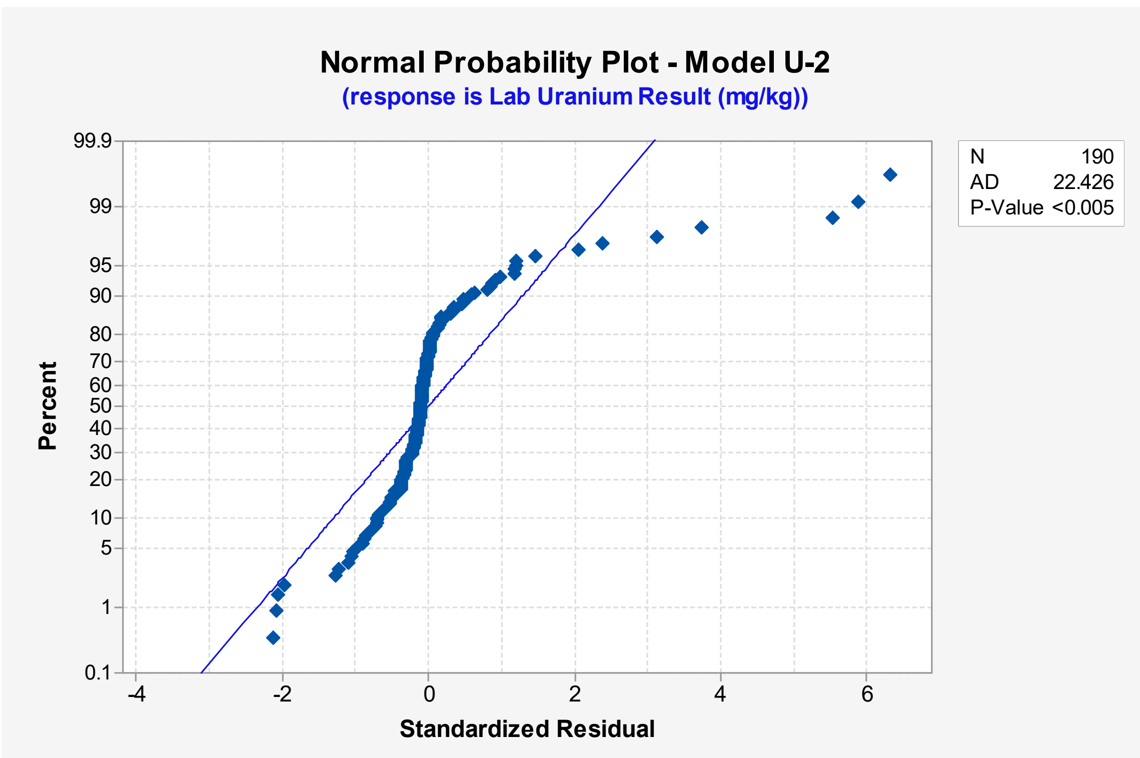


Figure B3-124. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-2

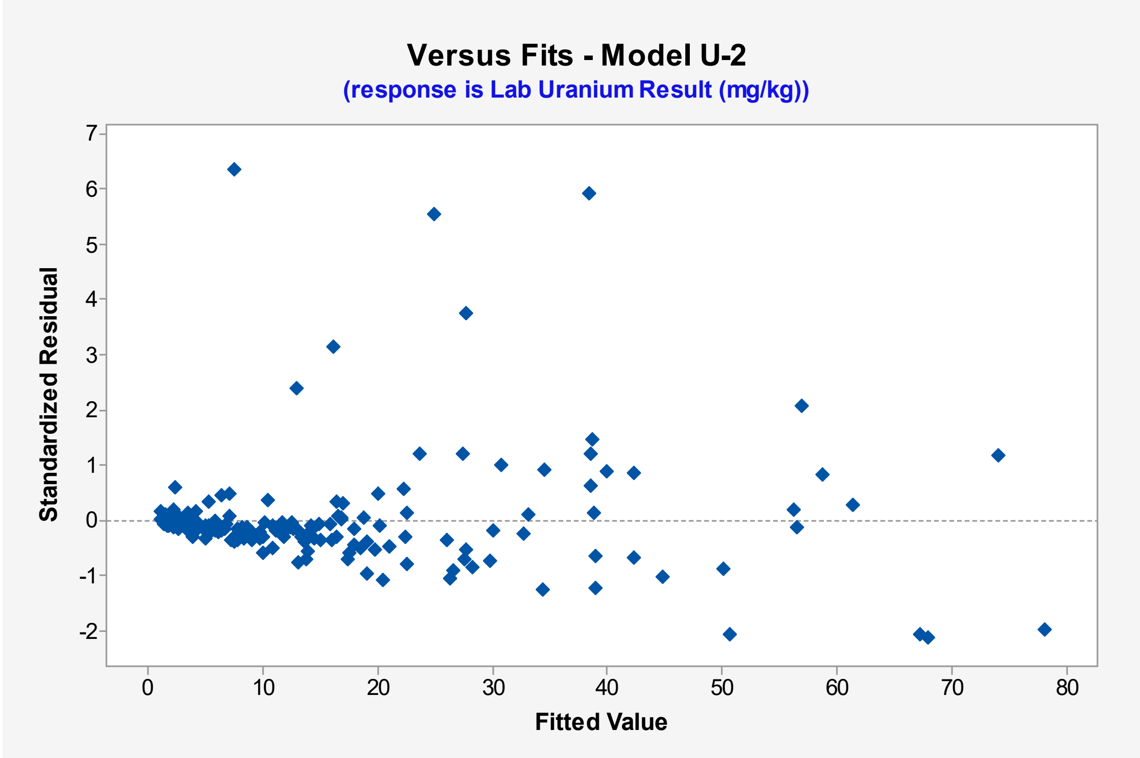


Figure B3-125. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-2

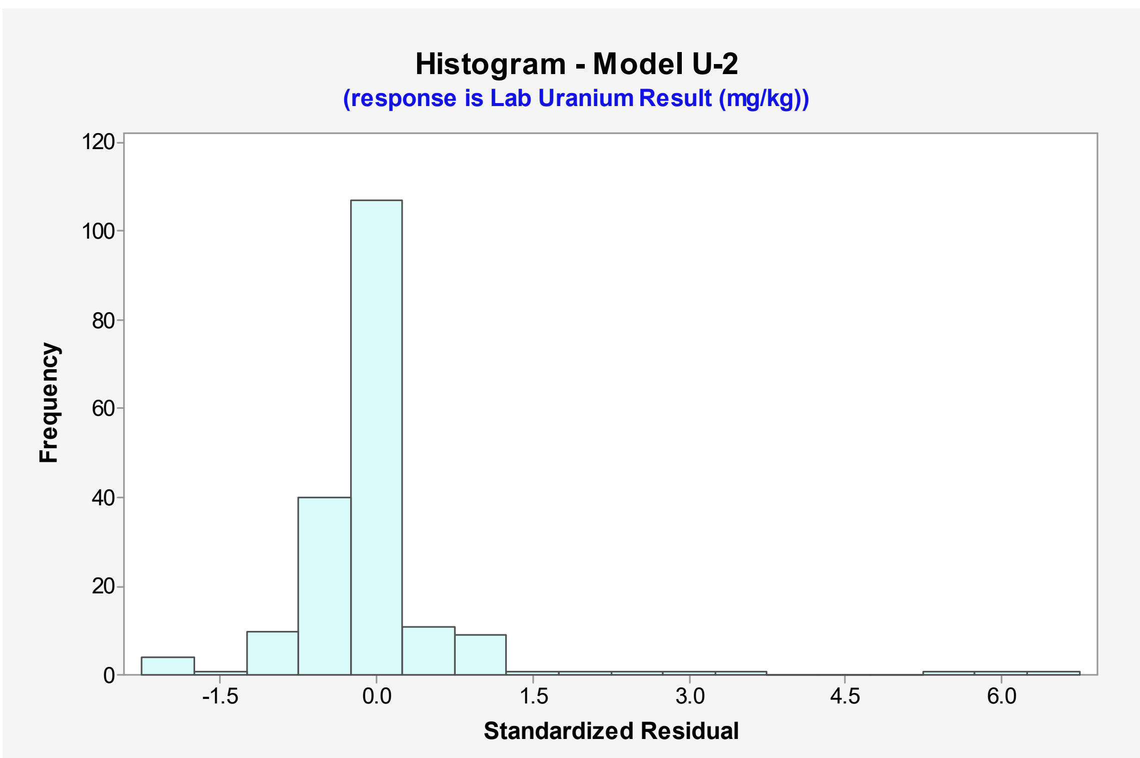


Figure B3-126. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-2

8.3 URANIUM STATISTICAL OUTPUT (MODEL U-2A)

Regression for Lab Uranium Result (mg/kg) vs Ex Situ XRF Uranium (ppm)

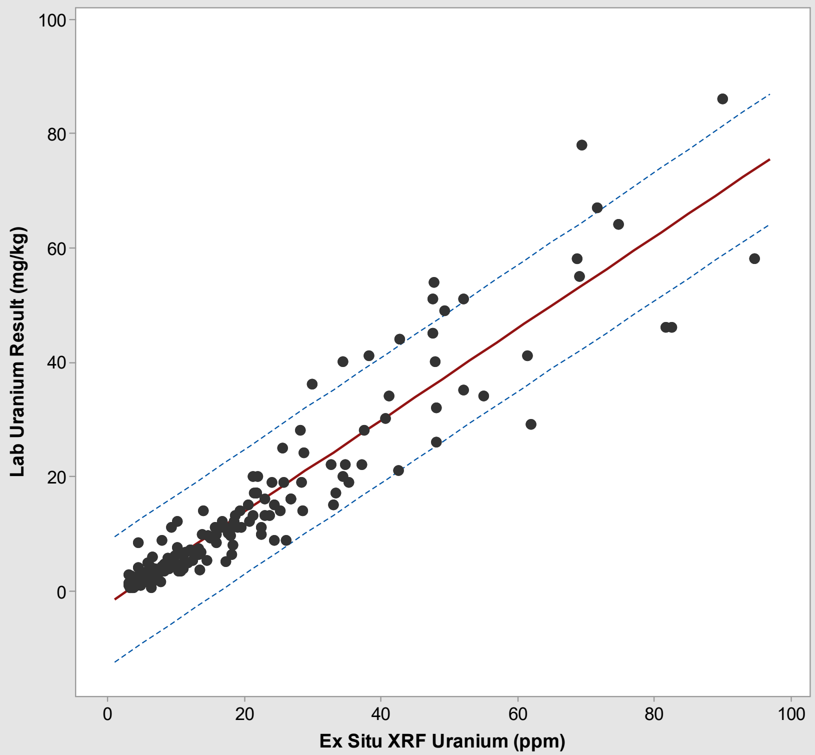
Prediction Report - Model U-2A

Y: Lab Uranium Result (mg/kg)

X: Ex Situ XRF Uranium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
1	-1.4628	(-12.422, 9.4963)
5	1.7495	(-9.1988, 12.698)
9	4.9617	(-5.9784, 15.902)
13	8.1739	(-2.7606, 19.108)
17	11.386	(0.45455, 22.318)
21	14.598	(3.6671, 25.530)
25	17.811	(6.8770, 28.744)
29	21.023	(10.084, 31.961)
33	24.235	(13.289, 35.181)
37	27.447	(16.491, 38.404)
41	30.660	(19.690, 41.629)
45	33.872	(22.887, 44.856)
49	37.084	(26.081, 48.087)
53	40.296	(29.273, 51.319)
57	43.508	(32.462, 54.555)
61	46.721	(35.649, 57.793)
65	49.933	(38.833, 61.033)
69	53.145	(42.014, 64.276)
73	56.357	(45.193, 67.522)
77	59.570	(48.369, 70.770)
81	62.782	(51.544, 74.020)
85	65.994	(54.715, 77.273)
89	69.206	(57.884, 80.528)
93	72.418	(61.051, 83.786)
97	75.631	(64.216, 87.045)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-127. Minitab Prediction Report for Model U-2A

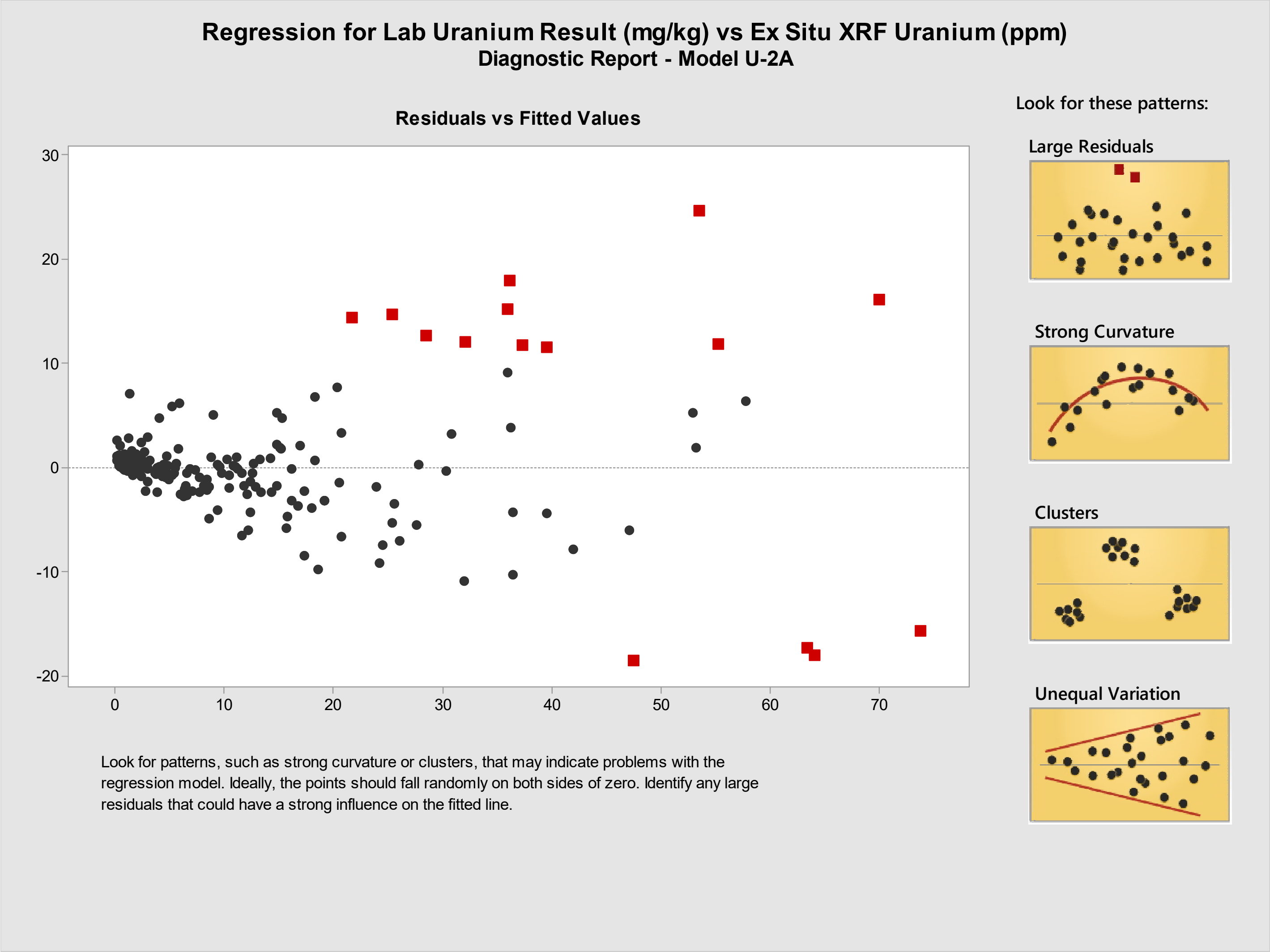


Figure B3-128. Minitab Residuals Report for Model U-2A

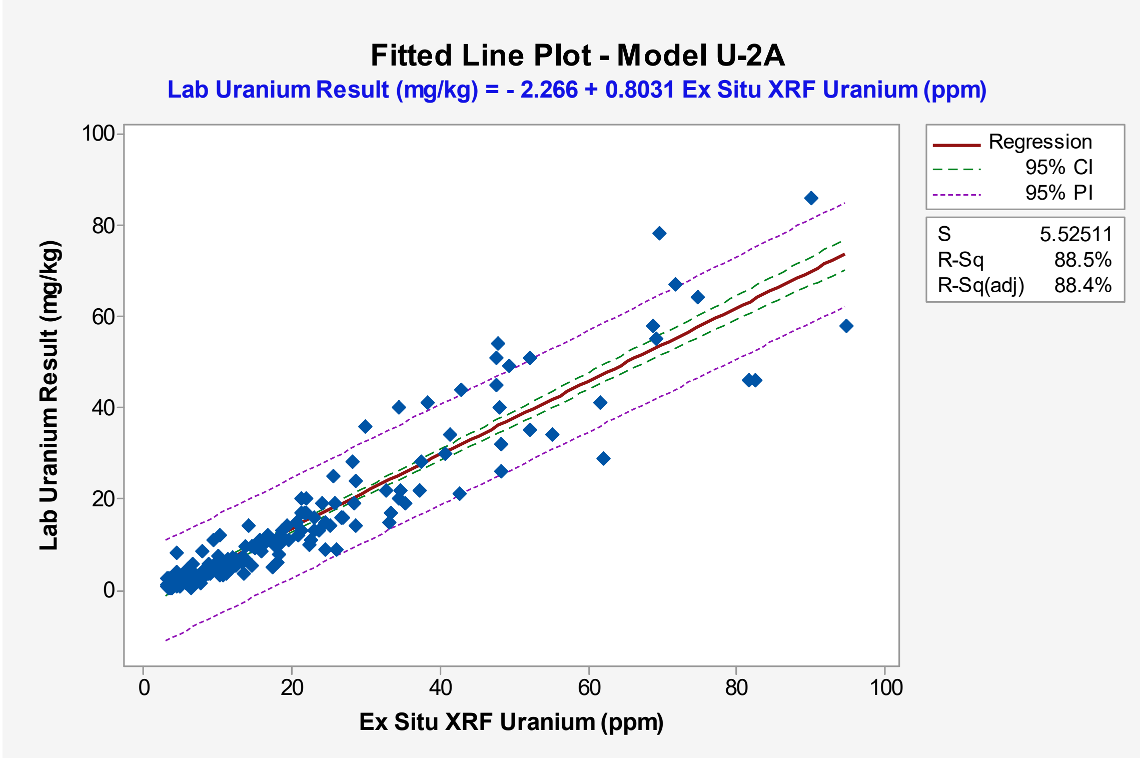


Figure B3-129. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-2A

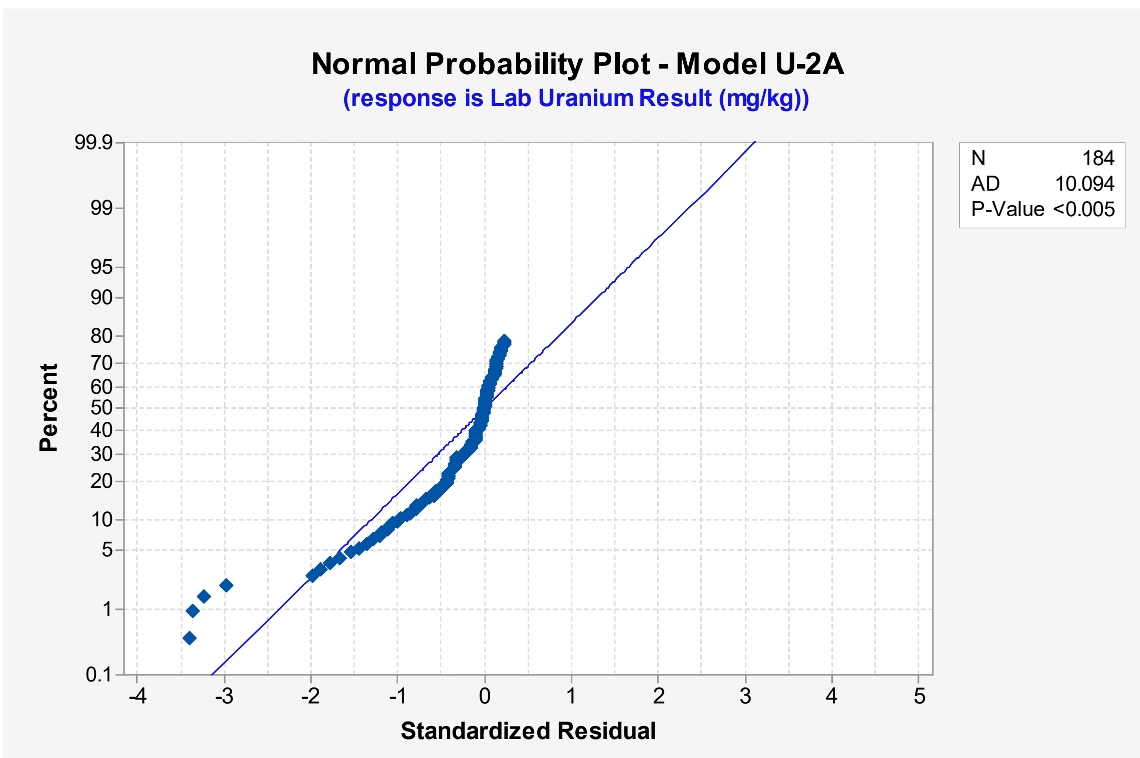


Figure B3-130. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-2A

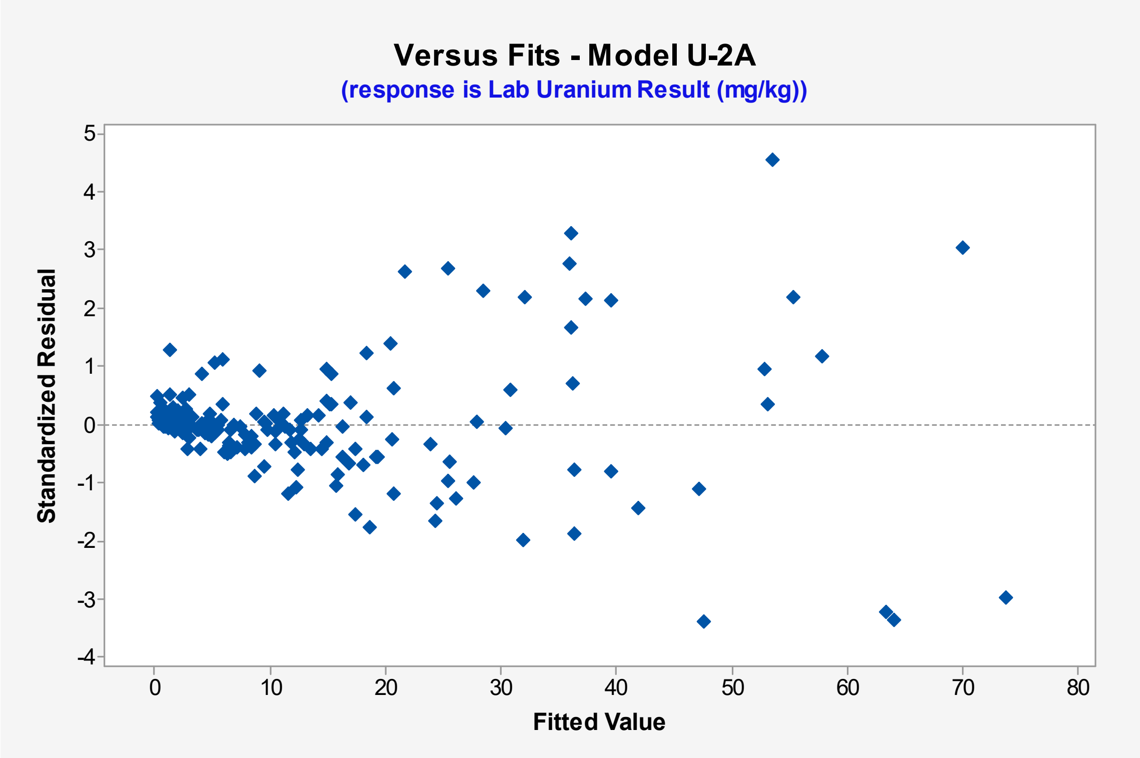


Figure B3-131. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-2A

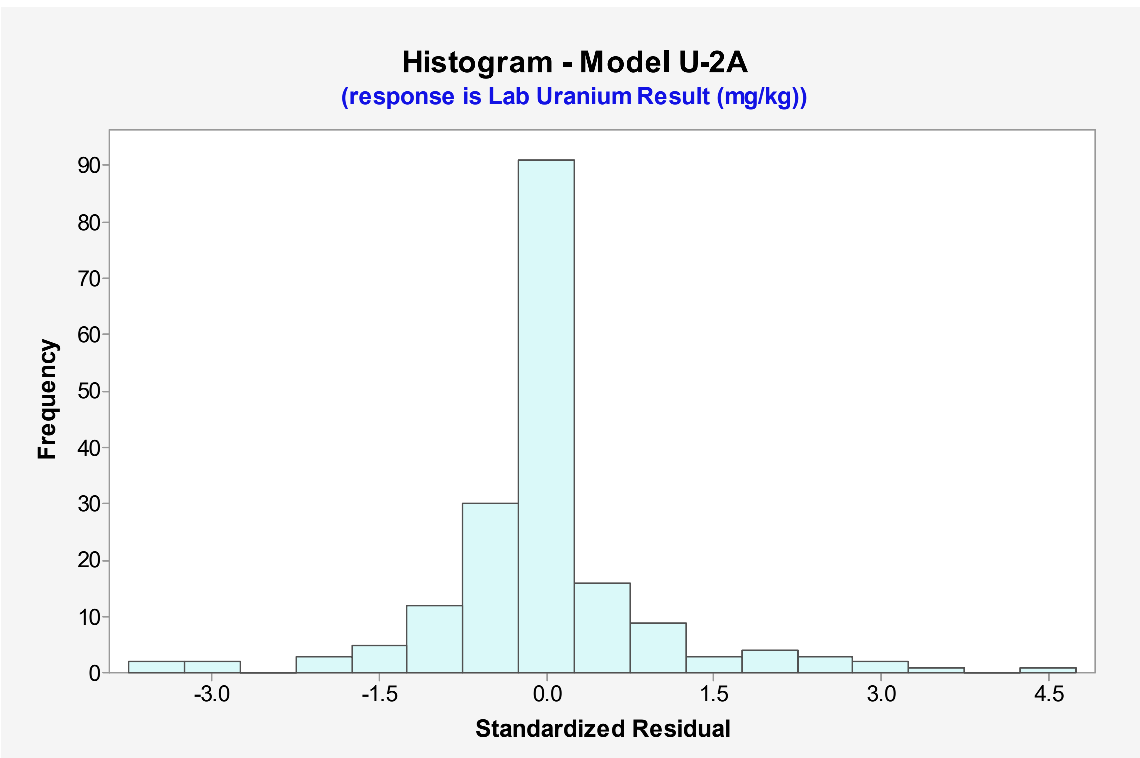


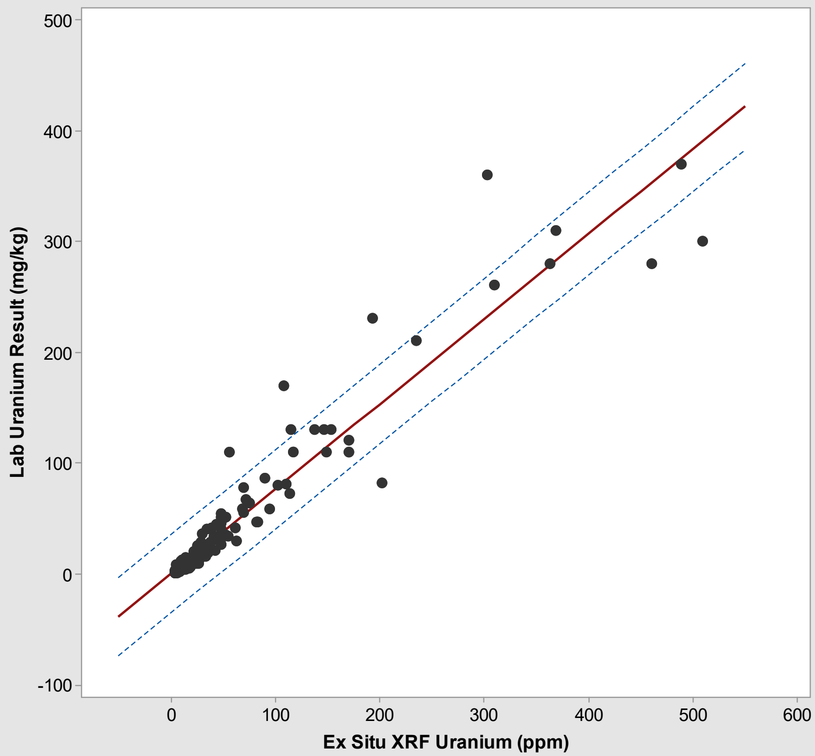
Figure B3-132. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-2A

8.4 URANIUM STATISTICAL OUTPUT (MODEL U-1A)

Regression for Lab Uranium Result (mg/kg) vs Ex Situ XRF Uranium (ppm)
Prediction Report - Model U-1A

Y: Lab Uranium Result (mg/kg)
X: Ex Situ XRF Uranium (ppm)

Prediction Plot
The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-50	-38.484	(-74.193, -2.7750)
-25	-19.292	(-54.946, 16.363)
0	-0.09981	(-35.717, 35.518)
25	19.092	(-16.505, 54.689)
50	38.284	(2.6899, 73.878)
75	57.476	(21.868, 93.085)
100	76.668	(41.028, 112.31)
125	95.860	(60.172, 131.55)
150	115.05	(79.298, 150.81)
175	134.24	(98.408, 170.08)
200	153.44	(117.50, 189.37)
225	172.63	(136.58, 208.68)
250	191.82	(155.64, 228.00)
275	211.01	(174.68, 247.34)
300	230.20	(193.71, 266.70)
325	249.40	(212.72, 286.07)
350	268.59	(231.71, 305.46)
375	287.78	(250.69, 324.86)
400	306.97	(269.66, 344.28)
425	326.16	(288.61, 363.72)
450	345.36	(307.55, 383.17)
475	364.55	(326.47, 402.63)
500	383.74	(345.37, 422.11)
525	402.93	(364.27, 441.60)
550	422.12	(383.15, 461.10)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-133. Minitab Prediction Report for Model U-1A

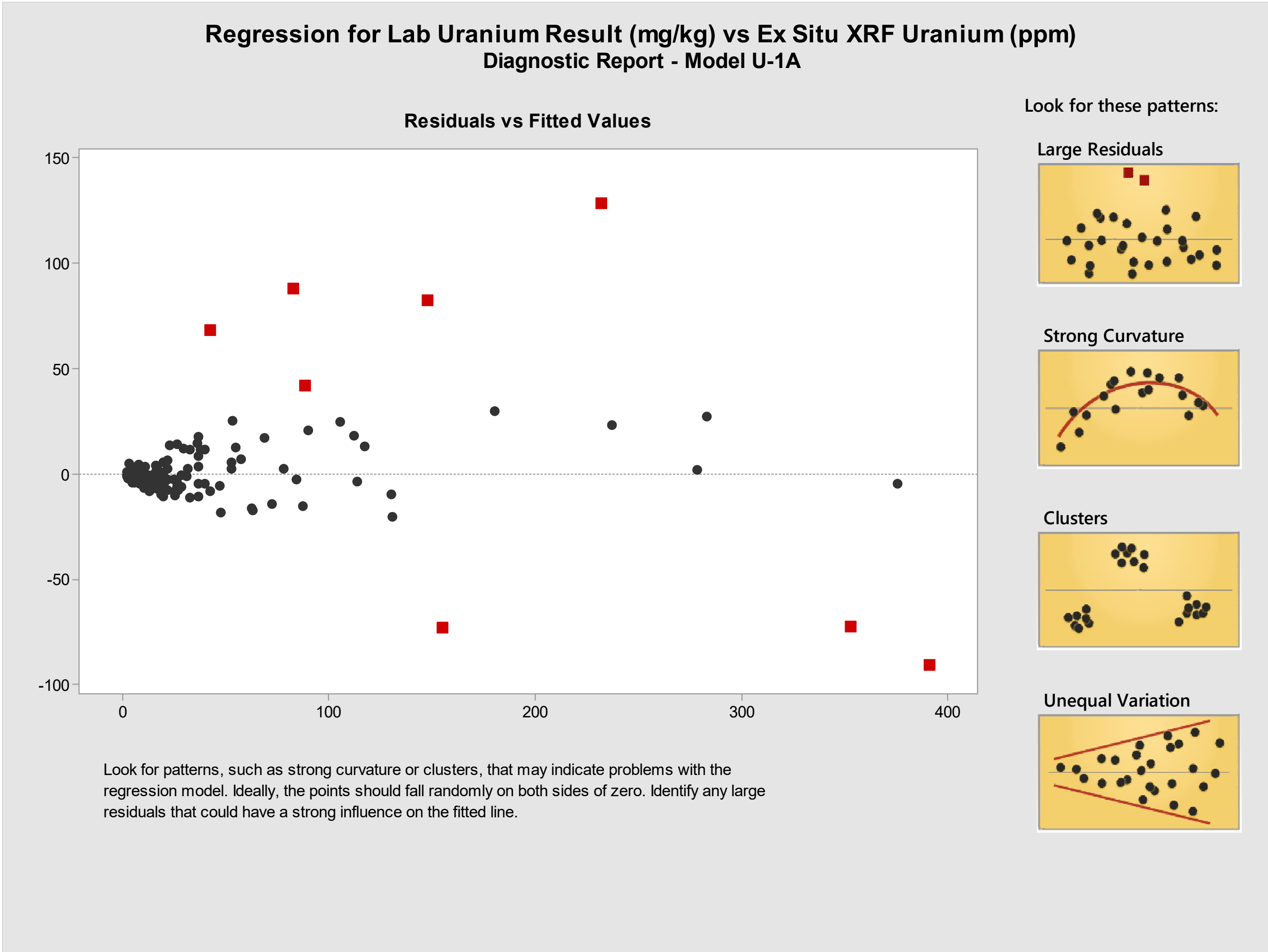


Figure B3-134. Minitab Residuals Report for Model U-1A

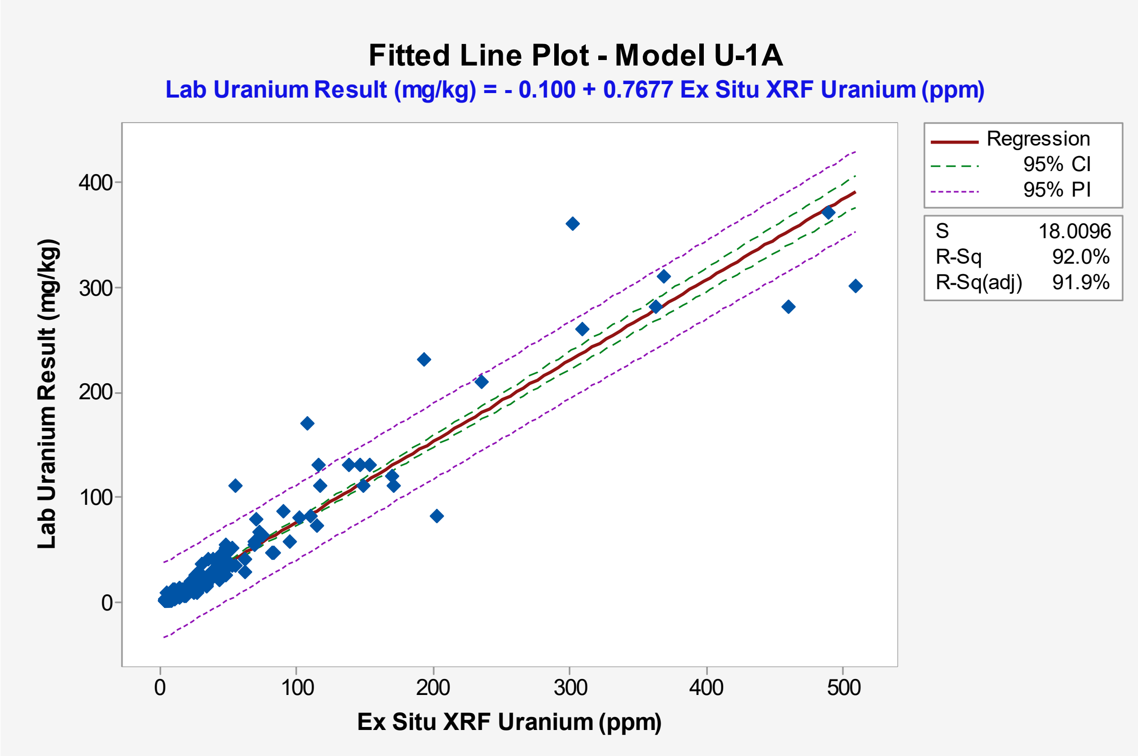


Figure B3-135. Ex Situ Bulk Sample Fitted Line Plot for Uranium Model U-1A

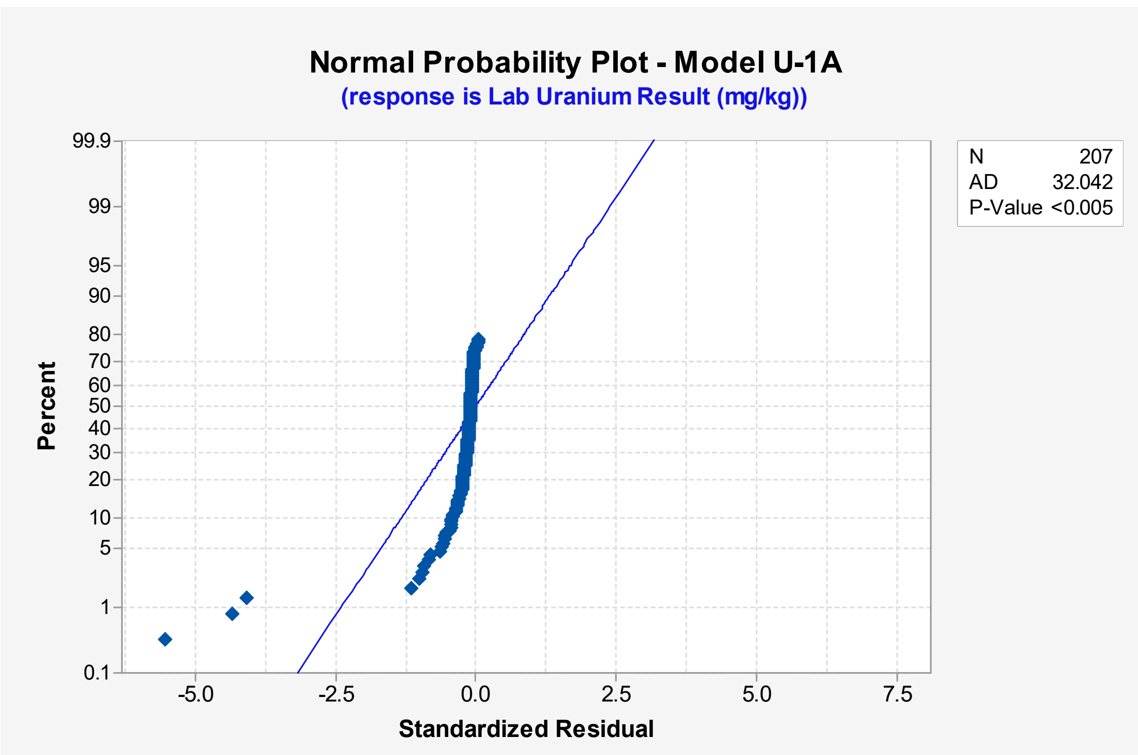


Figure B3-136. Ex Situ Bulk Sample Normal Probability Plot of Uranium Residuals for Model U-1A

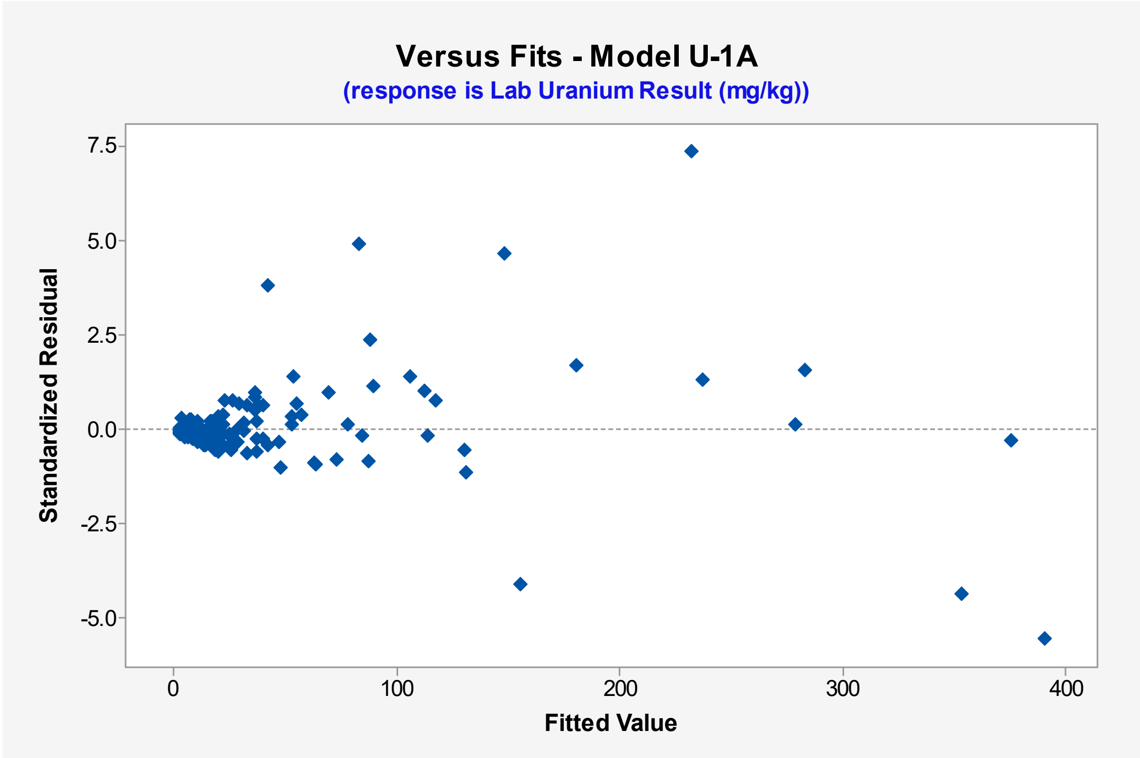


Figure B3-137. Ex Situ Bulk Sample Versus Fits Residuals Uranium for Model U-1A

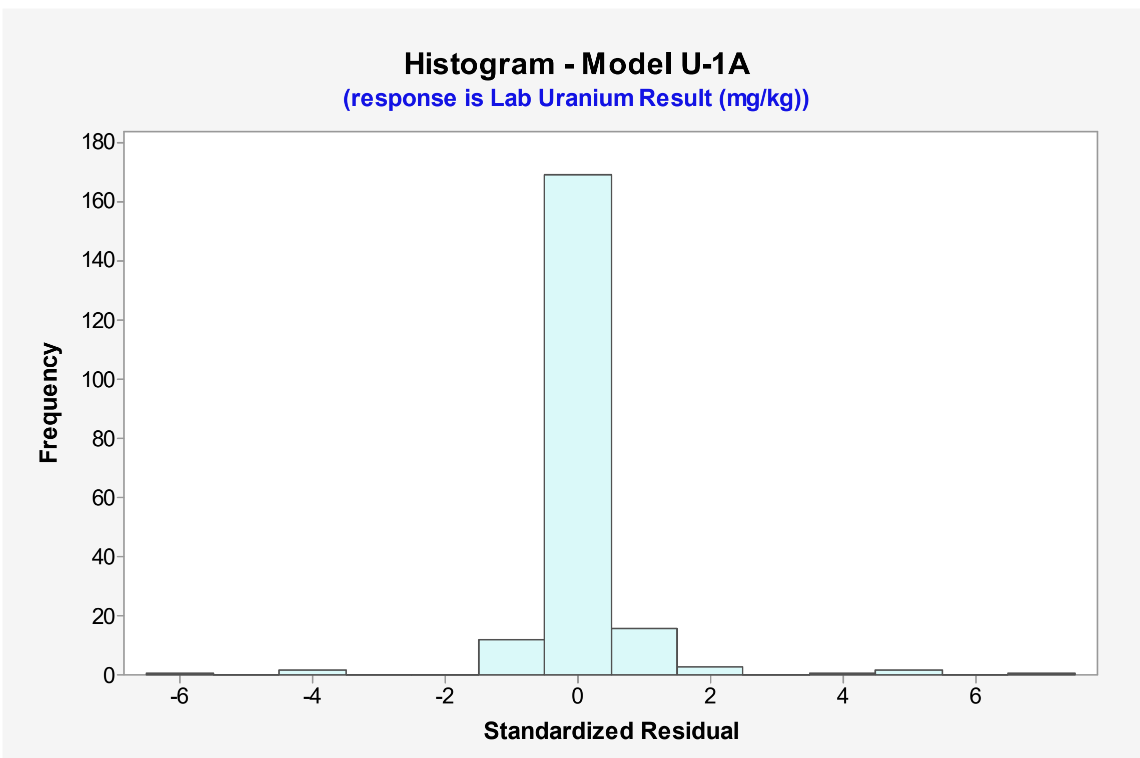


Figure B3-138. Ex Situ Bulk Sample Historgram of Uranium Residuals for Model U-1

9.0 VANADIUM EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

9.1 VANADIUM STATISTICAL OUTPUT (MODEL VA-1)

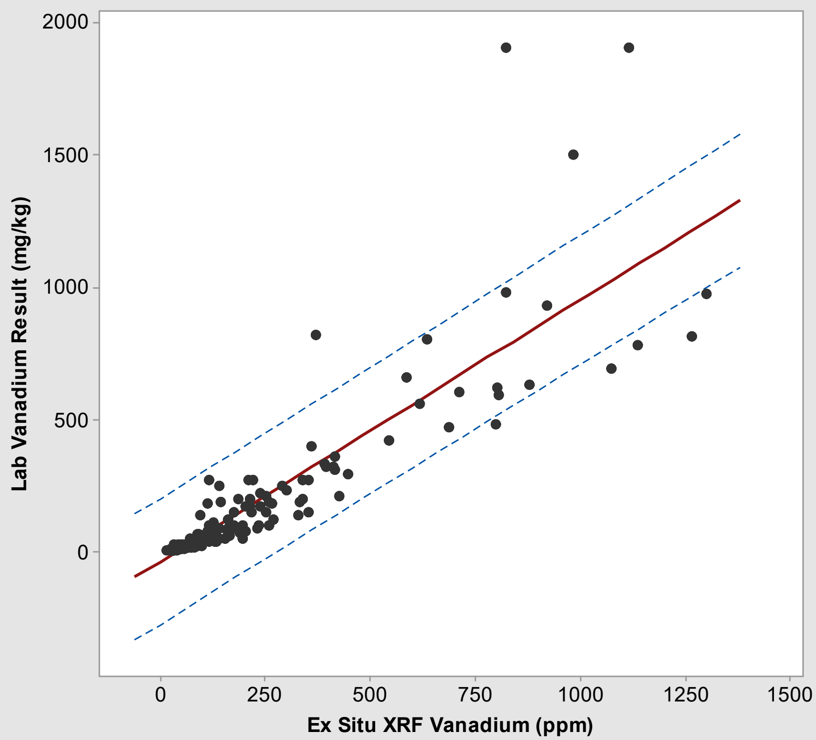
Regression for Lab Vanadium Result (mg/kg) vs Ex Situ XRF Vanadium (ppm)

Prediction Report - Model VA-1

Y: Lab Vanadium Result (mg/kg)
X: Ex Situ XRF Vanadium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-60	-93.233	(-330.56, 144.09)
0	-34.077	(-271.21, 203.05)
60	25.080	(-211.92, 262.08)
120	84.236	(-152.69, 321.16)
180	143.39	(-93.527, 380.31)
240	202.55	(-34.427, 439.52)
300	261.71	(24.610, 498.80)
360	320.86	(83.584, 558.14)
420	380.02	(142.50, 617.54)
480	439.17	(201.34, 677.01)
540	498.33	(260.13, 736.53)
600	557.49	(318.85, 796.12)
660	616.64	(377.52, 855.77)
720	675.80	(436.12, 915.48)
780	734.96	(494.66, 975.26)
840	794.11	(553.13, 1035.1)
900	853.27	(611.55, 1095.0)
960	912.43	(669.91, 1154.9)
1020	971.58	(728.21, 1215.0)
1080	1030.7	(786.46, 1275.0)
1140	1089.9	(844.64, 1335.1)
1200	1149.1	(902.77, 1395.3)
1260	1208.2	(960.84, 1455.6)
1320	1267.4	(1018.9, 1515.9)
1380	1326.5	(1076.8, 1576.2)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-139. Minitab Prediction Report for Model VA-1

Regression for Lab Vanadium Result (mg/kg) vs Ex Situ XRF Vanadium (ppm)
Diagnostic Report - Model VA-1

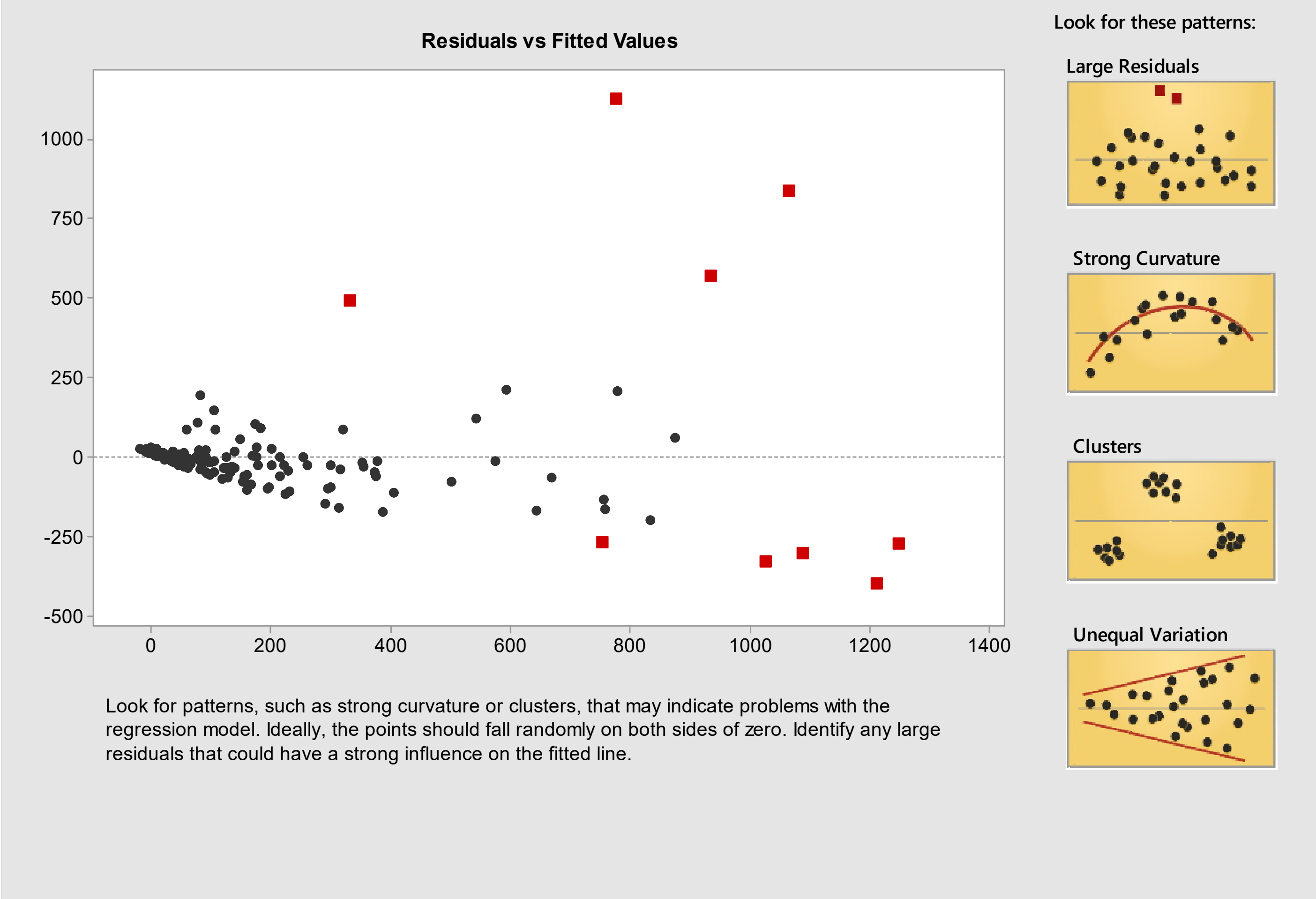


Figure B3-140. Minitab Residuals Report for Model VA-1

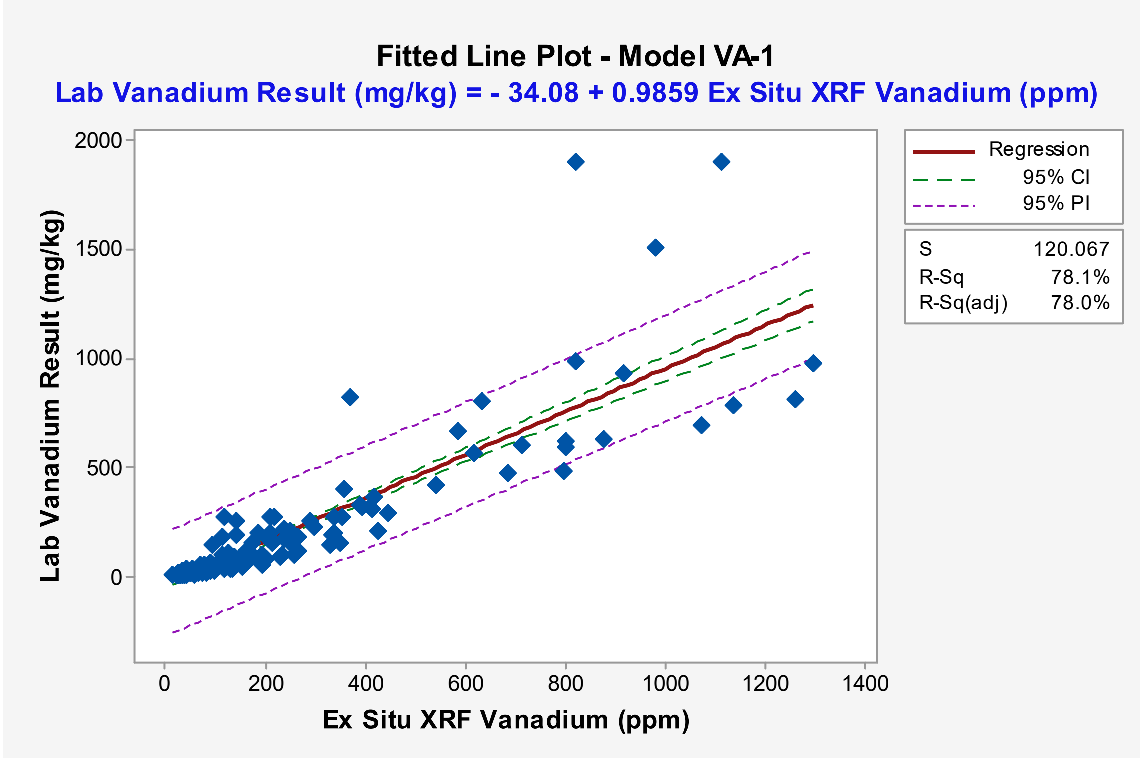


Figure B3-141. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model VA-1

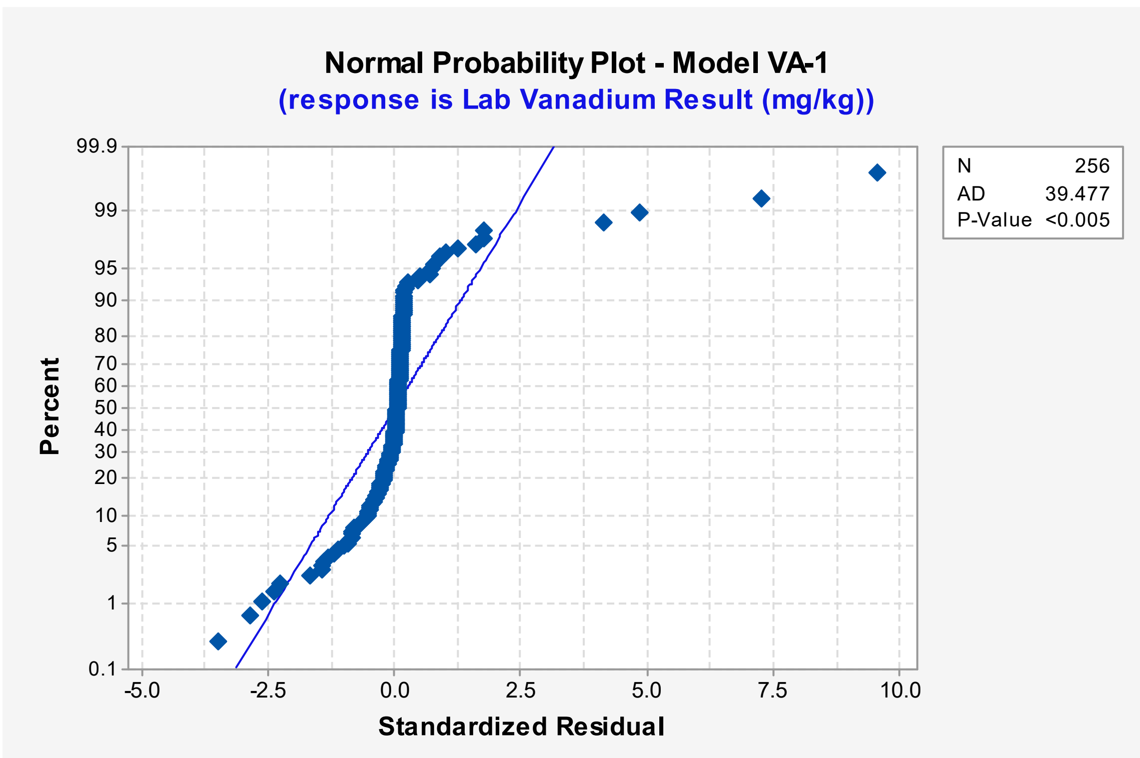


Figure B3-142. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model VA-1

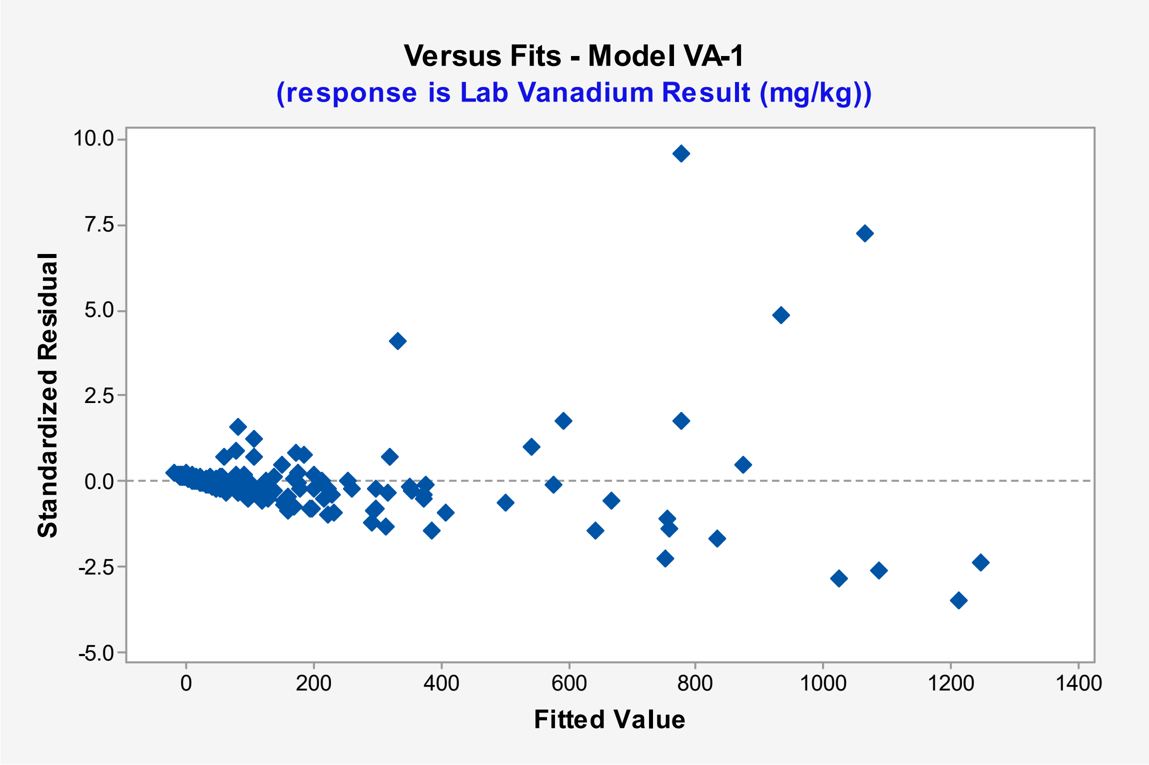


Figure B3-143. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model VA-1

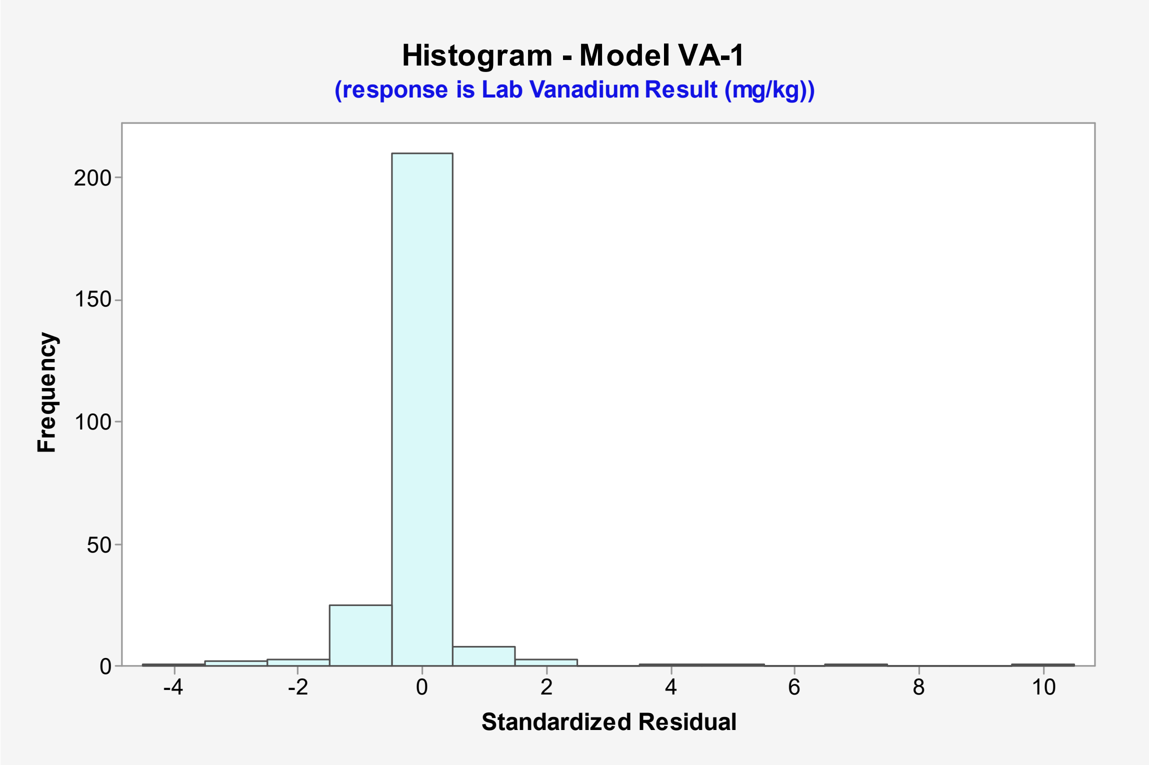


Figure B3-144. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model VA-1

9.2 VANADIUM STATISTICAL OUTPUT (MODEL VA-2)

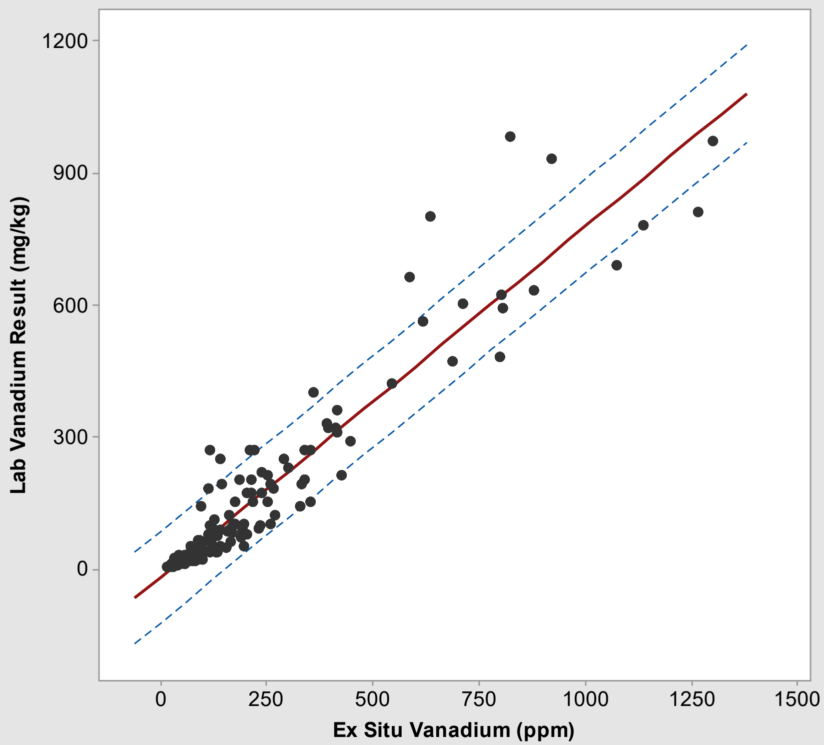
Regression for Lab Vanadium Result (mg/kg) vs Ex Situ Vanadium (ppm)

Prediction Report - Model VA-2

Y: Lab Vanadium Result (mg/kg)
X: Ex Situ Vanadium (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-60	-66.110	(-170.07, 37.849)
0	-18.334	(-122.20, 85.529)
60	29.442	(-74.357, 133.24)
120	77.218	(-26.551, 180.99)
180	124.99	(21.223, 228.77)
240	172.77	(68.965, 276.58)
300	220.55	(116.67, 324.42)
360	268.32	(164.35, 372.30)
420	316.10	(211.99, 420.21)
480	363.88	(259.60, 468.15)
540	411.65	(307.18, 516.12)
600	459.43	(354.73, 564.13)
660	507.20	(402.24, 612.17)
720	554.98	(449.72, 660.24)
780	602.76	(497.17, 708.34)
840	650.53	(544.59, 756.47)
900	698.31	(591.98, 804.63)
960	746.08	(639.34, 852.83)
1020	793.86	(686.67, 901.05)
1080	841.64	(733.97, 949.30)
1140	889.41	(781.24, 997.59)
1200	937.19	(828.48, 1045.9)
1260	984.96	(875.69, 1094.2)
1320	1032.7	(922.87, 1142.6)
1380	1080.5	(970.03, 1191.0)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-145. Minitab Prediction Report for Model VA-2

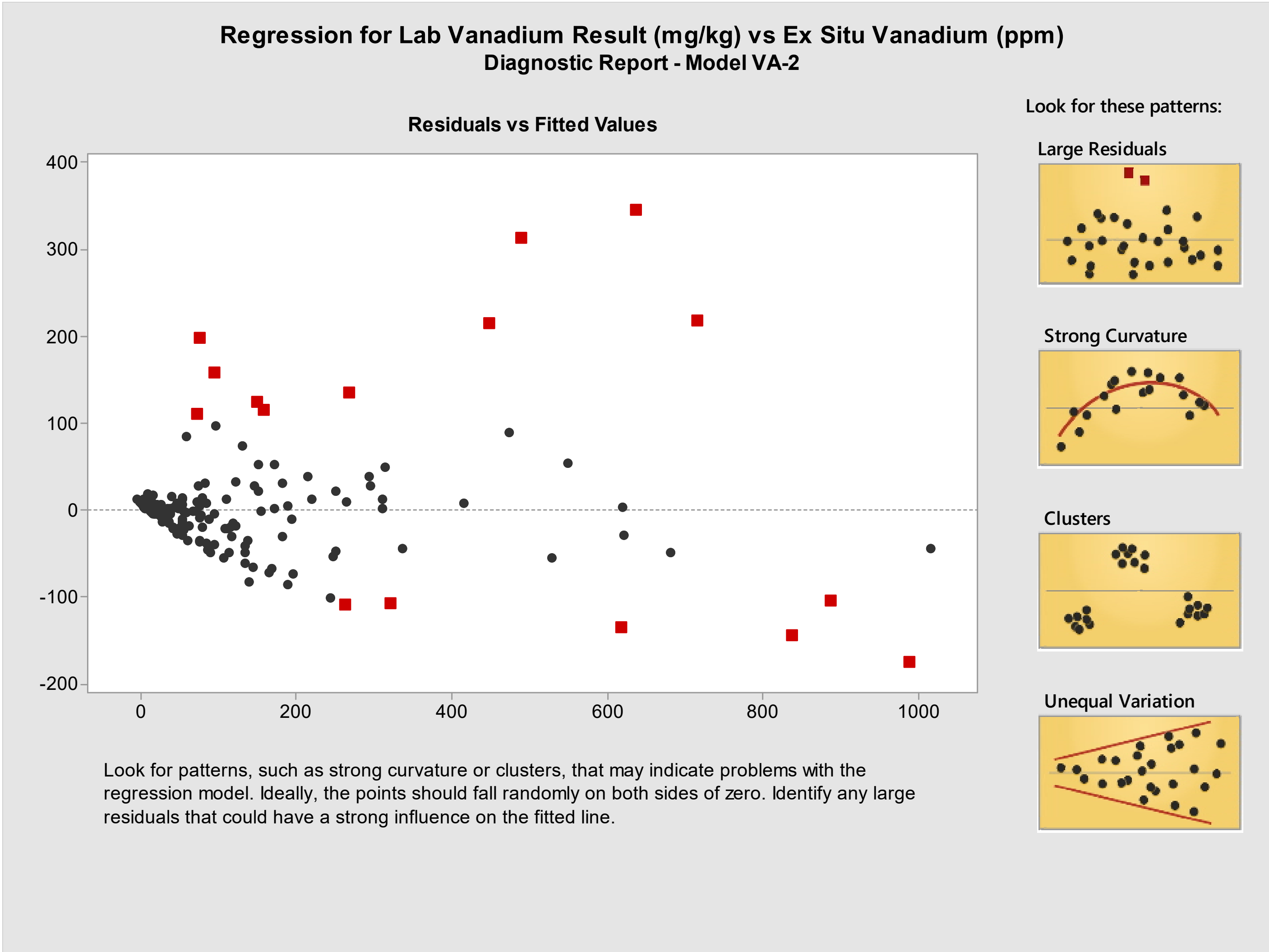


Figure B3-146. Minitab Residuals Report for Model VA-12

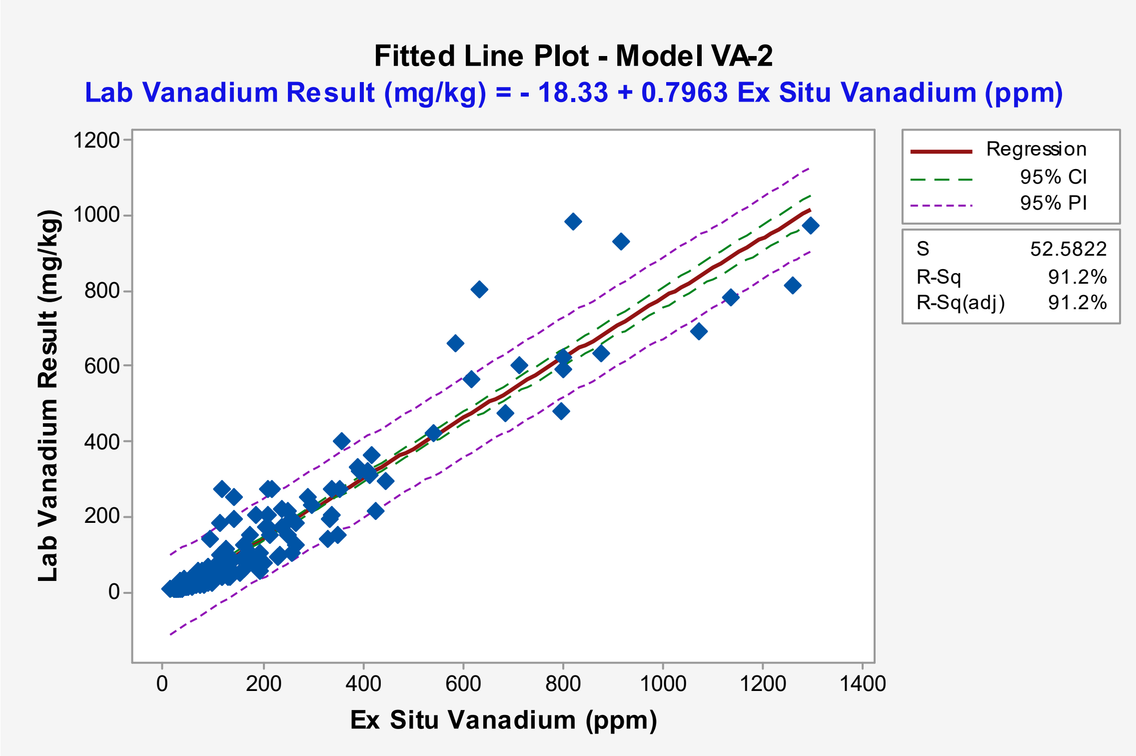


Figure B3-147. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model VA-2

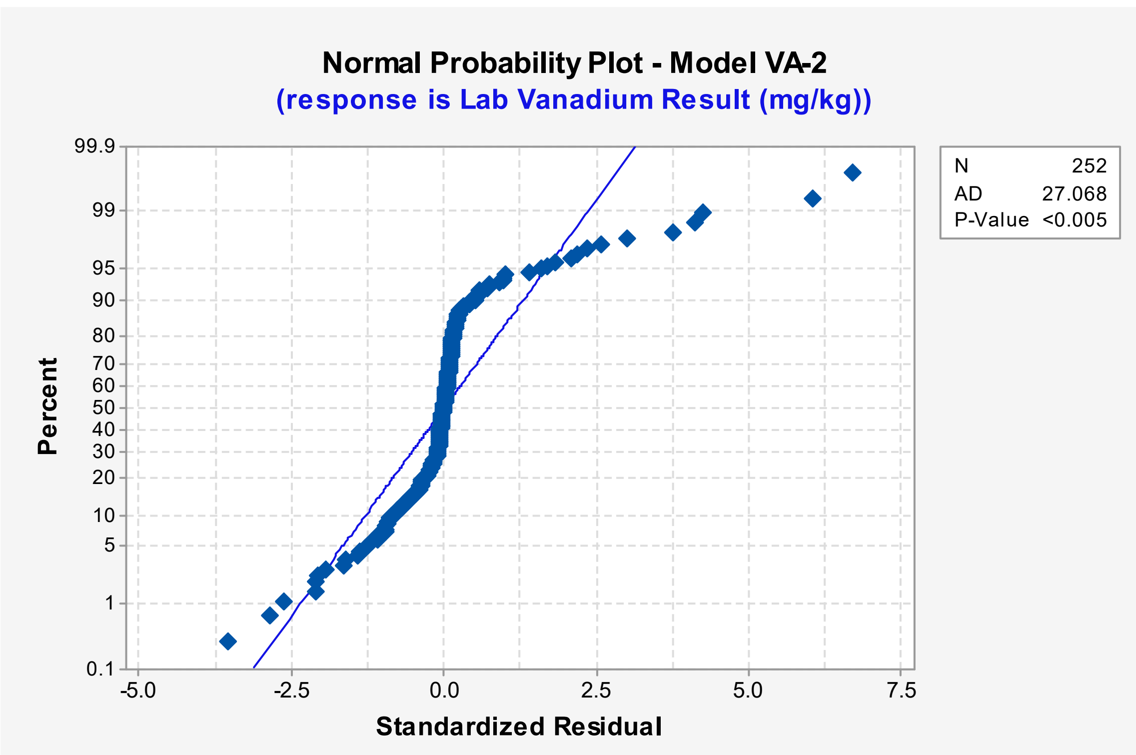


Figure B3-148. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model VA-2

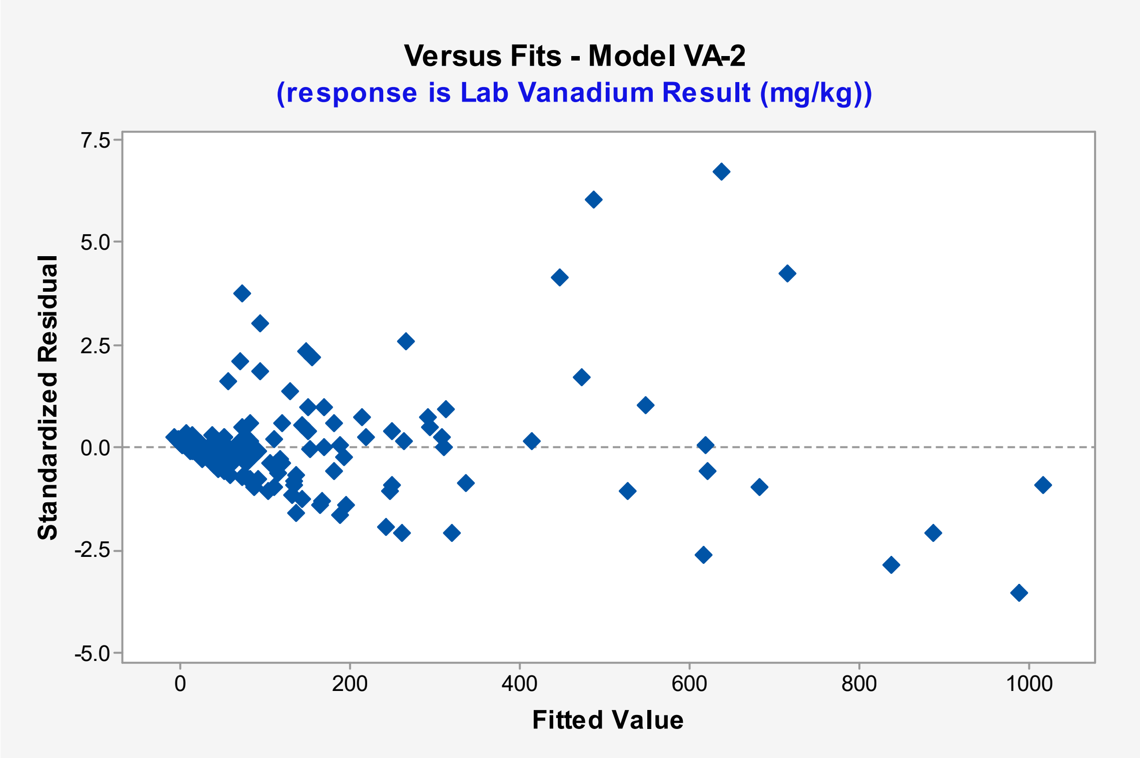


Figure B3-149. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model VA-2

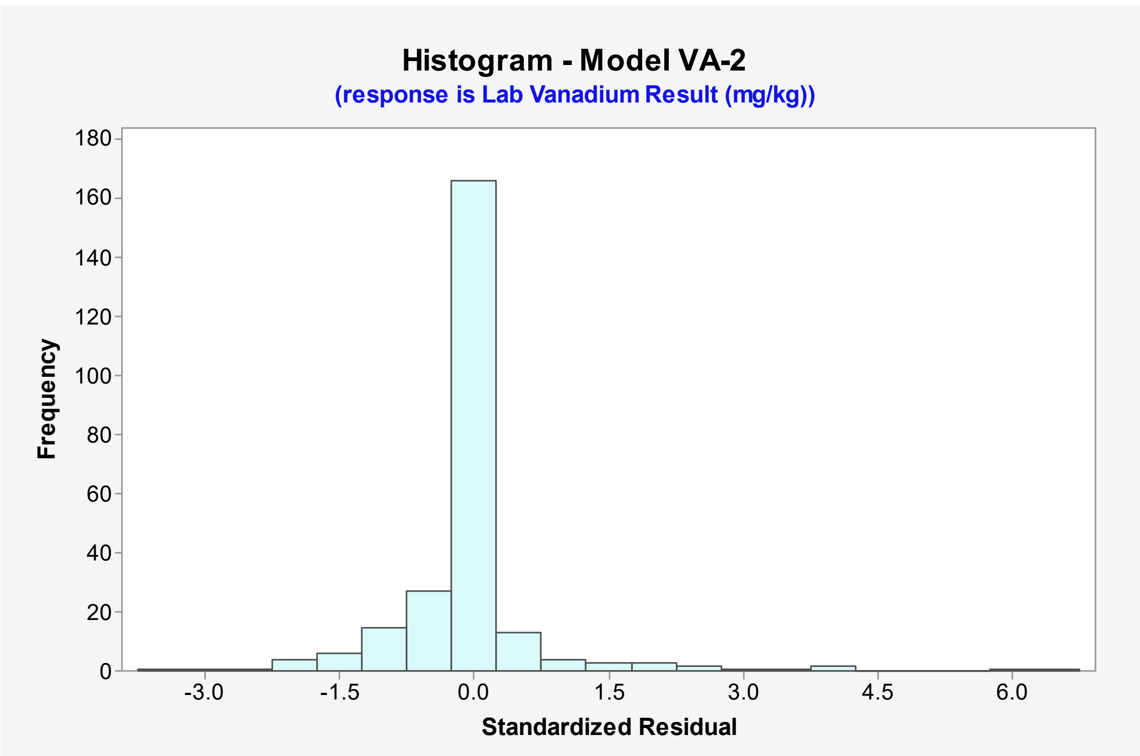


Figure B3-150. Ex Situ Bulk Sample Histogram of Standarized Vanadium Residuals for Model VA-2

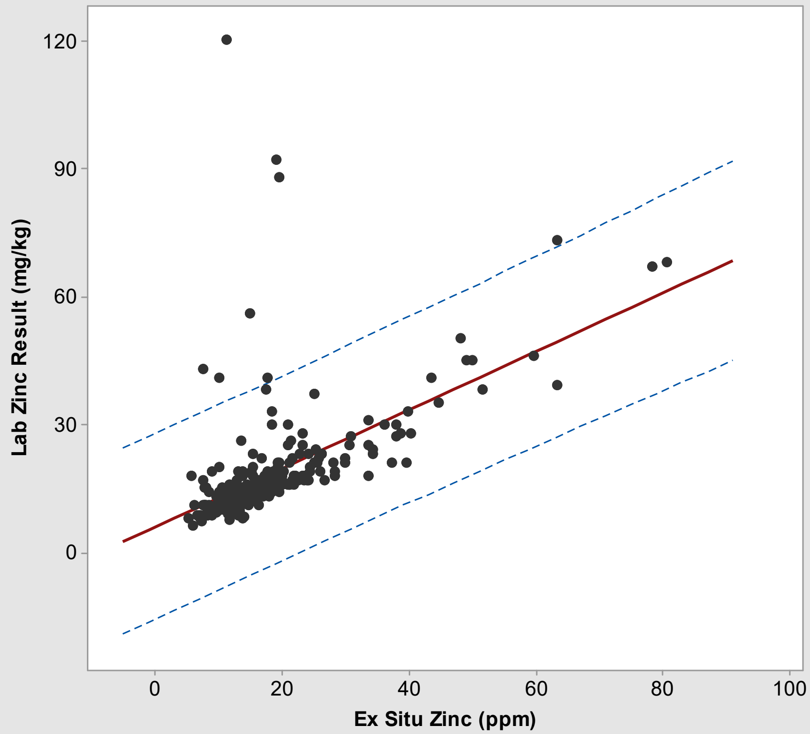
10.0 ZINC EX SITU BULK SAMPLE LINEAR REGRESSION RESULTS

10.1 ZINC STATISTICAL OUTPUT (MODEL ZN-1)

Regression for Lab Zinc Result (mg/kg) vs Ex Situ Zinc (ppm)
Prediction Report - Model ZN-1

Y: Lab Zinc Result (mg/kg)
X: Ex Situ Zinc (ppm)

Prediction Plot
The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-5	2.8076	(-19.028, 24.643)
-1	5.5420	(-16.235, 27.319)
3	8.2764	(-13.453, 30.005)
7	11.011	(-10.681, 32.703)
11	13.745	(-7.9210, 35.411)
15	16.480	(-5.1717, 38.131)
19	19.214	(-2.4334, 40.861)
23	21.948	(0.29386, 43.603)
27	24.683	(3.0102, 46.355)
31	27.417	(5.7155, 49.119)
35	30.152	(8.4099, 51.893)
39	32.886	(11.093, 54.678)
43	35.620	(13.766, 57.474)
47	38.355	(16.428, 60.281)
51	41.089	(19.080, 63.098)
55	43.823	(21.721, 65.926)
59	46.558	(24.351, 68.764)
63	49.292	(26.972, 71.613)
67	52.027	(29.582, 74.471)
71	54.761	(32.183, 77.339)
75	57.495	(34.773, 80.217)
79	60.230	(37.355, 83.105)
83	62.964	(39.927, 86.002)
87	65.699	(42.490, 88.908)
91	68.433	(45.043, 91.822)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-151. Minitab Prediction Report for Model ZN-1

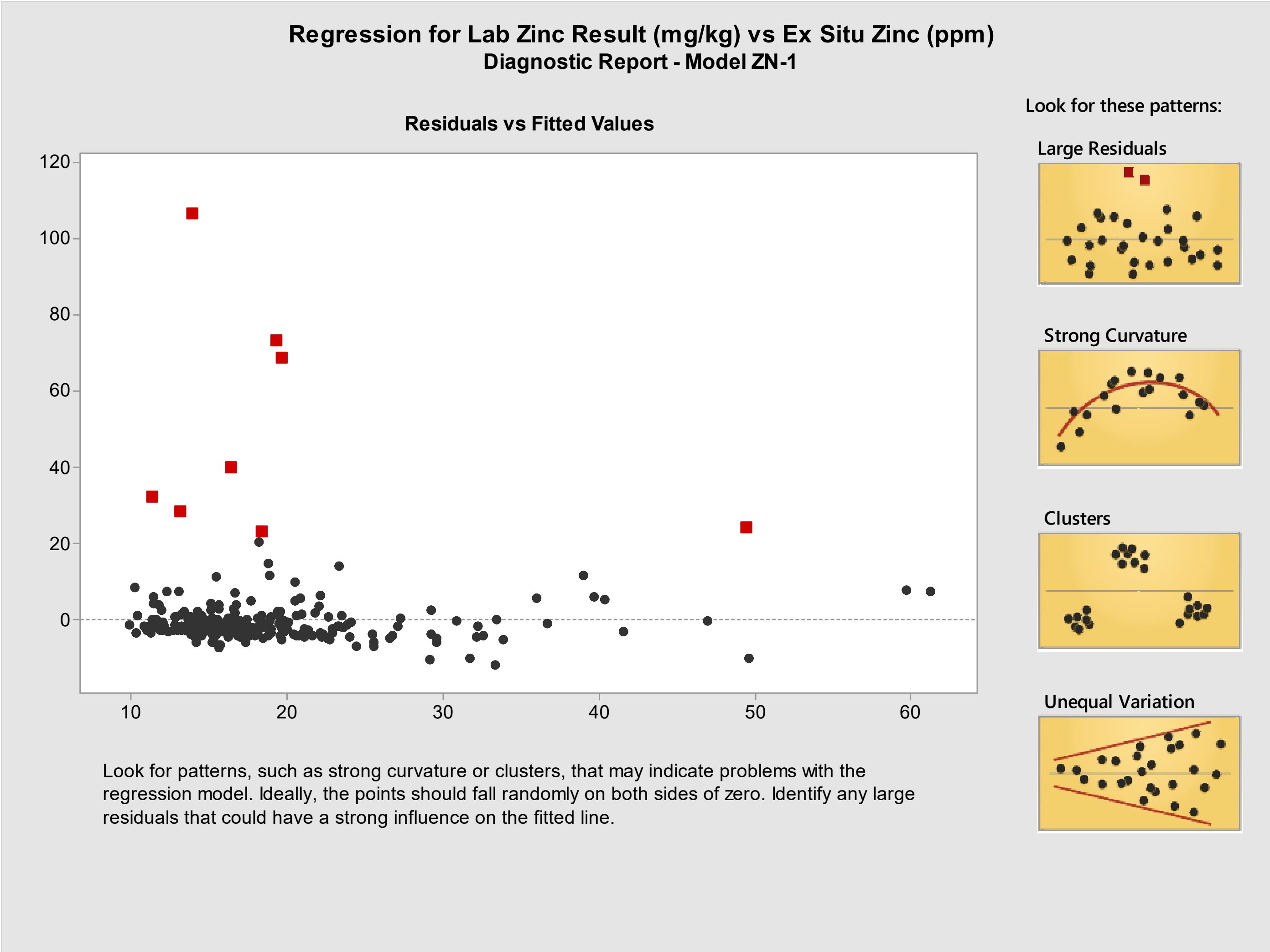


Figure B3-152. Minitab Residuals Report for Model ZN-1

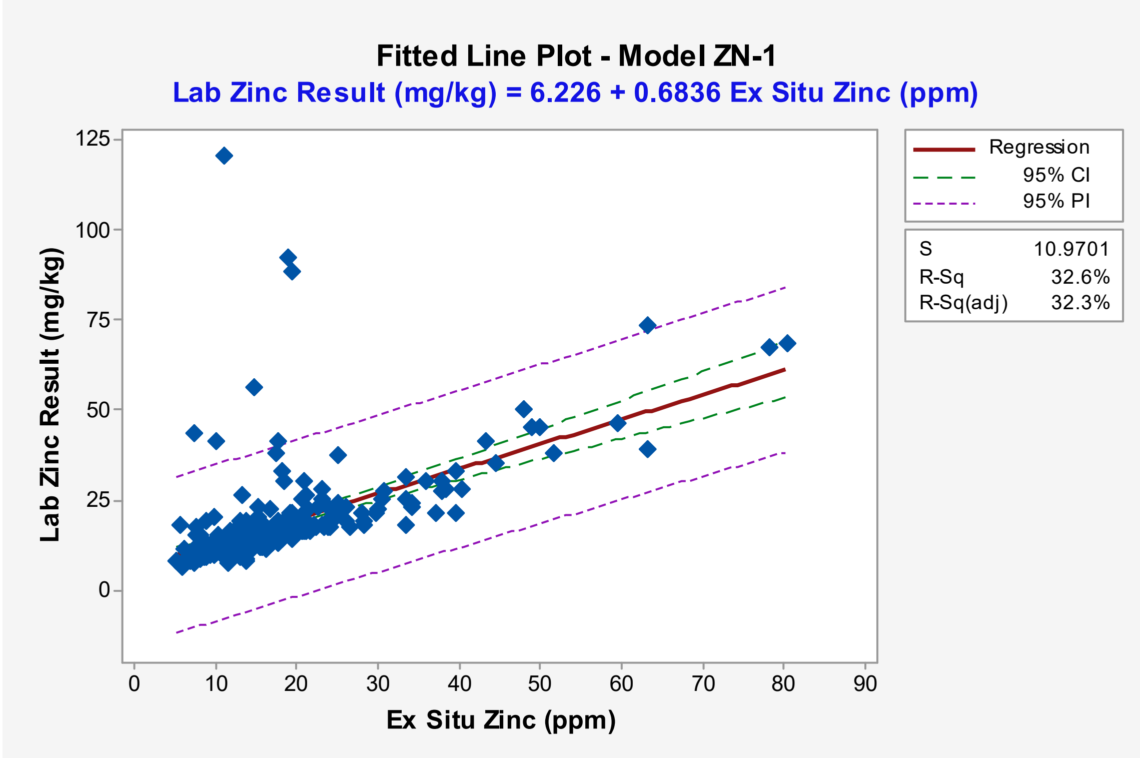


Figure B3-153. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model ZN-1

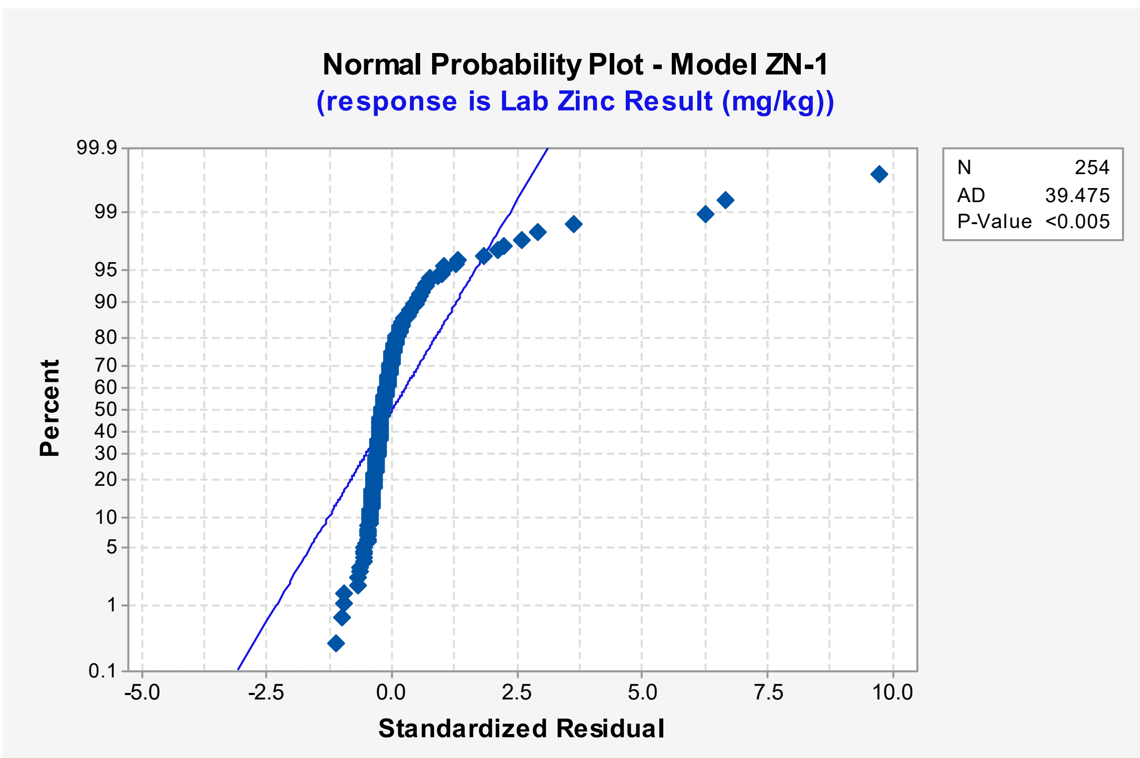


Figure B3-154. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model ZN-1

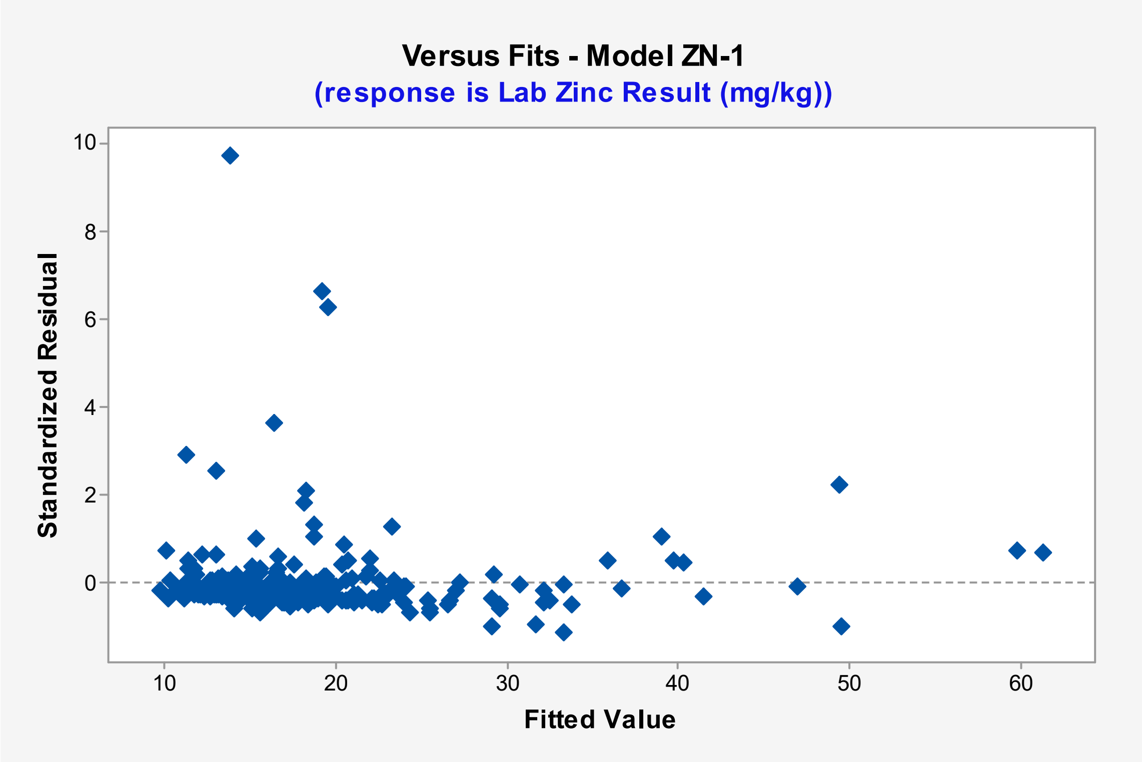


Figure B3-155. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model ZN-1

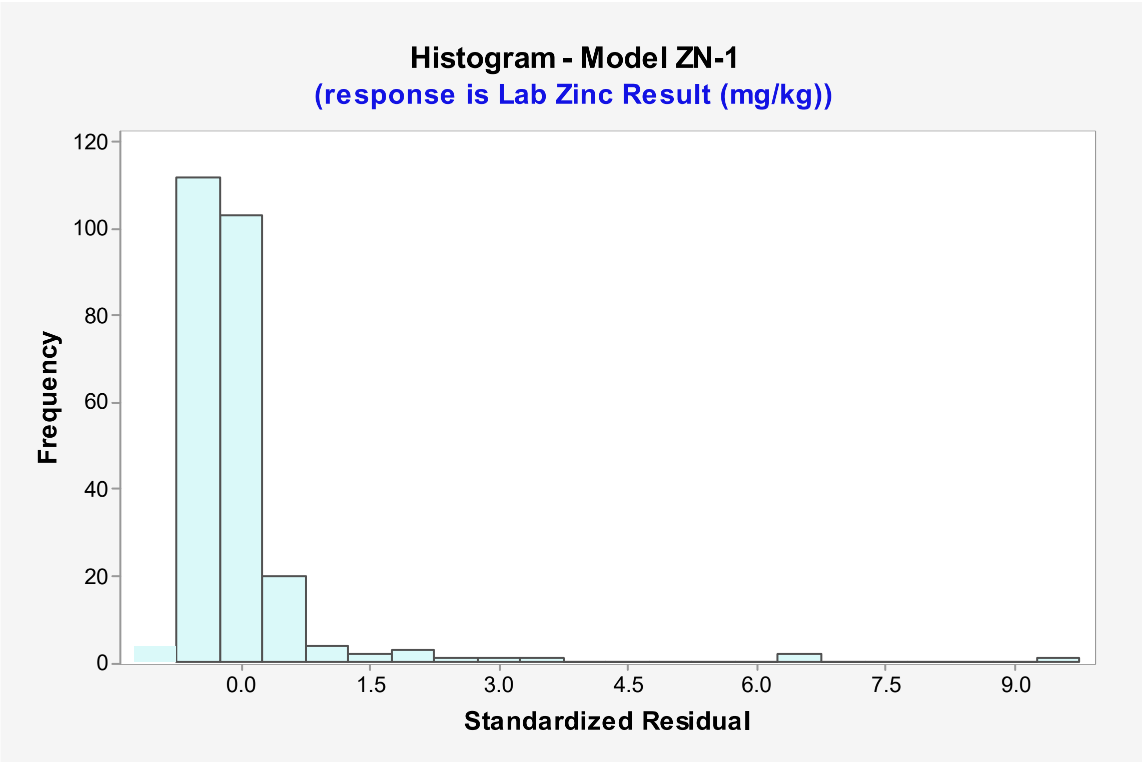


Figure B3-156. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model ZN-1

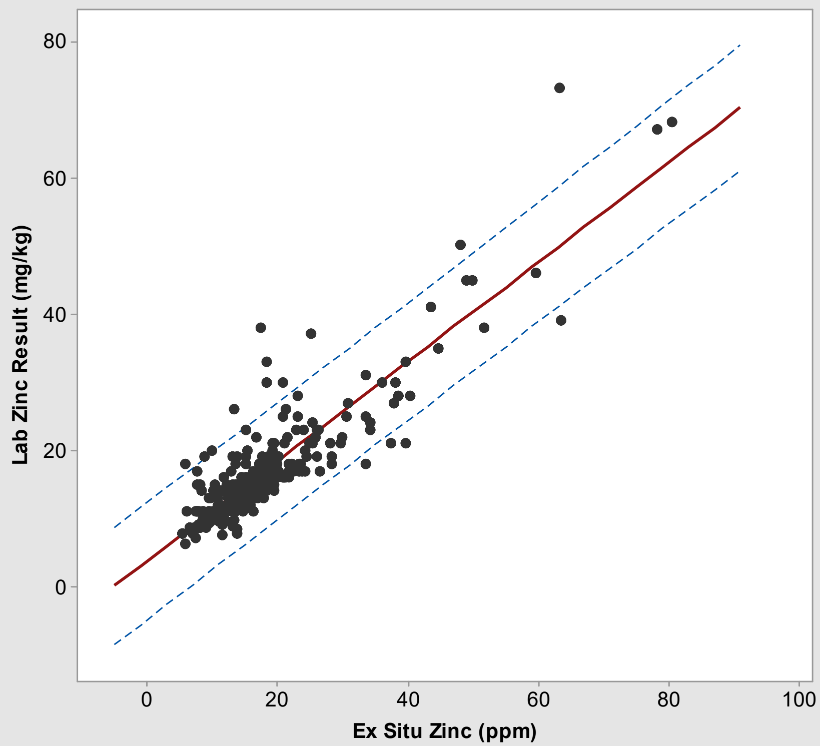
Regression for Lab Zinc Result (mg/kg) vs Ex Situ Zinc (ppm)

Prediction Report - Model ZN-2

Y: Lab Zinc Result (mg/kg)
X: Ex Situ Zinc (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-5	0.21702	(-8.3931, 8.8271)
-1	3.1375	(-5.4492, 11.724)
3	6.0580	(-2.5096, 14.626)
7	8.9784	(0.42560, 17.531)
11	11.899	(3.3565, 20.441)
15	14.819	(6.2830, 23.356)
19	17.740	(9.2052, 26.275)
23	20.660	(12.123, 29.198)
27	23.581	(15.036, 32.125)
31	26.501	(17.945, 35.057)
35	29.422	(20.850, 37.993)
39	32.342	(23.750, 40.934)
43	35.263	(26.647, 43.879)
47	38.183	(29.538, 46.828)
51	41.104	(32.426, 49.781)
55	44.024	(35.310, 52.739)
59	46.945	(38.189, 55.700)
63	49.865	(41.064, 58.666)
67	52.786	(43.935, 61.636)
71	55.706	(46.803, 64.609)
75	58.626	(49.666, 67.587)
79	61.547	(52.526, 70.568)
83	64.467	(55.382, 73.553)
87	67.388	(58.235, 76.541)
91	70.308	(61.083, 79.533)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-157. Minitab Prediction Report for Model ZN-2

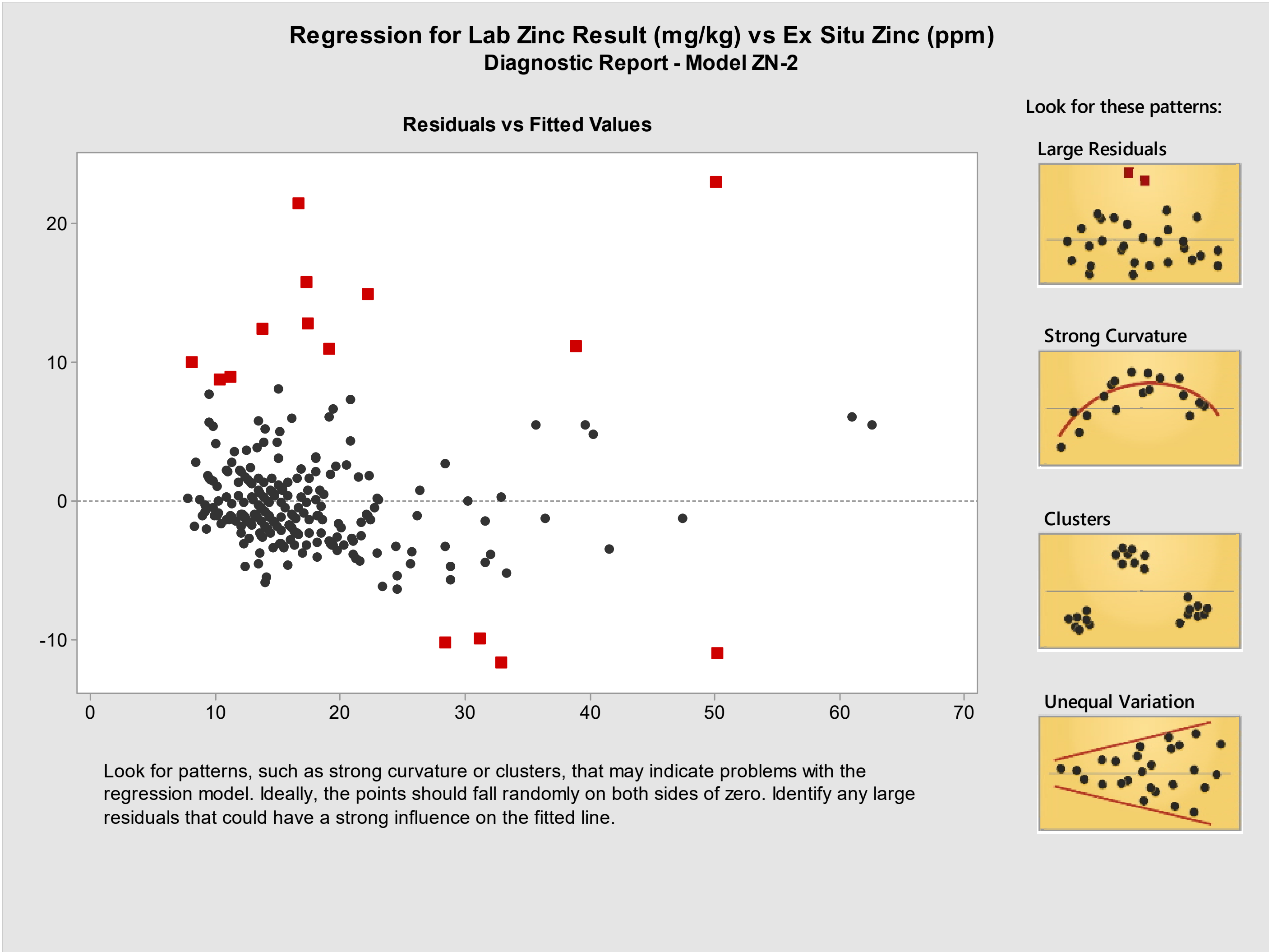


Figure B3-158. Minitab Residuals Report for Model ZN-2

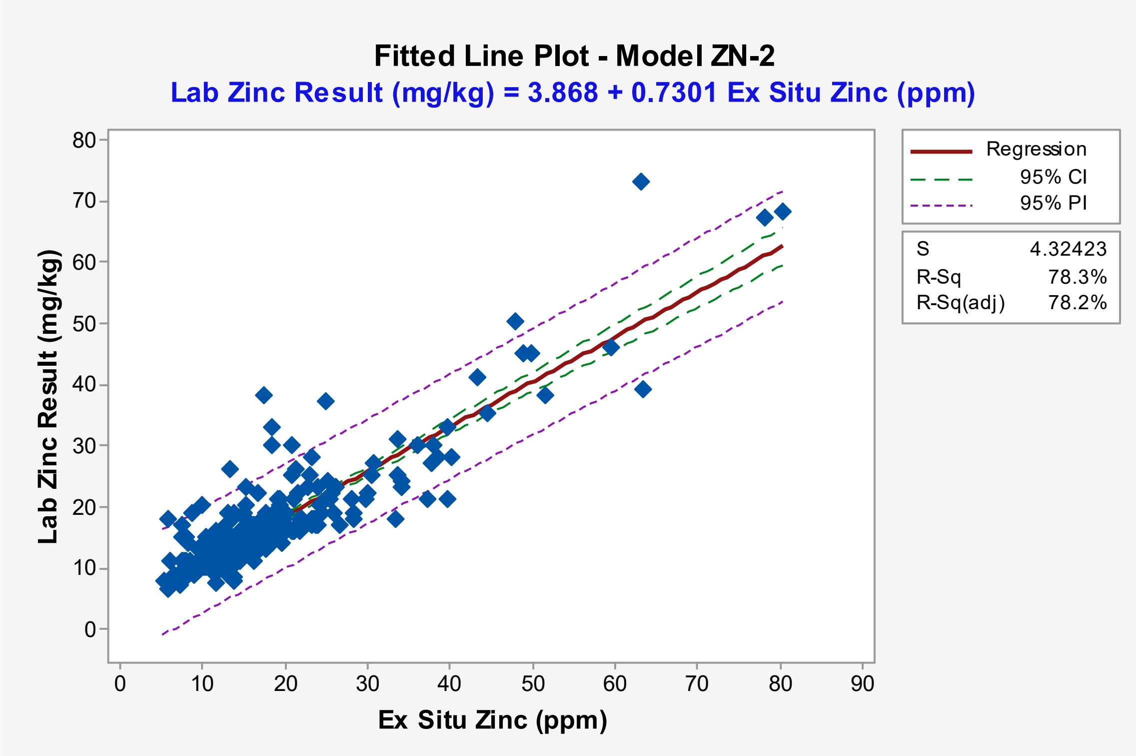


Figure B3-159. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model ZN-2

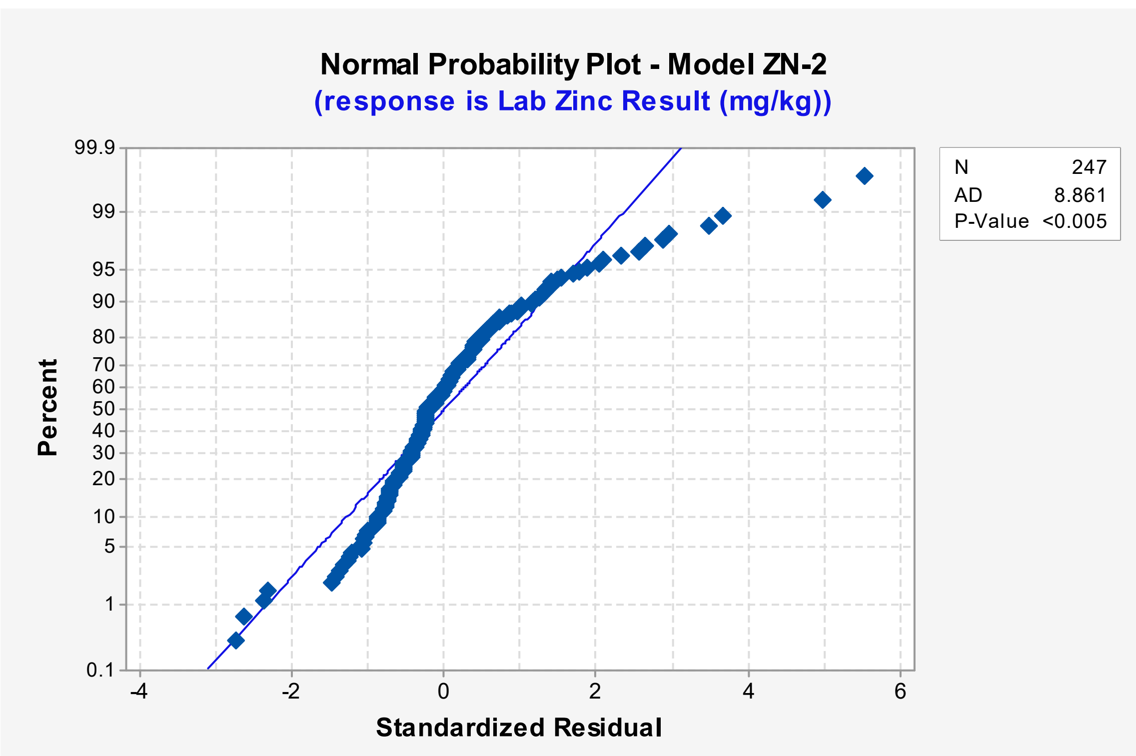


Figure B3-160. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model ZN-2

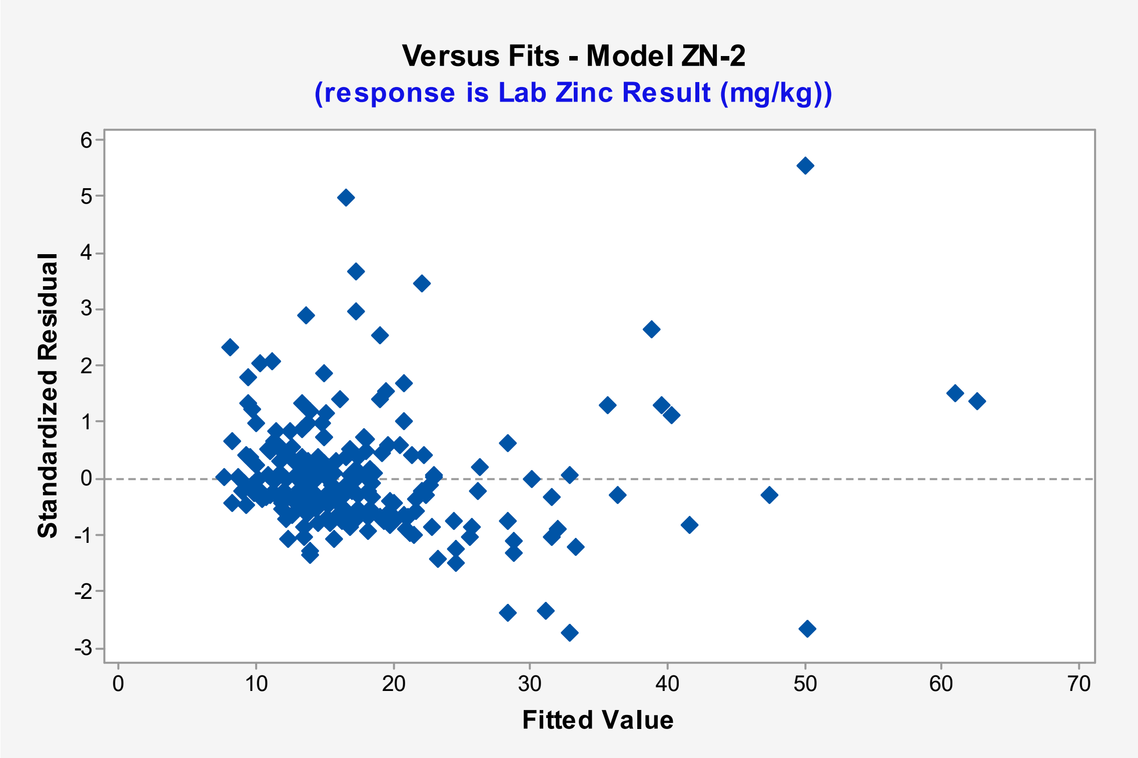


Figure B3-161. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model ZN-2

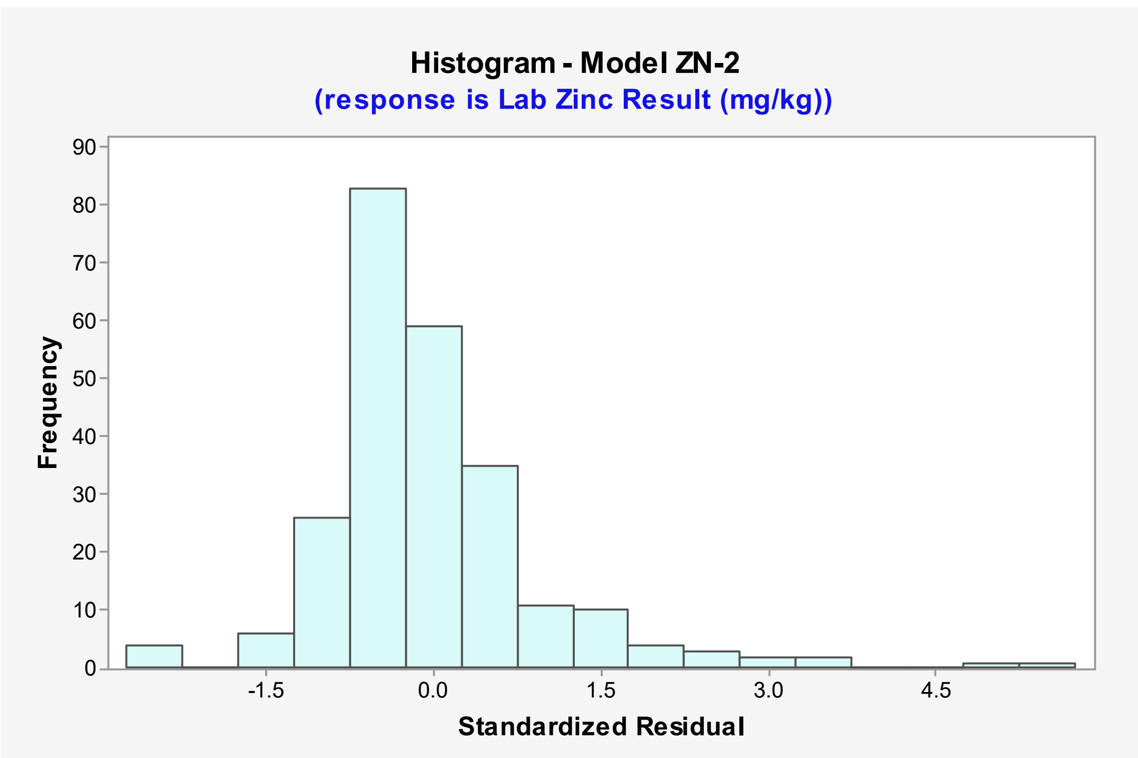


Figure B3-162. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model ZN-2

10.3 ZINC STATISTICAL OUTPUT (MODEL ZN-3)

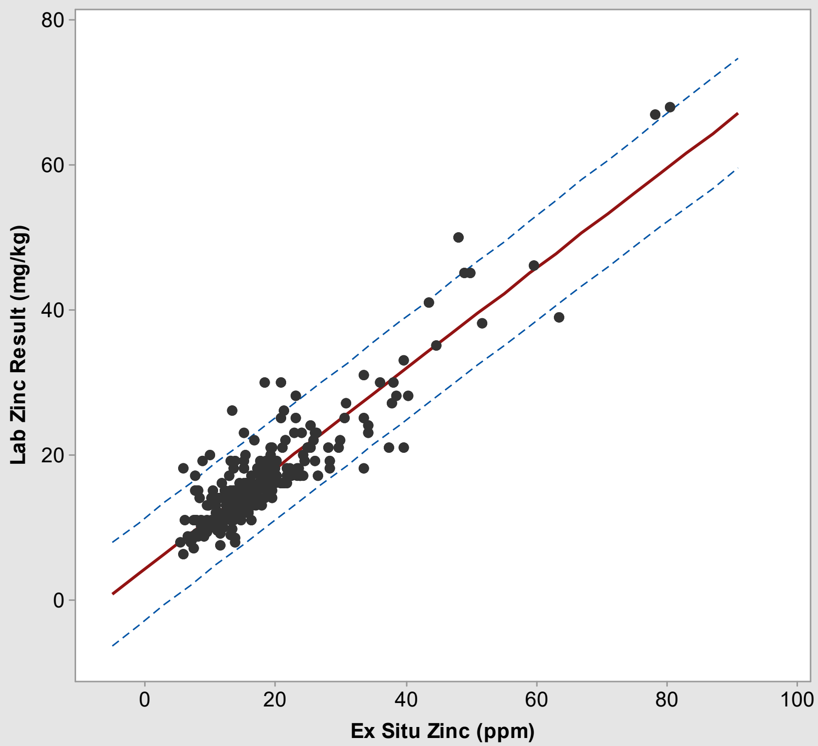
Regression for Lab Zinc Result (mg/kg) vs Ex Situ Zinc (ppm)

Prediction Report - Model ZN-3

Y: Lab Zinc Result (mg/kg)
X: Ex Situ Zinc (ppm)

Prediction Plot

The red fitted line shows the predicted Y for any X value. The blue dashed lines show the 95% prediction interval.



X	Predicted Y	95% PI
-5	0.79984	(-6.2933, 7.8930)
-1	3.5674	(-3.5054, 10.640)
3	6.3350	(-0.72119, 13.391)
7	9.1025	(2.0592, 16.146)
11	11.870	(4.8357, 18.904)
15	14.638	(7.6084, 21.667)
19	17.405	(10.377, 24.433)
23	20.173	(13.142, 27.203)
27	22.940	(15.903, 29.977)
31	25.708	(18.661, 32.755)
35	28.475	(21.414, 35.537)
39	31.243	(24.164, 38.322)
43	34.011	(26.910, 41.111)
47	36.778	(29.652, 43.904)
51	39.546	(32.390, 46.701)
55	42.313	(35.125, 49.501)
59	45.081	(37.856, 52.305)
63	47.848	(40.584, 55.113)
67	50.616	(43.308, 57.924)
71	53.383	(46.029, 60.738)
75	56.151	(48.746, 63.556)
79	58.919	(51.460, 66.377)
83	61.686	(54.171, 69.201)
87	64.454	(56.879, 72.029)
91	67.221	(59.583, 74.859)

To obtain additional predicted values, right-click the graph and use the crosshairs tool.

Figure B3-163. Minitab Prediction Report for Model ZN-3

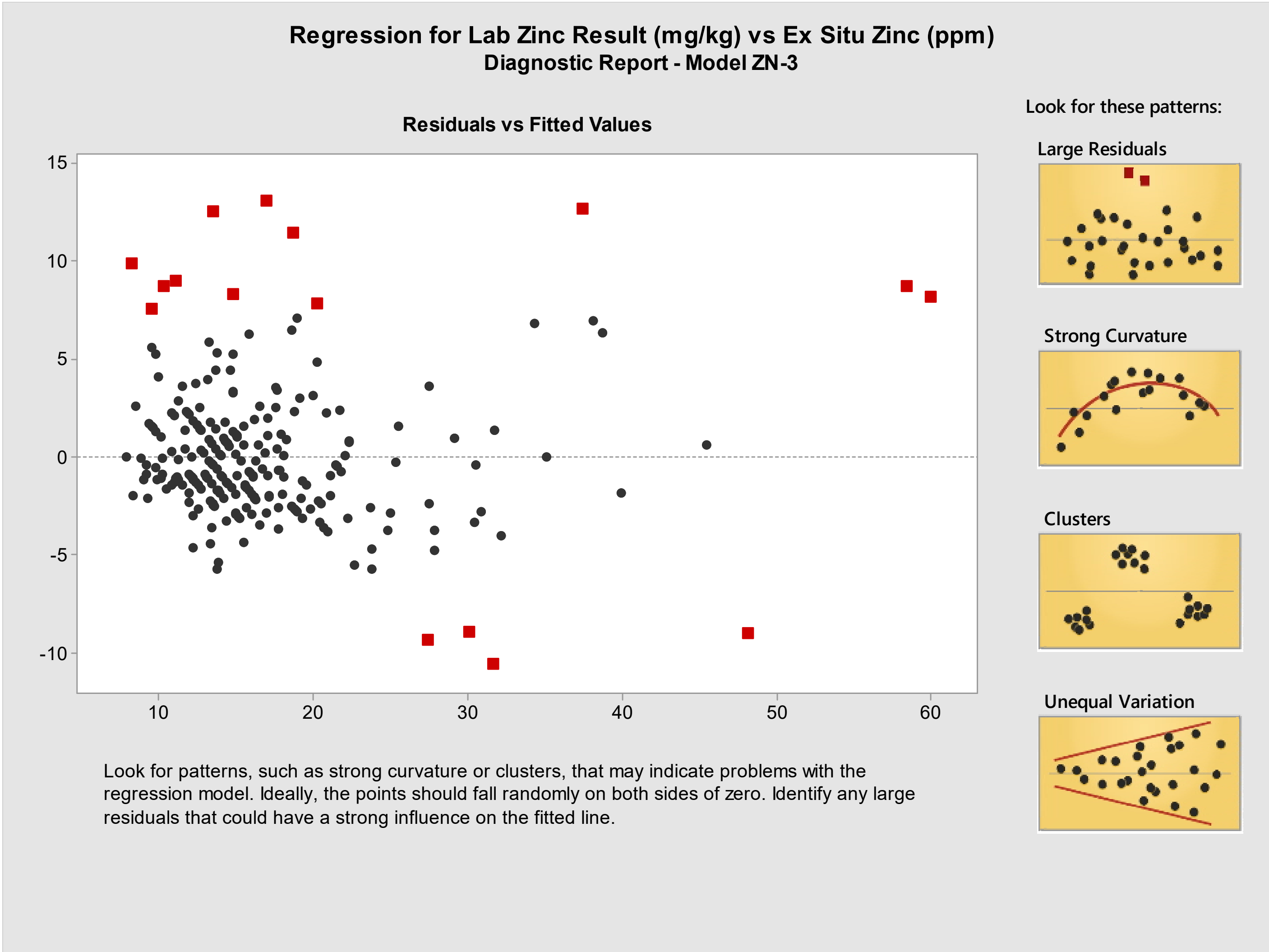


Figure B3-164. Minitab Residuals Report for Model ZN-3

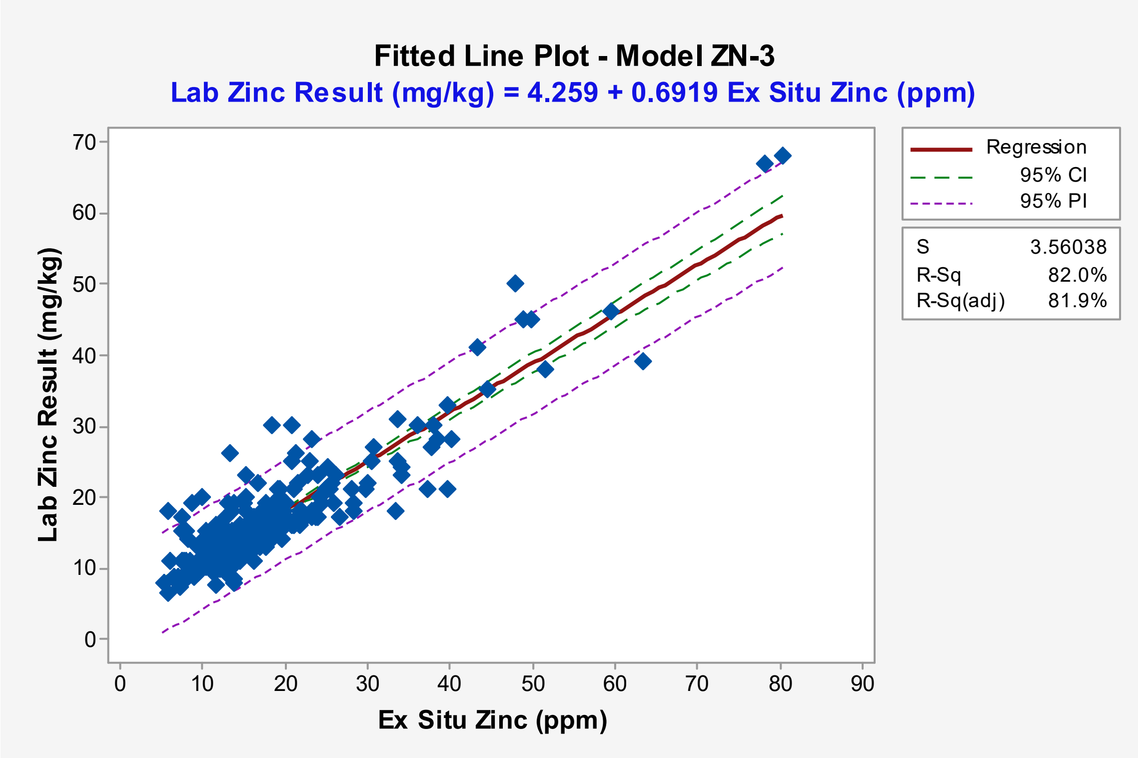


Figure B3-165. Ex Situ Bulk Sample Fitted Line Plot for Vanadium Model ZN-3

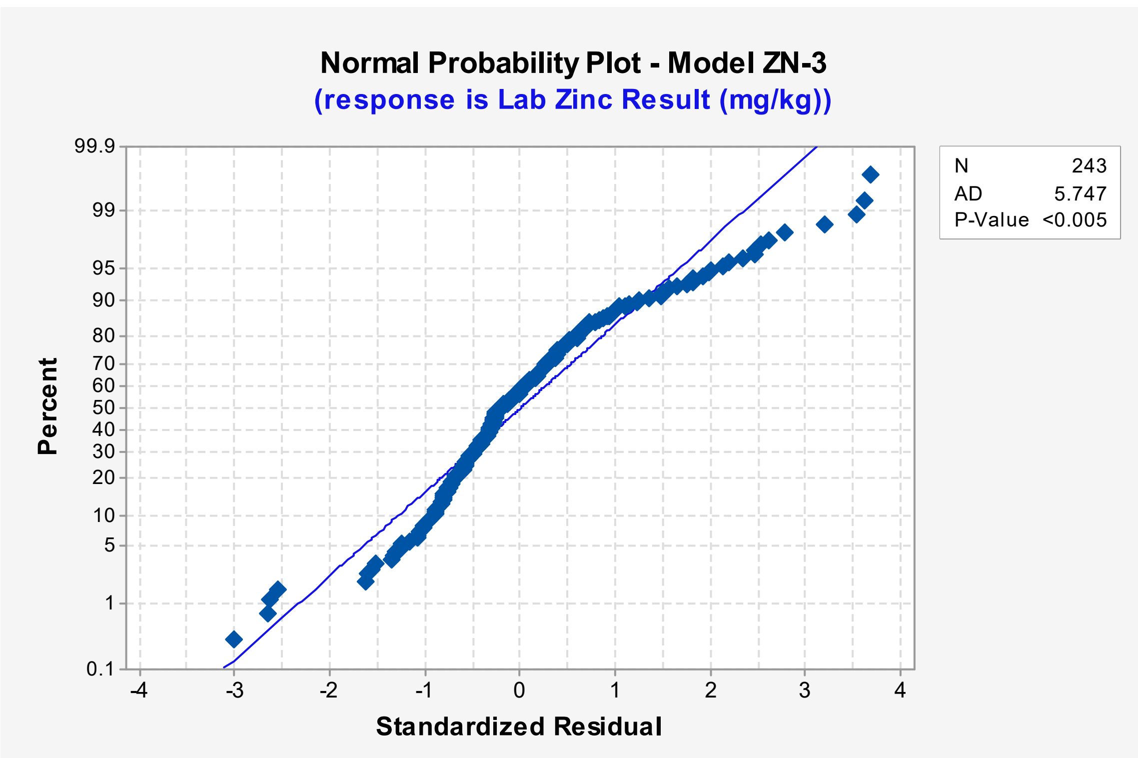


Figure B3-166. Ex Situ Bulk Sample Normal Probability Plot of Vanadium Standardized Residuals for Model ZN-3

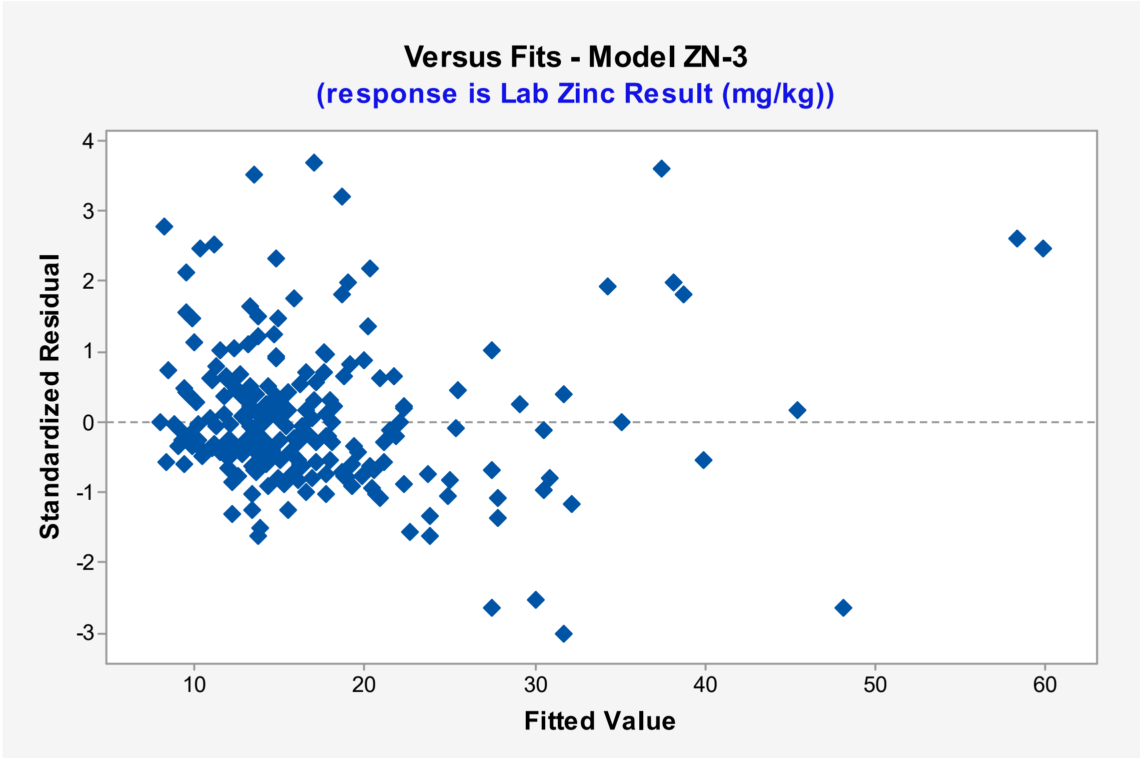


Figure B3-167. Ex Situ Bulk Sample Versus Fits Residuals Vanadium for Model ZN-3

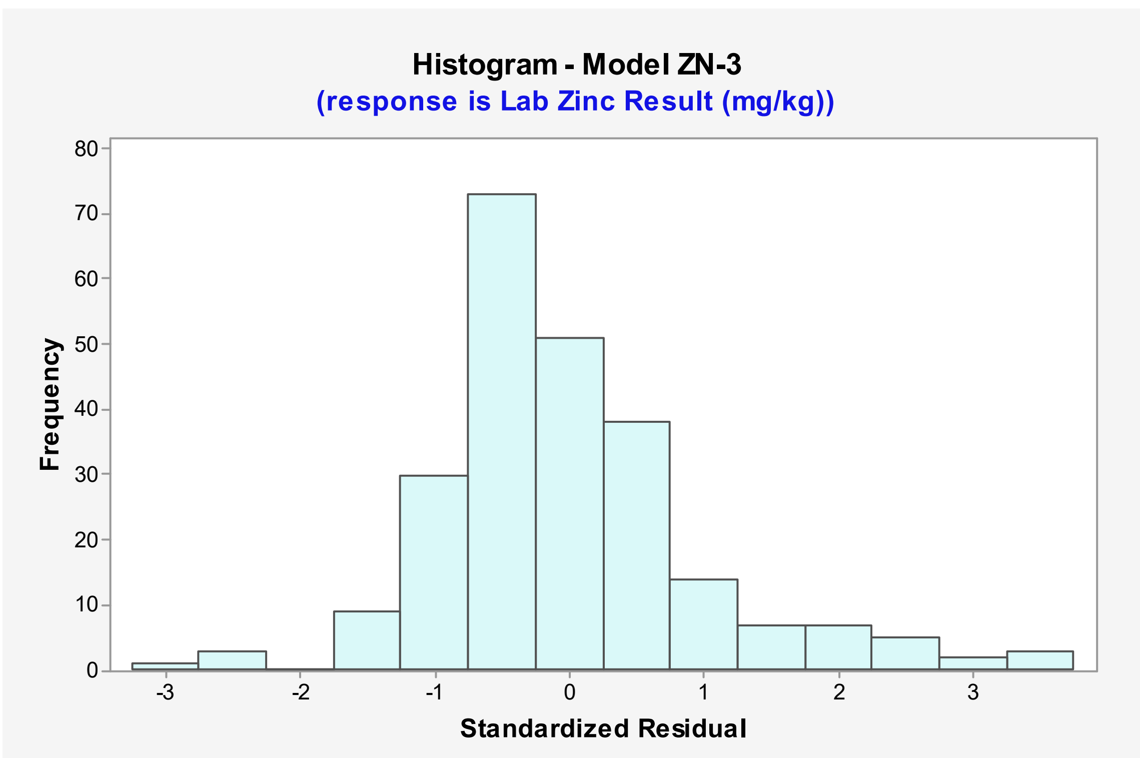
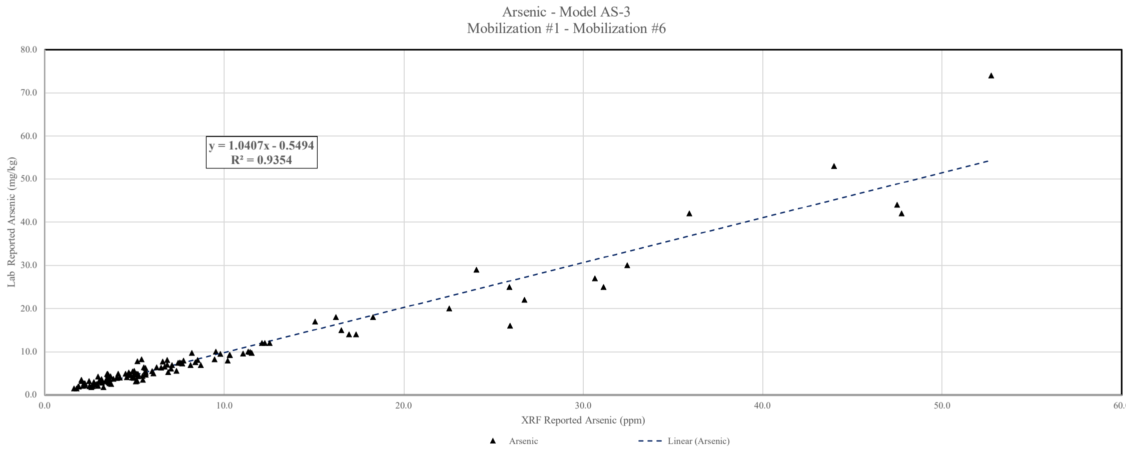


Figure B3-168. Ex Situ Bulk Sample Histogram of Standardized Vanadium Residuals for Model ZN-3

ATTACHMENT B4

EX SITU BULK SAMPLE REGRESSION MODEL DATA



Data Included in Model AS-3											
Trip	XRF Color	XRF ID	XRF - Arsenic				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	M3-XS36-01-043018	5.4	5.3	12%	4	M3-XS36-01-043018	1805042-2	8.2		41%
Trip 1	Pink	M6-XS251-01-04272018	3.6	3.7	22%	2	M6-XS251-01-04272018	1805039-2	3.0		17%
Trip 1	Pink	M6-XS269-01-04262018	5.1	3.7	78%	2	M6-XS269-01-04262018	1805039-3	4.9		5%
Trip 1	Pink	M6-XS269-02-04262018	4.5	4.4	32%	2	M6-XS269-02-04262018	1805039-4	4.9		8%
Trip 1	Pink	M6-XS285-01-04272018	3.5	3.6	27%	2	M6-XS285-01-04272018	1805039-5	4.9		33%
Trip 1	Pink	T10-XS78-01-042518	2.6	2.6	19%	2	T10-XS78-01-042518	1805036-5	1.8		36%
Trip 1	Pink	T11-XS1-01-042518	3.3	3.4	26%	2	T11-XS1-01-042518	1805036-6	1.8		58%
Trip 1	Pink	T17-XS20-01-04262018	4.8	4.9	10%	4	T17-XS20-01-04262018	1805039-12	4.6		3%
Trip 1	Pink	T17-XS251-01-04272018	6.6	6.6	10%	6	T17-XS251-01-04272018	1805039-13	7.7		16%
Trip 1	Pink	T17-XS257-01-04272018	3.6	3.5	18%	3	T17-XS257-01-04272018	1805039-14	2.9		21%
Trip 1	Pink	T17-XS287-01-04272018	18.3	18.0	13%	15	T17-XS287-01-04272018	1805039-15	18.0		2%
Trip 1	Pink	T17-XS317-01-04272018	10.3	8.8	31%	8	T17-XS317-01-04272018	1805039-16	9.3		10%
Trip 1	Pink	T17-XS377-01-042818	3.6	3.5	24%	3	T17-XS377-01-042818	1805041-10	3.6		1%
Trip 1	Pink	T17-XS417-01-04272018	1.8	1.7	18%	1	T17-XS417-01-04272018	1805039-18	1.5		16%
Trip 1	Pink	T17-XS479-01-042818	1.9	1.9	15%	2	T17-XS479-01-042818	1805041-14	1.9		2%
Trip 1	Pink	T9-XS217-01-042518	2.6	2.6	20%	2	T9-XS217-01-042518	1805036-17	2.0		26%
Trip 1	Pink	T9-XS61-01-042518	2.9	2.7	19%	2	T9-XS61-01-042518	1805036-18	2.3		21%
Trip 1	Orange	T9-XS61-02-042518	3.7	3.8	22%	2	T9-XS61-02-042518	1805041-17	2.5		39%
Trip 1	Pink	T9-XS93-01-042518	2.5	2.5	24%	2	T9-XS93-01-042518	1805036-20	2.0		22%
Trip 2	Pink	M4-XS18-01-050718	4.0	4.1	11%	3	M4-XS18-01-050718	1805322-2	3.9		3%
Trip 2	Orange	M4-XS219-01-051018	1.9	1.6	26%	1	M4-XS219-01-051018	1805322-3	1.9		0%
Trip 2	Pink	M4-XS238-01-051018	6.5	5.7	38%	5	M4-XS238-01-051018	1805322-4	6.3		3%
Trip 2	Pink	M4-XS63-02-050718	5.0	4.8	24%	4	M4-XS63-02-050718	1805322-8	4.7		6%
Trip 2	Pink	M4-XS78-01-051018	2.8	2.6	31%	2	M4-XS78-01-051018	1805322-9	2.7		2%
Trip 2	Pink	T13-XS12-01-050818	2.7	2.7	23%	2	T13-XS12-01-050818	1805322-21	2		28%
Trip 2	Pink	T14-XS12-01-050818	2.0	2.0	31%	1	T14-XS12-01-050818	1805322-23	3.5		53%
Trip 2	Pink	T14-XS27-01-050818	1.6	1.6	17%	1	T14-XS27-01-050818	1805322-24	1.5		9%
Trip 2	Pink	M8-XS102-01-050918	6.2	6.1	14%	6	M8-XS102-01-050918	1805328-4	6.4		3%
Trip 2	Pink	M8-XS102-02-050918	5.5	5.0	20%	5	M8-XS102-02-050918	1805328-5	6.4		15%
Trip 2	Orange	M8-XS19-01-051018	4.8	4.8	15%	4	M8-XS19-01-051018	1805328-7	4.7		1%
Trip 2	Orange	M8-XS32-01-051018	12.1	11.9	15%	9	M8-XS32-01-051018	1805328-8	12		1%
Trip 2	Pink	T1-XS20-01-051318	3.2	3.1	20%	2	T1-XS20-01-051318	1805328-11	2.8		13%
Trip 2	Pink	T1-XS54-01-051318	3.4	3.5	10%	3	T1-XS54-01-051318	1805328-12	3.1		8%
Trip 2	Pink	T1-XS54-02-051318	3.1	2.8	23%	2	T1-XS54-02-051318	1805328-13	3.1		1%
Trip 2	Pink	T1-XS69-01-051318	7.7	7.6	11%	7	T1-XS69-01-051318	1805328-14	7.9		2%
Trip 2	Pink	T1-XS104-01-051318	5.5	5.3	12%	5	T1-XS104-01-051318	1805328-10	3.5		44%
Trip 2	Pink	T4-XS43-01-051218	47.5	46.7	7%	44	T4-XS43-01-051218	1805328-19	44		8%
Trip 2	Pink	T5-XS19-01-051418	5.2	5.4	13%	4	T5-XS19-01-051418	1805328-20	4.8		8%
Trip 3	Pink	M14-XS64-01-052418	5.0	5.3	21%	3	M14-XS64-01-052418	1805632-3	5.6	J	12%
Trip 3	Pink	M15-XS22-01-052118	5.6	5.7	10%	5	M15-XS22-01-052118	1805589-1	6.2		10%
Trip 3	Pink	M15-XS3-01-052118	4.2	4.2	17%	3	M15-XS3-01-052118	1805589-2	4.0		4%
Trip 3	Pink	M15-XS46-01-052118	11.5	11.6	11%	10	M15-XS46-01-052118	1805589-3	9.7		17%
Trip 3	Pink	M15-XS46-02-052118	10.3	10.2	11%	9	M15-XS46-02-052118	1805589-4	9.2		11%
Trip 3	Pink	M15-XS82-01-052118	30.7	30.5	7%	27	M15-XS82-01-052118	1805589-6	27.0		13%
Trip 3	Pink	M15-XS93-01-052118	47.7	47.3	8%	43	M15-XS93-01-052118	1805589-7	42.0		13%
Trip 3	Pink	M16-XS128-01-052118	6.1	6.1	14%	5	M16-XS128-01-052118	1805589-8	5.0		19%
Trip 3	Pink	M16-XS154-01-052618	5.6	5.2	19%	5	M16-XS154-01-052618	1806235-2	5.1		10%
Trip 3	Blue	M16-XS177-01-052618	5.6	5.6	14%	5	M16-XS177-01-052618	1806235-3	4.7		18%
Trip 3	Pink	M16-XS191-01-052618	8.4	8.8	13%	7	M16-XS191-01-052618	1806235-4	7.6		10%
Trip 3	Pink	M16-XS191-02-052618	8.7	8.6	13%	7	M16-XS191-02-052618	1806235-5	6.9		23%
Trip 3	Blue	M16-XS30-01-052118	6.8	6.8	15%	6	M16-XS30-01-052118	1805589-10	8.1		17%
Trip 3	Pink	M16-XS31-01-052118	4.6	4.5	10%	4	M16-XS31-01-052118	1805589-11	4.1		11%
Trip 3	Pink	M16-XS4-01-052118	4.7	4.7	8%	4	M16-XS4-01-052118	1805589-12	4.8		1%
Trip 3	Pink	M17-XS55-01-052618	4.9	4.9	13%	4	M17-XS55-01-052618	1806235-6	4.0		20%
Trip 3	Pink	M17-XS83-01-052618	9.5	9.1	15%	8	M17-XS83-01-052618	1806235-7	10.0		5%
Trip 3	Pink	M17-XS83-02-052618	9.5	9.3	18%	8	M17-XS83-02-052618	1806235-8	8.2		14%
Trip 3	Pink	M18-XS161-01-052518	7.3	7.0	26%	6	M18-XS161-01-052518	1805632-6	5.6		27%
Trip 3	Pink	M19-XS22-01-052318	3.5	3.2	42%	2	M19-XS22-01-052318	1805632-7	3.8		9%
Trip 3	Pink	M19-XS22-02-052318	3.8	3.6	32%	2	M19-XS22-02-052318	1805632-8	3.7		3%
Trip 3	Pink	T23-XS23-01-052118	2.7	2.7	25%	2	T23-XS23-01-052118	1805589-19	2.4		13%
Trip 3	Pink	T23-XS40-01-052118	2.9	2.7	27%	2	T23-XS40-01-052118	1805589-20	2.5		15%
Trip 3	Pink	T24-XS48-01-052418	24.0	24.4	12%	20	T24-XS48-01-052418	1805632-12	29.0		19%

Data Included in Model AS-3											
			XRF - Arsenic						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M13-XS72-01-060618	5.1	5.0	22%	4	M13-XS72-01-060618	1806235-1	3.3		44%
Trip 4	Pink	M20-XS166-01-060518	17.0	17.0	5%	15	M20-XS166-01-060518	1806235-11	14.0		19%
Trip 4	Pink	M20-XS231-01-060418	3.6	3.3	26%	3	M20-XS231-01-060418	1806235-14	2.9		22%
Trip 4	Pink	M20-XS278-01-060418	10.2	9.7	23%	7	M20-XS278-01-060418	1806235-15	7.9		25%
Trip 4	Pink	M20-XS312-01-060518	3.6	3.6	13%	3	M20-XS312-01-060518	1806235-17	4.5		23%
Trip 4	Pink	M20-XS365-01-060618	6.0	5.4	38%	3	M20-XS365-01-060618	1806235-18	5.5		8%
Trip 4	Pink	M20-XS365-02-060618	5.6	5.7	18%	4	M20-XS365-02-060618	1806235-19	5.5		2%
Trip 4	Pink	M20-XS5-01-060518	6.7	6.3	18%	6	M20-XS5-01-060518	1806235-20	6.5		3%
Trip 4	Pink	M20-XS86-01-060618	3.0	2.9	13%	3	M20-XS86-01-060618	1806235-21	3.1		3%
Trip 4	Pink	M21-XS122-01-060818	5.0	4.9	12%	4	M21-XS122-01-060818	1806234-1	3.9		24%
Trip 4	Pink	M21-XS126-01-060818	31.1	31.8	11%	26	M21-XS126-01-060818	1806234-2	25.0		22%
Trip 4	Pink	M21-XS14-01-060818	26.7	26.4	11%	24	M21-XS14-01-060818	1806234-3	22.0		19%
Trip 4	Pink	M21-XS175-01-060818	7.1	7.3	16%	6	M21-XS175-01-060818	1806234-4	6.9		3%
Trip 4	Pink	M21-XS225-01-060518	22.5	21.9	9%	20	M21-XS225-01-060518	1806235-22	20.0		12%
Trip 4	Pink	M21-XS259-01-060918	11.3	11.4	12%	10	M21-XS259-01-060918	1806234-5	10.0		12%
Trip 4	Pink	M21-XS260-01-060918	8.5	8.1	20%	7	M21-XS260-01-060918	1806234-6	8.1		5%
Trip 4	Pink	M21-XS27-01-060818	12.5	12.2	9%	11	M21-XS27-01-060818	1806234-7	12.0		4%
Trip 4	Pink	M21-XS27-02-060818	12.3	12.1	10%	11	M21-XS27-02-060818	1806234-8	12.0		2%
Trip 4	Pink	M21-XS282-01-060918	3.6	4.0	25%	2	M21-XS282-01-060918	1806234-9	3.6		0%
Trip 4	Pink	M21-XS292-01-060518	17.3	17.6	9%	14	M21-XS292-01-060518	1806235-23	14.0		21%
Trip 4	Pink	M21-XS302-01-060918	9.8	9.7	6%	9	M21-XS302-01-060918	1806234-11	9.5		3%
Trip 4	Pink	M21-XS302-02-060918	11.1	10.6	14%	9	M21-XS302-02-060918	1806234-12	9.6		14%
Trip 4	Pink	M21-XS334-01-060918	7.7	7.7	23%	5	M21-XS334-01-060918	1806234-13	7.3		5%
Trip 4	Pink	M21-XS377-01-060918	3.6	3.3	46%	2	M21-XS377-01-060918	1806234-14	2.7		29%
Trip 4	Pink	M21-XS40-01-060818	32.5	32.4	4%	31	M21-XS40-01-060818	1806234-15	30.0		8%
Trip 4	Pink	M21-XS403-01-060818	5.0	4.8	32%	3	M21-XS403-01-060818	1806234-16	4.9		2%
Trip 4	Pink	M21-XS419-01-060818	11.4	9.2	62%	7	M21-XS419-01-060818	1806234-17	9.9		15%
Trip 4	Pink	M21-XS46-01-060818	8.1	8.1	9%	7	M21-XS46-01-060818	1806234-18	6.9		16%
Trip 4	Pink	M21-XS477-01-060818	5.5	5.6	24%	3	M21-XS477-01-060818	1806234-19	4.4		21%
Trip 4	Pink	M21-XS619-01-060618	15.1	15.3	20%	10	M21-XS619-01-060618	1806235-26	17.0		12%
Trip 4	Pink	M22-XS14-01-060418	25.9	23.8	21%	22	M22-XS14-01-060418	1806235-27	16.0		47%
Trip 4	Pink	M22-XS40-01-060518	7.0	6.5	31%	5	M22-XS40-01-060518	1806235-29	6.1		14%
Trip 4	Pink	M22-XS60-01-060418	4.7	4.2	38%	3	M22-XS60-01-060418	1806235-30	5.2		11%
Trip 4	Pink	M22-XS87-01-060418	6.9	6.9	15%	6	M22-XS87-01-060418	1806235-31	5.3		26%
Trip 4	Pink	M23-XS102-01-061018	3.7	3.7	10%	3	M23-XS102-01-061018	1806233-1	4.3		16%
Trip 4	Pink	M23-XS20-01-061018	3.0	2.8	13%	3	M23-XS20-01-061018	1806233-3	2.1		34%
Trip 4	Pink	M23-XS54-01-061118	8.2	7.9	13%	7	M23-XS54-01-061118	1806312-1	9.7	J	17%
Trip 4	Pink	M23-XS79-01-061018	2.2	1.9	35%	2	M23-XS79-01-061018	1806233-7	2.2		2%
Trip 4	Pink	M24-XS100-01-061118	2.5	2.6	27%	1	M24-XS100-01-061118	1806312-3	2.0		22%
Trip 4	Pink	T26-XS1-01-061018	4.9	5.2	20%	3	T26-XS1-01-061018	1806233-8	5.4		10%
Trip 4	Pink	T26-XS8-01-061018	6.8	6.7	10%	6	T26-XS8-01-061018	1806233-9	7.0		3%
Trip 5	Pink	M27-XS108-01-061918	4.0	3.3	54%	2	M27-XS108-01-061918	1806558-3	3.9		2%
Trip 5	Pink	M27-XS109-01-061918	3.4	3.3	17%	3	M27-XS109-01-061918	1806558-4	3.2		7%
Trip 5	Pink	M27-XS188-01-061918	4.6	4.5	12%	4	M27-XS188-01-061918	1806558-6	4.6		1%
Trip 5	Pink	M27-XS197-01-061918	3.4	3.3	33%	2	M27-XS197-01-061918	1806558-7	3.3		4%
Trip 5	Pink	M27-XS210-02-061818	2.2	2.1	34%	1	M27-XS210-02-061818	1806558-9	2.7		21%
Trip 5	Pink	M27-XS21-01-061918	7.5	6.0	41%	5	M27-XS21-01-061918	1806558-10	7.5		0%
Trip 5	Pink	M27-XS275-01-061918	3.5	3.3	25%	3	M27-XS275-01-061918	1806558-12	4.6		27%
Trip 5	Pink	M27-XS283-01-061818	7.6	6.4	45%	5	M27-XS283-01-061818	1806558-13	7.4		3%
Trip 5	Pink	M27-XS29-01-061818	2.7	2.5	22%	2	M27-XS29-01-061818	1806558-14	3.0		9%
Trip 5	Pink	M27-XS38-01-061918	3.0	3.0	12%	2	M27-XS38-01-061918	1806558-15	4.2		34%
Trip 5	Pink	M28-XS148-01-062018	35.9	35.4	17%	29	M28-XS148-01-062018	1806558-17	42.0		16%
Trip 5	Pink	M28-XS170-01-062018	16.5	13.5	51%	11	M28-XS170-01-062018	1806558-19	15.0		10%
Trip 5	Pink	M28-XS43-01-062018	44.0	43.9	8%	40	M28-XS43-01-062018	1806558-20	53.0		19%
Trip 5	Pink	M30-XS138-01-062218	16.2	16.1	10%	14	M30-XS138-01-062218	1806693-1	18.0		10%
Trip 5	Pink	M30-XS222-01-062218	7.4	7.2	22%	6	M30-XS222-01-062218	1806693-2	7.4		0%
Trip 6	Orange	M10-XS10A-01-071118	2.1	2.1	11%	2	M10-XS10A-01-071118	1807369-1	2.1		1%
Trip 6	Orange	M11-XS11-01-071118	3.5	3.4	27%	2	M11-XS11-01-071118	1807369-4	4.8		32%
Trip 6	Red	M11-XS7-01-071118	4.1	4.2	17%	3	M11-XS7-01-071118	1807369-5	4.9		18%
Trip 6	Orange	M24-XS115-01-071418	25.9	24.8	15%	22	M24-XS115-01-071418	1807369-7	25.0		4%
Trip 6	Red	M25-XS47-01-071718	3.2	2.3	81%	1	M25-XS47-01-071718	1807452-3	3.3		4%
Trip 6	Red	M25-XS88-01-071718	2.5	2.0	35%	2	M25-XS88-01-071718	1807452-4	3.2		26%
Trip 6	Orange	M30-XS170-01-071618	2.1	2.1	16%	2	M30-XS170-01-071618	1807369-10	3.2		43%
Trip 6	Orange	M32-XS58-01-071018	3.2	3.2	14%	3	M32-XS58-01-071018	1807369-13	3.6		13%
Trip 6	Red	M32-XS89-01-071018	5.2	5.6	16%	4	M32-XS89-01-071018	1807369-14	4.3	J	19%
Trip 6	Orange	M33-XS22-01-071218	52.7	49.9	13%	46	M33-XS22-01-071218	1807369-15	74.0		34%
Trip 6	Orange	M33-XS85-01-071218	2.2	2.4	26%	1	M33-XS85-01-071218	1807369-16	2.7		18%
Trip 6	Red	M33-XS93-01-071218	5.2	5.0	10%	5	M33-XS93-01-071218	1807369-17	7.8		41%
Trip 6	Red	T33-XS43-01-071718	5.1	5.2	23%	3	T33-XS43-01-071718	1807452-5	3.1		48%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
			XRF - Arsenic						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	0.2	0.0	245%	0	M2-XS15-01-042418	1805041-1	1.6	J	157%
Trip 1	Pink	M2-XS15-02-042418	0.8	0.7	111%	0	M2-XS15-02-042418	1805041-2	1.0	J	25%
Trip 1	Pink	M2-XS32-01-042418	1.4	1.4	63%	0	M2-XS32-01-042418	1805041-3	1.3		9%
Trip 1	Pink	M2-XS59-01-042418	0.8	0.6	113%	0	M2-XS59-01-042418	1805041-4	1.2		38%
Trip 1	Pink	M2-XS73-01-042418	0.3	0.0	245%	0	M2-XS73-01-042418	1805041-5	1.4		136%
Trip 1	Pink	M3-XS34-01-043018	1.6	1.8	55%	0	M3-XS34-01-043018	1805042-1	1.7		3%
Trip 1	Pink	M6-XS140-01-042818	1.3	1.8	79%	0	M6-XS140-01-042818	1805041-6	2.2		54%
Trip 1	Orange	M6-XS159-01-04262018	1.6	1.9	53%	0	M6-XS159-01-04262018	1805039-1	2.1		26%
Trip 1	Pink	T10-XS1-01-042518	2.2	2.6	18%	0	T10-XS1-01-042518	1805036-1	1.6		31%
Trip 1	Pink	T10-XS20-01-042518	0.0	0.0	-	0	T10-XS20-01-042518	1805036-2	1.3		200%
Trip 1	Pink	T10-XS33-01-042518	1.0	0.9	110%	0	T10-XS33-01-042518	1805036-3	1.3		30%
Trip 1	Pink	T10-XS56-01-042518	2.6	2.9	55%	0	T10-XS56-01-042518	1805036-4	1.8		37%
Trip 1	Pink	T11-XS20-01-042518	1.8	1.9	54%	0	T11-XS20-01-042518	1805036-7	1.8		2%
Trip 1	Pink	T11-XS60-01-042518	1.1	1.4	80%	0	T11-XS60-01-042518	1805036-8	1.2		11%
Trip 1	Pink	T17-XS1-01-04262018	1.3	1.7	79%	0	T17-XS1-01-04262018	1805039-6	2.0		43%
Trip 1	Pink	T17-XS1-02-04262018	1.6	1.9	54%	0	T17-XS1-02-04262018	1805039-7	2.1		27%
Trip 1	Pink	T17-XS143-01-04262018	1.9	2.4	80%	0	T17-XS143-01-04262018	1805039-8	2.4		24%
Trip 1	Orange	T17-XS144-01-04262018	6.0	6.2	60%	0	T17-XS144-01-04262018	1805039-9	1.7		111%
Trip 1	Pink	T17-XS194-01-04272018	1.4	1.6	52%	0	T17-XS194-01-04272018	1805039-10	1.7		17%
Trip 1	Pink	T17-XS194-02-04272018	1.1	1.5	78%	0	T17-XS194-02-04272018	1805039-11	1.7		47%
Trip 1	Pink	T17-XS208-01-042818	1.0	0.7	119%	0	T17-XS208-01-042818	1805041-7	1.4		36%
Trip 1	Pink	T17-XS273-01-042818	1.4	1.9	80%	0	T17-XS273-01-042818	1805041-8	1.3		8%
Trip 1	Pink	T17-XS304-01-042818	0.6	0.0	163%	0	T17-XS304-01-042818	1805041-9	1.3		68%
Trip 1	Pink	T17-XS328-01-04272018	1.9	2.0	59%	0	T17-XS328-01-04272018	1805039-17	1.4		31%
Trip 1	Pink	T17-XS369-01-043018	1.6	2.2	79%	0	T17-XS369-01-043018	1805042-4	1.5		4%
Trip 1	Pink	T17-XS393-01-043018	0.9	0.0	155%	0	T17-XS393-01-043018	1805042-5	1.2		34%
Trip 1	Pink	T17-XS438-01-042818	0.0	0.0	-	0	T17-XS438-01-042818	1805041-11	1.3		200%
Trip 1	Pink	T17-XS44-01-04262018	0.9	0.8	110%	0	T17-XS44-01-04262018	1805039-19	1.6		53%
Trip 1	Pink	T17-XS442-01-04272018	1.7	2.0	59%	0	T17-XS442-01-04272018	1805039-20	1.7		0%
Trip 1	Pink	T17-XS46-01-042618	2.1	2.3	51%	0	T17-XS46-01-042618	1805041-12	1.8		14%
Trip 1	Pink	T17-XS473-01-042818	2.0	2.3	56%	0	T17-XS473-01-042818	1805041-13	1.7		15%
Trip 1	Pink	T17-XS479-02-042818	2.0	2.4	53%	0	T17-XS479-02-042818	1805041-15	1.8		12%
Trip 1	Pink	T17-XS603-01-042818	0.9	0.8	110%	0	T17-XS603-01-042818	1805041-16	1.2		30%
Trip 1	Pink	T17-XS659-01-043018	0.5	0.0	155%	0	T17-XS659-01-043018	1805042-6	1.0		60%
Trip 1	Pink	T17-XS679-01-043018	1.9	1.8	66%	0	T17-XS679-01-043018	1805042-7	1.5		22%
Trip 1	Pink	T17-XS704-01-043018	0.2	0.0	245%	0	T17-XS704-01-043018	1805042-8	1.0		126%
Trip 1	Pink	T7-XS11-01-042418	1.1	1.4	19%	0	T7-XS11-01-042418	1805036-9	1.0		12%
Trip 1	Pink	T7-XS5-01-042418	0.6	0.0	155%	0	T7-XS5-01-042418	1805036-10	1.0		47%
Trip 1	Pink	T7-XS58-01-042418	0.8	0.6	114%	0	T7-XS58-01-042418	1805036-11	1.0		18%
Trip 1	Pink	T7-XS7-01-042418	0.2	0.0	245%	0	T7-XS7-01-042418	1805036-12	1.0		126%
Trip 1	Pink	T7-XS9-01-042418	0.7	0.0	160%	0	T7-XS9-01-042418	1805036-13	1.1		51%
Trip 1	Pink	T8-XS15-01-042418	0.7	0.0	160%	0	T8-XS15-01-042418	1805036-14	1.3		63%
Trip 1	Pink	T8-XS23-01-042418	0.9	0.9	110%	0	T8-XS23-01-042418	1805036-15	1.4		40%
Trip 1	Pink	T8-XS6-01-042418	1.2	1.5	81%	0	T8-XS6-01-042418	1805036-16	1.2		4%
Trip 1	Pink	T9-XS86-01-042518	2.4	2.7	53%	0	T9-XS86-01-042518	1805036-19	2.1		14%
Trip 2	Orange	M1-XS31-01-051218	0.8	0.8	100%	0	M1-XS31-01-051218	1805328-1	1.7		70%
Trip 2	Pink	M1-XS32-01-051218	0.9	0.7	102%	0	M1-XS32-01-051218	1805328-2	1.2		27%
Trip 2	Pink	M4-XS136-01-050918	1.3	1.4	79%	0	M4-XS136-01-050918	1805322-1	1.8		29%
Trip 2	Pink	M4-XS4-01-050718	0.2	0.0	224%	0	M4-XS4-01-050718	1805322-5	1.1		127%
Trip 2	Pink	M4-XS45-01-050718	0.4	0.0	142%	0	M4-XS45-01-050718	1805322-6	1.4		104%
Trip 2	Pink	M4-XS63-01-050718	3.2	3.4	62%	0	M4-XS63-01-050718	1805322-7	4.0		22%
Trip 2	Orange	M5-XS115-01-051118	1.2	1.5	74%	0	M5-XS115-01-051118	1805322-10	2.2		56%
Trip 2	Pink	M5-XS385-01-051118	0.0	0.0	0%	0	M5-XS385-01-051118	1805322-11	1.3		200%
Trip 2	Pink	M5-XS69-01-051118	1.6	1.8	79%	0	M5-XS69-01-051118	1805322-12	1.9		19%
Trip 2	Orange	M6-XS41-01-051118	1.3	1.4	83%	0	M6-XS41-01-051118	1805322-13	1.0		27%
Trip 2	Pink	M6-XS44-01-051018	0.7	0.0	143%	0	M6-XS44-01-051018	1805322-14	1.1		48%
Trip 2	Pink	M6-XS81-01-051018	0.0	0.0	0%	0	M6-XS81-01-051018	1805322-15	0.8		200%
Trip 2	Pink	M7-XS181-01-051018	1.3	1.5	65%	0	M7-XS181-01-051018	1805322-16	1.8		34%
Trip 2	Orange	M7-XS181-02-051018	1.7	1.9	49%	0	M7-XS181-02-051018	1805322-17	1.9		14%
Trip 2	Orange	M7-XS39-01-051018	0.3	0.0	224%	0	M7-XS39-01-051018	1805322-18	1.9		139%
Trip 2	Orange	M7-XS74-01-051018	2.3	2.4	50%	0	M7-XS74-01-051018	1805322-19	2.6		12%
Trip 2	Orange	M7-XS77-01-051018	2.0	1.9	40%	0	M7-XS77-01-051018	1805322-20	2.3		16%
Trip 2	Pink	M8-XS100-01-050918	1.5	1.7	50%	0	M8-XS100-01-050918	1805328-3	1.9		23%
Trip 2	Pink	M8-XS110-01-050918	2.3	2.7	53%	0	M8-XS110-01-050918	1805328-6	1.7		28%
Trip 2	Pink	M8-XS94-01-050918	2.6	2.6	62%	0	M8-XS94-01-050918	1805328-9	2.6		0%
Trip 2	Pink	T13-XS24-01-050818	0.0	0.0	0%	0	T13-XS24-01-050818	1805322-22	0.9		200%
Trip 2	Pink	T15-XS2-01-050818	1.3	1.5	77%	0	T15-XS2-01-050818	1805322-25	1.7		29%
Trip 2	Pink	T15-XS45-01-050818	1.8	2.0	54%	0	T15-XS45-01-050818	1805322-26	3.1	J	55%
Trip 2	Pink	T17-XS122-01-050718	1.3	1.7	75%	0	T17-XS122-01-050718	1805322-27	1.4		5%
Trip 2	Pink	T17-XS176-01-050718	1.0	0.8	103%	0	T17-XS176-01-050718	1805322-28	1.5		38%
Trip 2	Pink	T17-XS178-01-050718	0.6	0.0	142%	0	T17-XS178-01-050718	1805322-29	1.1		66%
Trip 2	Pink	T17-XS619-01-050718	0.9	0.7	106%	0	T17-XS619-01-050718	1805322-30	1.5		53%
Trip 2	Pink	T17-XS619-02-050718	1.0	1.4	71%	0	T17-XS619-02-050718	1805322-31	1.4		35%
Trip 2	Pink	T17-XS645-01-050718	1.3	1.5	77%	0	T17-XS645-01-050718	1805322-32	1.3		2%

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Arsenic: Average Ex Situ XRF (ppm)	XRF - Arsenic: Median Ex Situ XRF (ppm)	XRF - Arsenic: Relative Standard Deviation	XRF - Arsenic: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 2	Pink	T17-XS669-01-050718	0.7	0.7	101%	0	T17-XS669-01-050718	1805322-33	1.3		54%
Trip 2	Orange	T3-XS10-01-051218	2.1	2.5	45%	0	T3-XS10-01-051218	1805328-15	1.7		19%
Trip 2	Orange	T3-XS5-01-051218	1.0	1.3	74%	0	T3-XS5-01-051218	1805328-16	1.1		10%
Trip 2	Pink	T4-XS23-01-051218	0.9	0.7	104%	0	T4-XS23-01-051218	1805328-17	1.2		30%
Trip 2	Orange	T4-XS32-01-051218	0.5	0.0	142%	0	T4-XS32-01-051218	1805328-18	0.9		70%
Trip 2	Pink	T6-XS2-01-051218	0.0	0.0	0%	0	T6-XS2-01-051218	1805328-21	1.1		200%
Trip 2	Orange	T6-XS25-01-051218	1.2	1.6	73%	0	T6-XS25-01-051218	1805328-22	1.6		30%
Trip 3	Pink	M14-XS36-01-052418	0.2	0.0	245%	0	M14-XS36-01-052418	1805632-1	1.3		138%
Trip 3	Pink	M14-XS40-01-052418	1.6	2.0	82%	0	M14-XS40-01-052418	1805632-2	1.6		1%
Trip 3	Pink	M14-XS67-01-052418	0.6	0.0	156%	0	M14-XS67-01-052418	1805632-4	1.5		86%
Trip 3	Blue	M15-XS73-01-052118	0.0	0.0	0%	0	M15-XS73-01-052118	1805589-5	5.2		200%
Trip 3	Pink	M16-XS166-01-052118	0.0	0.0	0%	0	M16-XS166-01-052118	1805589-9	10.0		200%
Trip 3	Pink	M16-XS45-01-052118	0.0	0.0	0%	0	M16-XS45-01-052118	1805589-13	6.7		200%
Trip 3	Pink	M18-XS155-01-052518	1.5	1.7	54%	0	M18-XS155-01-052518	1805632-5	3.0		67%
Trip 3	Pink	M19-XS43-01-052318	1.6	2.0	81%	0	M19-XS43-01-052318	1805632-9	2.3		36%
Trip 3	Blue	T20-XS14-01-052218	0.0	0.0	0%	0	T20-XS14-01-052218	1805632-10	2.4		200%
Trip 3	Blue	T21-XS35-01-052118	0.0	0.0	0%	0	T21-XS35-01-052118	1805589-14	1.9		200%
Trip 3	Blue	T21-XS55-01-052118	0.0	0.0	0%	0	T21-XS55-01-052118	1805589-15	1.9		200%
Trip 3	Blue	T21-XS55-02-052118	1.4	0.8	121%	0	T21-XS55-02-052118	1805589-16	1.8		28%
Trip 3	Pink	T21-XS6-01-052118	0.0	0.0	0%	0	T21-XS6-01-052118	1805589-17	1.2		200%
Trip 3	Blue	T22-XS17-01-052118	0.0	0.0	0%	0	T22-XS17-01-052118	1805589-18	1.7		200%
Trip 3	Pink	T22-XS64-01-052218	1.6	1.7	56%	0	T22-XS64-01-052218	1805632-11	1.7		7%
Trip 4	Pink	M20-XS11-01-060618	1.5	2.0	80%	0	M20-XS11-01-060618	1806235-9	1.5		1%
Trip 4	Pink	M20-XS130-01-060418	1.2	0.9	122%	0	M20-XS130-01-060418	1806235-10	1.8		41%
Trip 4	Pink	M20-XS18-01-060618	1.1	0.7	115%	0	M20-XS18-01-060618	1806235-12	1.8		48%
Trip 4	Pink	M20-XS185-01-060418	1.6	1.9	83%	0	M20-XS185-01-060418	1806235-13	2.0		23%
Trip 4	Pink	M20-XS306-01-060518	2.6	2.8	66%	0	M20-XS306-01-060518	1806235-16	2.1		20%
Trip 4	Pink	M21-XS541-01-060818	0.8	0.0	159%	0	M21-XS541-01-060818	1806234-20	1.3		48%
Trip 4	Pink	M21-XS596-01-060518	2.3	2.7	55%	0	M21-XS596-01-060518	1806235-24	1.8		24%
Trip 4	Pink	M21-XS615-01-060518	0.0	0.0	0%	0	M21-XS615-01-060518	1806235-25	1.0		200%
Trip 4	Pink	M22-XS30-01-060418	2.3	2.3	59%	0	M22-XS30-01-060418	1806235-28	2.5		8%
Trip 4	Pink	M23-XS123-01-061018	0.8	0.7	110%	0	M23-XS123-01-061018	1806233-2	1.6		71%
Trip 4	Pink	M23-XS48-01-061018	0.9	0.8	110%	0	M23-XS48-01-061018	1806233-4	1.4		44%
Trip 4	Pink	M23-XS64-01-061018	2.3	2.6	55%	0	M23-XS64-01-061018	1806233-5	2.2		6%
Trip 4	Pink	M23-XS70-01-061018	1.5	2.1	78%	0	M23-XS70-01-061018	1806233-6	1.5		0%
Trip 4	Pink	T18-XS14-01-061118	2.1	2.3	54%	0	T18-XS14-01-061118	1806312-5	1.8		17%
Trip 4	Pink	T18-XS27-01-061118	0.0	0.0	0%	0	T18-XS27-01-061118	1806312-6	0.7		200%
Trip 4	Pink	T25-XS2-01-060618	1.2	1.6	80%	0	T25-XS2-01-060618	1806235-32	2.6		73%
Trip 4	Pink	T27-XS19-01-061018	0.3	0.0	245%	0	T27-XS19-01-061018	1806233-10	1.2		127%
Trip 4	Pink	T27-XS6-01-061018	1.2	1.6	79%	0	T27-XS6-01-061018	1806233-11	1.6		27%
Trip 5	Pink	M26-XS13-01-061818	1.3	1.6	85%	0	M26-XS13-01-061818	1806558-1	1.4		5%
Trip 5	Pink	M26-XS25-01-061818	1.9	1.8	63%	0	M26-XS25-01-061818	1806558-2	2.9		41%
Trip 5	Pink	M27-XS123-01-061818	0.8	0.7	112%	0	M27-XS123-01-061818	1806558-5	1.3		46%
Trip 5	Pink	M27-XS210-01-061818	1.1	0.9	111%	0	M27-XS210-01-061818	1806558-8	2.8		88%
Trip 5	Pink	M27-XS239-01-061818	0.9	0.6	117%	0	M27-XS239-01-061818	1806558-11	1.9		73%
Trip 5	Pink	M28-XS105-01-062018	0.9	0.8	110%	0	M28-XS105-01-062018	1806558-16	1.5		46%
Trip 5	Pink	M28-XS155-01-062018	1.9	2.2	59%	0	M28-XS155-01-062018	1806558-18	2.9		39%
Trip 5	Pink	M28-XS8-01-062018	0.4	0.0	245%	0	M28-XS8-01-062018	1806558-21	1.0		74%
Trip 5	Pink	T32-XS5-01-062018	0.0	0.0	0%	0	T32-XS5-01-062018	1806558-22	1.1		200%
Trip 6	Orange	M10-XS31-01-071118	1.5	1.5	54%	0	M10-XS31-01-071118	1807369-2	1.9	J	27%
Trip 6	Orange	M10-XS31-02-071118	0.7	0.0	156%	0	M10-XS31-02-071118	1807369-3	3.8	J	141%
Trip 6	Red	M12-XS27-01-071518	0.0	0.0	0%	0	M12-XS27-01-071518	1807369-6	0.5		200%
Trip 6	Red	M25-XS16-01-071718	1.4	1.8	82%	0	M25-XS16-01-071718	1807452-1	4.9		112%
Trip 6	Red	M25-XS23-01-071718	2.0	2.3	56%	0	M25-XS23-01-071718	1807452-2	2.2		8%
Trip 6	Orange	M30-XS127-01-071618	0.0	0.0	0%	0	M30-XS127-01-071618	1807369-9	2.5		200%
Trip 6	Red	M30-XS95-01-071618	2.0	2.1	61%	0	M30-XS95-01-071618	1807369-11	5.2		88%
Trip 6	Red	M31-XS9-01-071018	0.9	0.6	118%	0	M31-XS9-01-071018	1807369-12	1.4		39%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Arsenic: Average Ex Situ XRF (ppm)	XRF - Arsenic: Median Ex Situ XRF (ppm)	XRF - Arsenic: Relative Standard Deviation	XRF - Arsenic: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M21-XS290-01-060918	11.6	11.6	18%	9	M21-XS290-01-060918	1806234-10	25.0		73%
Trip 4	Pink	M24-XS128-01-061118	3.6	3.7	20%	3	M24-XS128-01-061118	1806312-4	91.0		185%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

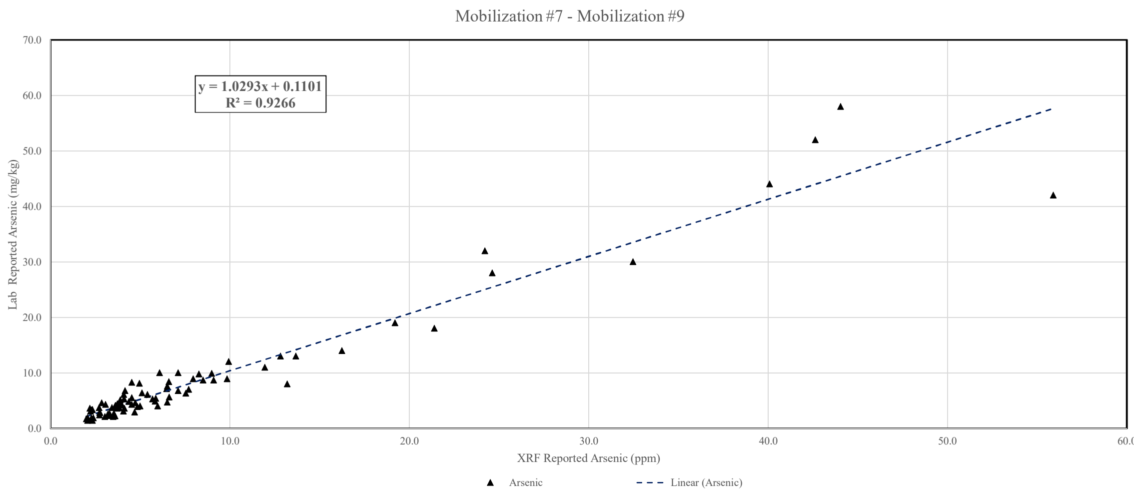
ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included											
			XRF - Arsenic						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Pink	M34-XS22-01-081218	5.9	5.8	10%	5	M34-XS22-01-081218	1808303-2	5.4		8%
Trip 7	Pink	M34-XS50-01-081218	6.5	6.5	24%	5	M34-XS50-01-081218	1808303-4	7.6		16%
Trip 7	Pink	M34-XS68-01-081218	21.4	21.7	15%	17	M34-XS68-01-081218	1808303-5	18.0		17%
Trip 7	Pink	M35-XS11-01-081218	13.2	12.0	31%	11	M35-XS11-01-081218	1808303-6	8.0		49%
Trip 7	Pink	M35-XS20-01-081318	24.6	24.2	48%	10	M35-XS20-01-081318	1808303-7	28.0		13%
Trip 7	Pink	M35-XS31-01-081218	4.1	4.2	25%	3	M35-XS31-01-081218	1808303-8	3.6		13%
Trip 7	Pink	M36-XS20-01-081218	2.4	2.3	31%	2	M36-XS20-01-081218	1808303-12	1.9		22%
Trip 7	Pink	M36-XS31-01-081218	4.5	4.4	17%	4	M36-XS31-01-081218	1808303-15	5.5		19%
Trip 7	Pink	M37-XS124A-01-081318	6.5	6.2	8%	6	M37-XS124A-01-081318	1808303-16	7.1		9%
Trip 7	Pink	M37-XS144-01-081318	7.5	7.6	22%	5	M37-XS144-01-081318	1808303-17	6.3		18%
Trip 7	Pink	M37-XS50-01-081318	9.8	9.2	18%	9	M37-XS50-01-081318	1808356-3	8.9		10%
Trip 7	Red	M38-XS20-01-081818	4.4	4.3	24%	3	M38-XS20-01-081818	1808483-2	4.8		9%
Trip 7	Pink	M7-XS162A-01-081518	4.7	4.0	35%	4	M7-XS162A-01-081518	1808356-5	2.9		47%
Trip 7	Pink	M7-XS203-01-081418	3.0	3.2	18%	2	M7-XS203-01-081418	1808356-6	2.1		36%
Trip 7	Pink	M7-XS235A-01-081418	5.0	4.8	11%	4	M7-XS235A-01-081418	1808356-9	4.0		22%
Trip 7	Pink	M7-XS244-01-081518	2.1	2.1	20%	1	M7-XS244-01-081518	1808356-10	1.4		38%
Trip 7	Pink	M8-XSG28-01-081418	2.3	2.3	25%	2	M8-XSG28-01-081418	1808356-12	1.4		50%
Trip 7	Pink	M8-XSG4-01-081518	4.5	4.4	16%	4	M8-XSG4-01-081518	1808356-16	4.3		5%
Trip 7	Pink	M8-XSG44-01-081418	3.3	3.5	11%	3	M8-XSG44-01-081418	1808356-17	2.6		24%
Trip 7	Pink	M8-XSG47-01-081418	3.2	3.2	16%	3	M8-XSG47-01-081418	1808356-19	2.6		21%
Trip 7	Red	T15-XS20-01-081718	3.9	4.1	31%	2	T15-XS20-01-081718	1808483-11	4.5	J	13%
Trip 7	Red	T15-XSG5-01-081718	2.0	1.9	11%	2	T15-XSG5-01-081718	1808483-12	1.7		15%
Trip 7	Red	T1-XSG49A-01-081918	11.9	11.7	20%	9	T1-XSG49A-01-081918	1808483-14	11.0		8%
Trip 7	Red	T4-XS15A-01-081918	55.9	48.6	33%	37	T4-XS15A-01-081918	1808487-9	42.0		28%
Trip 7	Red	T4-XSG50A-01-081918	3.5	3.6	32%	2	T4-XSG50A-01-081918	1808483-18	2.1		49%
Trip 7	Red	T5-XSG10-01-081918	32.5	31.3	11%	29	T5-XSG10-01-081918	1808483-19	30.0		8%
Trip 8	Red	M13-XS112-01-091518	7.1	7.2	16%	6	M13-XS112-01-091518	1809475-1	10.0		34%
Trip 8	Red	M14-XS62-01-091818	3.9	4.2	20%	3	M14-XS62-01-091818	1809475-21	4.2		7%
Trip 8	Red	M14-XSG14A-01-091818	2.3	2.1	42%	2	M14-XSG14A-01-091818	1809475-22	3.4		37%
Trip 8	Red	M14-XSG41-01-091818	5.8	5.8	6%	5	M14-XSG41-01-091818	1809475-24	4.9		17%
Trip 8	Red	M14-XSG58-01-091818	4.1	4.1	26%	3	M14-XSG58-01-091818	1809475-26	5.3		26%
Trip 8	Red	M14-XSG6-01-091818	2.3	2.3	19%	2	M14-XSG6-01-091818	1809475-27	3.3		37%
Trip 8	Red	M16-XSG13-01-091118	12.8	12.3	12%	11	M16-XSG13-01-091118	1809473-22	13.0		1%
Trip 8	Red	M17-XS79-01-091318	2.7	2.8	38%	1	M17-XS79-01-091318	1809473-1	2.9		6%
Trip 8	Red	M17-XSG1-01-091318	7.7	6.9	22%	6	M17-XSG1-01-091318	1809473-2	7.0		10%
Trip 8	Red	M18-XSG30-01-091318	2.8	2.7	43%	2	M18-XSG30-01-091318	1809473-7	4.6		47%
Trip 8	Red	M19-XSG43-01-091318	2.1	2.1	27%	1	M19-XSG43-01-091318	1809473-14	1.8		13%
Trip 8	Red	M20-XS422-01-091418	3.5	3.1	37%	2	M20-XS422-01-091418	1809475-6	2.7		26%
Trip 8	Red	M20-XSG28-01-091418	4.7	4.8	10%	4	M20-XSG28-01-091418	1809475-8	4.6		3%
Trip 8	Red	M21-XS317-01-091218	3.7	3.6	39%	2	M21-XS317-01-091218	1809473-25	4.4		17%
Trip 8	Red	M21-XS323-01-091218	7.1	6.8	18%	5	M21-XS323-01-091218	1809473-26	6.8		4%
Trip 8	Red	M21-XS366-01-091418	7.9	8.1	20%	6	M21-XS366-01-091418	1809475-10	8.9		11%
Trip 8	Red	M21-XS366-02-091418	8.5	8.2	12%	7	M21-XS366-02-091418	1809475-11	8.7		2%
Trip 8	Red	M21-XS465-01-091218	13.7	13.6	5%	13	M21-XS465-01-091218	1809473-27	13.0		5%
Trip 8	Red	M21-XS536-01-091218	19.2	18.9	5%	18	M21-XS536-01-091218	1809473-30	19.0		1%
Trip 8	Red	M21-XSG38-01-091418	16.2	15.6	15%	14	M21-XSG38-01-091418	1809475-12	14.0		15%
Trip 8	Red	M22-XS112-01-091418	3.4	3.1	32%	2	M22-XS112-01-091418	1809475-14	3.7		8%
Trip 8	Red	M22-XS115-01-091418	3.9	4.2	25%	2	M22-XS115-01-091418	1809475-15	4.4		12%
Trip 8	Red	M22-XS121-01-091418	2.2	2.2	24%	2	M22-XS121-01-091418	1809475-16	3.1		33%
Trip 8	Red	M6-XS353A-01-091618	24.2	24.7	11%	21	M6-XS353A-01-091618	1809475-36	32.0		28%
Trip 8	Red	M6-XSG13A-01-091618	4.1	4.7	43%	2	M6-XSG13A-01-091618	1809475-38	6.8		48%

Data Included											
			XRF - Arsenic						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	T26-XSG2-01-091518	4.1	4.1	17%	3	T26-XSG2-01-091518	1809475-43	6.1	J	40%
Trip 9	Blue	M11-XSG28-01-092818	4.8	4.3	38%	3	M11-XSG28-01-092818	1810122-6	3.9		22%
Trip 9	White	M16-XSR1-01-093018	3.7	3.8	27%	3	M16-XSR1-01-093018	1810072-23	3.6		3%
Trip 9	White	M23-XSR4-01-093018	5.1	5.1	26%	3	M23-XSR4-01-093018	1810072-29	6.4		23%
Trip 9	Red	M24-XS114-01-092518	4.1	3.9	17%	3	M24-XS114-01-092518	1810032-2	3.1		27%
Trip 9	Red	M24-XSG15-01-092518	9.0	8.8	14%	8	M24-XSG15-01-092518	1810032-3	9.9		10%
Trip 9	Red	M24-XSG3-01-092518	2.7	2.9	27%	1	M24-XSG3-01-092518	1810032-4	3.7		31%
Trip 9	Red	M24-XSR1-01-093018	2.2	2.0	31%	1	M24-XSR1-01-093018	1810072-30	3.6		49%
Trip 9	Red	M27-XS163-01-092618	3.6	3.6	23%	2	M27-XS163-01-092618	1810072-5	3.9		9%
Trip 9	Red	M27-XSG28-01-092618	44.0	43.5	12%	38	M27-XSG28-01-092618	1810072-6	58.0		27%
Trip 9	Red	M27-XSG28-02-092618	42.6	42.1	8%	37	M27-XSG28-02-092618	1810072-7	52.0		20%
Trip 9	Red	M27-XSG48-01-092618	4.1	4.0	13%	3	M27-XSG48-01-092618	1810072-8	5.3		26%
Trip 9	Red, Blue	M28-XS162-01-092818	40.1	41.1	33%	18	M28-XS162-01-092818	1810122-14	44.0		9%
Trip 9	Red	M28-XS29-01-092618	6.1	6.3	19%	4	M28-XS29-01-092618	1810032-6	10.0		49%
Trip 9	Red, White	M28-XSG54-01-092918	6.5	6.7	29%	4	M28-XSG54-01-092918	1810122-17	4.7		32%
Trip 9	Red	M28-XSG7-01-092618	5.4	5.3	31%	3	M28-XSG7-01-092618	1810032-8	6.1		12%
Trip 9	White	M28-XSG76-01-092918	3.9	3.9	12%	3	M28-XSG76-01-092918	1810122-18	5.1		27%
Trip 9	Red	M29-XS19-01-092518	6.6	6.7	18%	5	M29-XS19-01-092518	1810032-9	8.4		24%
Trip 9	Red	M29-XS59-01-092518	4.5	4.4	24%	3	M29-XS59-01-092518	1810032-11	8.3		59%
Trip 9	White	M30-XS144-01-092918	3.6	3.8	29%	2	M30-XS144-01-092918	1810122-19	4.1		13%
Trip 9	White	M30-XS185-01-092918	6.6	6.9	27%	5	M30-XS185-01-092918	1810122-20	5.6		17%
Trip 9	White	M30-XS62-01-092918	2.3	2.3	24%	2	M30-XS62-01-092918	1810122-21	1.9		18%
Trip 9	White	M30-XSG18-01-092918	6.0	4.8	67%	3	M30-XSG18-01-092918	1810122-22	4.0		40%
Trip 9	White	M30-XSG29-01-092918	3.8	3.8	18%	3	M30-XSG29-01-092918	1810122-23	3.7		3%
Trip 9	White	M30-XSR5-01-093018	2.7	2.5	35%	2	M30-XSR5-01-093018	1810072-36	2.4		12%
Trip 9	Red	M31-XS1-01-092918	2.1	1.9	17%	2	M31-XS1-01-092918	1810122-28	1.9		8%
Trip 9	Blue	M31-XS39-01-092918	9.9	9.8	14%	8	M31-XS39-01-092918	1810122-29	12.0		19%
Trip 9	White	M31-XS8-01-092918	3.3	3.8	31%	2	M31-XS8-01-092918	1810122-30	2.3		34%
Trip 9	White	M31-XSG12-01-092918	3.6	3.7	29%	2	M31-XSG12-01-092918	1810122-32	2.2		48%
Trip 9	Red	M32-XSG23-01-092918	3.1	3.3	21%	2	M32-XSG23-01-092918	1810072-10	4.3		34%
Trip 9	Red	M32-XSG34-01-092918	2.7	2.5	29%	2	M32-XSG34-01-092918	1810072-12	2.8		2%
Trip 9	Red	M34-XSG15-01-092718	5.7	5.7	43%	3	M34-XSG15-01-092718	1810072-15	5.3		7%
Trip 9	Red	M36-XSG1-01-092718	5.0	5.0	14%	4	M36-XSG1-01-092718	1810072-18	8.1		48%
Trip 9	White	M7-XSR1-01-093018	9.1	8.9	9%	8	M7-XSR1-01-093018	1810072-38	8.7		4%
Trip 9	White	M7-XSR1-02-093018	8.3	7.9	16%	7	M7-XSR1-02-093018	1810072-39	9.8		17%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
			XRF - Arsenic						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M10-XS22-01-082118	0.6	0.0	158%	0	M10-XS22-01-082118	1808494-1	1.3		78%
Trip 7	Red	M10-XS39-01-082118	0.8	0.6	114%	0	M10-XS39-01-082118	1808494-2	1.2		46%
Trip 7	Red	M10-XS43-01-082118	0.6	0.0	158%	0	M10-XS43-01-082118	1808494-3	1.5		83%
Trip 7	Red	M1-XSG2-01-081918	1.7	1.8	53%	0	M1-XSG2-01-081918	1808483-1	1.6		5%
Trip 7	Pink	M34-XS110-01-081218	1.5	2.0	82%	0	M34-XS110-01-081218	1808303-1	1.7		10%
Trip 7	Pink	M34-XS43-01-081218	2.1	2.3	56%	0	M34-XS43-01-081218	1808303-3	1.9		10%
Trip 7	Pink	M35-XS63-01-081218	1.1	1.5	79%	0	M35-XS63-01-081218	1808303-9	1.7		42%
Trip 7	Pink	M35-XS74-01-081318	0.9	0.8	113%	0	M35-XS74-01-081318	1808303-10	2.7	J	101%
Trip 7	Pink	M35-XS74-02-081318	1.8	2.2	83%	0	M35-XS74-02-081318	1808303-11	1.8	J	0%
Trip 7	Pink	M36-XS2-01-081218	2.5	2.8	58%	0	M36-XS2-01-081218	1808303-13	2.1	J	18%
Trip 7	Pink	M36-XS3-01-081218	0.0	0.0	0%	0	M36-XS3-01-081218	1808303-14	0.8		200%
Trip 7	Pink	M37-XS2-01-081318	2.0	2.3	50%	0	M37-XS2-01-081318	1808303-18	1.7		16%
Trip 7	Pink	M37-XS23-01-081318	1.8	1.9	96%	0	M37-XS23-01-081318	1808303-19	2.3		26%
Trip 7	Pink	M37-XS31-01-081318	0.0	0.0	0%	0	M37-XS31-01-081318	1808303-20	0.6		200%
Trip 7	Pink	M37-XS38-01-081318	1.2	1.6	80%	0	M37-XS38-01-081318	1808356-1	1.8		39%
Trip 7	Pink	M37-XS44-01-081318	2.3	2.5	58%	0	M37-XS44-01-081318	1808356-2	1.6		35%
Trip 7	Pink	M37-XS7-01-081318	2.2	2.5	54%	0	M37-XS7-01-081318	1808356-4	2.3		3%
Trip 7	Red	M3-XS19-01-081718	0.3	0.0	245%	0	M3-XS19-01-081718	1808476-1	1.4		138%
Trip 7	Red	M3-XS41-01-081718	1.4	1.5	96%	0	M3-XS41-01-081718	1808476-2	1.9		28%
Trip 7	Red	M4-XS210-01-081818	0.0	0.0	0%	0	M4-XS210-01-081818	1808483-3	0.8		200%
Trip 7	Red	M4-XSG11-01-081818	0.0	0.0	0%	0	M4-XSG11-01-081818	1808483-4	0.9		200%
Trip 7	Red	M4-XSG2-01-081818	0.0	0.0	0%	0	M4-XSG2-01-081818	1808483-5	0.9		200%
Trip 7	Red	M5-XS131-01-082018	1.0	0.7	115%	0	M5-XS131-01-082018	1808487-1	1.9		66%
Trip 7	Red	M5-XS15-01-081818	0.0	0.0	0%	0	M5-XS15-01-081818	1808483-6	0.8		200%
Trip 7	Red	M5-XS192-01-081818	1.4	1.5	53%	0	M5-XS192-01-081818	1808483-7	3.7		89%
Trip 7	Red	M5-XS199-01-082018	0.7	0.6	110%	0	M5-XS199-01-082018	1808487-2	1.4		70%
Trip 7	Red	M5-XS207A-01-082018	0.5	0.0	158%	0	M5-XS207A-01-082018	1808487-3	2.2		124%
Trip 7	Red	M5-XS261-01-082018	0.9	0.6	114%	0	M5-XS261-01-082018	1808487-4	1.8		72%
Trip 7	Red	M5-XS263-01-082018	2.4	2.3	74%	0	M5-XS263-01-082018	1808487-5	2.8		14%
Trip 7	Red	M5-XS305-01-082018	0.5	0.0	155%	0	M5-XS305-01-082018	1808487-6	1.7		103%
Trip 7	Red	M5-XS476-01-082018	0.6	0.0	155%	0	M5-XS476-01-082018	1808487-7	1.2		69%
Trip 7	Red	M5-XS488-01-082018	0.7	0.0	157%	0	M5-XS488-01-082018	1808487-8	1.3		65%
Trip 7	Red	M6-XS108-01-081618	1.7	1.8	58%	0	M6-XS108-01-081618	1808476-3	2.0		14%
Trip 7	Red	M6-XS108-02-081618	1.0	1.4	79%	0	M6-XS108-02-081618	1808476-4	2.4		79%
Trip 7	Red	M6-XS198-01-081618	1.9	2.2	84%	0	M6-XS198-01-081618	1808476-5	2.7		36%
Trip 7	Red	M6-XS249-01-081618	1.4	1.9	78%	0	M6-XS249-01-081618	1808476-6	1.3		6%
Trip 7	Red	M6-XS289-01-081618	0.9	0.7	120%	0	M6-XS289-01-081618	1808476-7	1.9		72%
Trip 7	Red	M6-XS324-01-081618	0.8	0.0	171%	0	M6-XS324-01-081618	1808476-8	3.9		129%
Trip 7	Red	M6-XS60-01-081618	1.0	0.8	112%	0	M6-XS60-01-081618	1808476-9	1.4		34%
Trip 7	Red	M6-XS72-01-081618	0.0	0.0	0%	0	M6-XS72-01-081618	1808476-10	1.5		200%
Trip 7	Pink	M7-XS213-01-081518	1.5	1.8	82%	0	M7-XS213-01-081518	1808356-7	3.0		66%
Trip 7	Pink	M7-XS214-01-081518	1.1	1.0	110%	0	M7-XS214-01-081518	1808356-8	1.5		34%
Trip 7	Pink	M8-XS55-01-081418	2.8	3.5	54%	0	M8-XS55-01-081418	1808356-20	1.3		73%
Trip 7	Red	M8-XS83-01-081418	1.8	2.2	84%	0	M8-XS83-01-081418	1808476-12	1.9		5%
Trip 7	Pink	M8-XSG16-01-081518	0.8	0.7	113%	0	M8-XSG16-01-081518	1808356-11	1.3		45%
Trip 7	Pink	M8-XSG31-01-081518	1.9	2.2	50%	0	M8-XSG31-01-081518	1808356-13	1.6		16%
Trip 7	Pink	M8-XSG37-01-081418	2.0	2.3	59%	0	M8-XSG37-01-081418	1808356-14	1.8		13%
Trip 7	Pink	M8-XSG40-01-081418	1.5	2.0	80%	0	M8-XSG40-01-081418	1808356-15	1.8		20%
Trip 7	Pink	M8-XSG44-02-081418	1.9	2.3	58%	0	M8-XSG44-02-081418	1808356-18	2.7		32%
Trip 7	Red	M8-XSG6-01-081518	0.6	0.0	156%	0	M8-XSG6-01-081518	1808476-11	1.3		77%
Trip 7	Red	M9-XS19A-01-081718	0.0	0.0	0%	0	M9-XS19A-01-081718	1808483-8	0.9		200%
Trip 7	Red	M9-XS28A-01-081718	0.0	0.0	0%	0	M9-XS28A-01-081718	1808483-9	2.4		200%
Trip 7	Red	T10-XSG1-01-081818	1.3	0.9	115%	0	T10-XSG1-01-081818	1808483-10	1.5		12%
Trip 7	Red	T13-XSG16-01-081618	0.0	0.0	0%	0	T13-XSG16-01-081618	1808476-13	1.7		200%
Trip 7	Red	T13-XSG26-01-081618	1.9	2.2	54%	0	T13-XSG26-01-081618	1808476-14	2.2		12%
Trip 7	Red	T13-XSG7-01-081618	1.7	1.8	57%	0	T13-XSG7-01-081618	1808476-15	1.6		9%
Trip 7	Red	T17-XSG17-01-081618	0.0	0.0	0%	0	T17-XSG17-01-081618	1808476-16	2.9		200%
Trip 7	Red	T17-XSG27-01-081618	0.0	0.0	0%	0	T17-XSG27-01-081618	1808476-17	1.5		200%
Trip 7	Red	T17-XSG31-01-081518	0.0	0.0	0%	0	T17-XSG31-01-081518	1808476-18	1.4		200%
Trip 7	Red	T17-XSG7-01-081618	0.0	0.0	0%	0	T17-XSG7-01-081618	1808476-19	2.0		200%
Trip 7	Red	T17-XSG7-02-081618	1.4	1.8	80%	0	T17-XSG7-02-081618	1808476-20	1.7		18%
Trip 7	Red	T1-XSG38-01-081918	1.7	2.0	54%	0	T1-XSG38-01-081918	1808483-13	1.4		21%
Trip 7	Red	T1-XSG5A-01-081918	0.6	0.0	185%	0	T1-XSG5A-01-081918	1808483-15	1.2		68%
Trip 7	Red	T4-XSG10-01-081918	0.9	0.7	114%	0	T4-XSG10-01-081918	1808483-16	1.6		58%
Trip 7	Red	T4-XSG39-01-081918	0.3	0.0	245%	0	T4-XSG39-01-081918	1808483-17	1.0		116%
Trip 7	Red	T6-XSG6-01-081918	0.2	0.0	245%	0	T6-XSG6-01-081918	1808487-10	1.2		138%
Trip 7	Red	T6-XSG6-02-081918	0.5	0.0	155%	0	T6-XSG6-02-081918	1808487-11	1.1		79%
Trip 7	Red	T9-XSG12-01-081818	1.5	1.7	89%	0	T9-XSG12-01-081818	1808483-20	2.0		29%
Trip 8	Red	M13-XS258-01-091518	0.4	0.0	155%	0	M13-XS258-01-091518	1809475-2	1.9		129%
Trip 8	Red	M14-XSG27A-01-091818	1.1	1.4	81%	0	M14-XSG27A-01-091818	1809475-23	2.6		83%
Trip 8	Red	M14-XSG49-01-091818	1.6	1.8	54%	0	M14-XSG49-01-091818	1809475-25	3.0		59%

Removed Data - Below Limit of Detection											
			XRF - Arsenic						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M15-XSG20-01-091118	0.0	0.0	0%	0	M15-XSG20-01-091118	1809473-20	2.8		200%
Trip 8	Red	M15-XSG2-01-091118	2.1	2.2	53%	0	M15-XSG2-01-091118	1809473-21	2.9	J	34%
Trip 8	Red	M16-XSG30-01-091518	1.3	1.3	55%	0	M16-XSG30-01-091518	1809475-3	1.9		40%
Trip 8	Red	M16-XSG38-01-091518	0.0	0.0	0%	0	M16-XSG38-01-091518	1809475-4	1.2		200%
Trip 8	Red	M17-XSG27-01-091318	0.4	0.0	245%	0	M17-XSG27-01-091318	1809473-3	1.7		126%
Trip 8	Red	M17-XSG36-01-091318	1.0	1.3	80%	0	M17-XSG36-01-091318	1809473-4	1.6		46%
Trip 8	Red	M17-XSG36-02-091318	0.4	0.0	155%	0	M17-XSG36-02-091318	1809473-5	1.5		113%
Trip 8	Red	M18-XSG16-01-091318	1.4	1.6	84%	0	M18-XSG16-01-091318	1809473-6	2.1		43%
Trip 8	Red	M18-XSG32-01-091318	1.6	2.2	81%	0	M18-XSG32-01-091318	1809473-8	2.8		53%
Trip 8	Red	M19-XSG11-01-091318	2.0	1.8	78%	0	M19-XSG11-01-091318	1809473-9	2.5		23%
Trip 8	Red	M19-XSG19-01-091318	3.3	2.3	110%	0	M19-XSG19-01-091318	1809473-10	3.9		17%
Trip 8	Red	M19-XSG25-01-091318	1.1	0.8	114%	0	M19-XSG25-01-091318	1809473-11	2.4		74%
Trip 8	Red	M19-XSG29-01-091318	0.3	0.0	245%	0	M19-XSG29-01-091318	1809473-12	2.2		159%
Trip 8	Red	M19-XSG39-01-091318	1.3	1.7	79%	0	M19-XSG39-01-091318	1809473-13	2.2		55%
Trip 8	Red	M20-XS146-01-091718	0.0	0.0	0%	0	M20-XS146-01-091718	1809475-28	2.6		200%
Trip 8	Red	M20-XS243-01-091718	1.7	1.8	53%	0	M20-XS243-01-091718	1809475-29	5.7		109%
Trip 8	Red	M20-XS247-01-091718	0.9	0.7	112%	0	M20-XS247-01-091718	1809475-30	2.1		83%
Trip 8	Red	M20-XS267-01-091718	0.4	0.0	245%	0	M20-XS267-01-091718	1809475-31	2.5		142%
Trip 8	Red	M20-XS271-01-091718	0.0	0.0	0%	0	M20-XS271-01-091718	1809475-32	1.9		200%
Trip 8	Red	M20-XS30-01-091718	1.6	1.9	51%	0	M20-XS30-01-091718	1809475-33	2.8		52%
Trip 8	Red	M20-XS335-01-091418	1.5	1.7	54%	0	M20-XS335-01-091418	1809475-5	2.9		63%
Trip 8	Red	M20-XS58-01-091718	1.9	2.2	53%	0	M20-XS58-01-091718	1809475-34	2.4		25%
Trip 8	Red	M20-XS60-01-091718	0.4	0.0	245%	0	M20-XS60-01-091718	1809475-35	2.4		140%
Trip 8	Red	M20-XSG15-01-091418	2.4	2.7	50%	0	M20-XSG15-01-091418	1809475-7	4.1		52%
Trip 8	Red	M20-XSG7-01-091418	0.0	0.0	0%	0	M20-XSG7-01-091418	1809475-9	1.4		200%
Trip 8	Red	M21-XS1-01-091218	0.0	0.0	0%	0	M21-XS1-01-091218	1809473-24	4.0		200%
Trip 8	Red	M21-XS503-01-091218	0.0	0.0	0%	0	M21-XS503-01-091218	1809473-28	2.1		200%
Trip 8	Red	M21-XS511-01-091218	1.1	0.9	112%	0	M21-XS511-01-091218	1809473-29	2.7		88%
Trip 8	Red	M21-XSG43-01-091418	0.0	0.0	0%	0	M21-XSG43-01-091418	1809475-13	2.1		200%
Trip 8	Red	M21-XSG7-01-091218	0.0	0.0	0%	0	M21-XSG7-01-091218	1809473-32	2.3		200%
Trip 8	Red	M22-XS94-01-091418	0.8	0.7	115%	0	M22-XS94-01-091418	1809475-17	2.0		81%
Trip 8	Red	M23-XSG1-01-091418	0.7	0.0	162%	0	M23-XSG1-01-091418	1809475-18	3.0		122%
Trip 8	Red	M23-XSG20-01-091418	1.0	0.7	122%	0	M23-XSG20-01-091418	1809475-19	2.4		80%
Trip 8	Red	M23-XSG5-01-091418	0.6	0.0	156%	0	M23-XSG5-01-091418	1809475-20	2.0		113%
Trip 8	Red	M6-XS164-01-091118	0.0	0.0	0%	0	M6-XS164-01-091118	1809473-33	1.1		200%
Trip 8	Red	M6-XS369-01-091618	0.0	0.0	0%	0	M6-XS369-01-091618	1809475-37	1.5		200%
Trip 8	Red	M6-XS52-01-091118	0.3	0.0	245%	0	M6-XS52-01-091118	1809473-35	2.1		154%
Trip 8	Red	M6-XSG22-01-091618	0.0	0.0	0%	0	M6-XSG22-01-091618	1809475-39	2.5		200%
Trip 8	Red	M7-XSG34-01-091618	1.3	1.4	86%	0	M7-XSG34-01-091618	1809475-40	2.2		52%
Trip 8	Red	M7-XSG41-01-091618	0.5	0.0	155%	0	M7-XSG41-01-091618	1809475-41	1.7		114%
Trip 8	Red	T18-XSG7-01-091518	0.2	0.0	245%	0	T18-XSG7-01-091518	1809475-42	2.0		159%
Trip 8	Red	T19-XS9-01-091118	0.0	0.0	0%	0	T19-XS9-01-091118	1809473-36	3.6		200%
Trip 8	Red	T20-XSG3-01-091118	0.0	0.0	0%	0	T20-XSG3-01-091118	1809473-37	2.1		200%
Trip 8	Red	T21-XSG13-01-091118	1.6	1.9	82%	0	T21-XSG13-01-091118	1809473-38	2.5		46%
Trip 8	Red	T21-XSG26-01-091118	1.6	1.9	51%	0	T21-XSG26-01-091118	1809473-39	1.9		15%
Trip 8	Red	T22-XS20-01-091118	0.0	0.0	0%	0	T22-XS20-01-091118	1809473-15	2.0		200%
Trip 8	Red	T23-XSG26-01-091118	1.8	1.8	61%	0	T23-XSG26-01-091118	1809473-16	2.0	J	13%
Trip 8	Red	T23-XSG7-01-091118	2.1	2.4	52%	0	T23-XSG7-01-091118	1809473-17	2.8		30%
Trip 8	Red	T24-XSG2-01-091118	0.3	0.0	245%	0	T24-XSG2-01-091118	1809473-18	1.8		149%
Trip 8	Red	T24-XSG26-01-091118	0.5	0.0	245%	0	T24-XSG26-01-091118	1809473-19	6.2		168%
Trip 8	Red	T26-XSG9-01-091518	2.2	2.7	55%	0	T26-XSG9-01-091518	1809475-44	3.6		47%
Trip 9	Red	M10-XSG2-01-092818	1.3	1.7	81%	0	M10-XSG2-01-092818	1810122-1	1.9		35%
Trip 9	Blue	M10-XSG4-01-092818	1.7	1.9	52%	0	M10-XSG4-01-092818	1810122-2	1.6		6%
Trip 9	Red	M11-XS47-01-092818	2.2	1.9	72%	0	M11-XS47-01-092818	1810122-3	1.6		32%
Trip 9	Blue	M11-XSG2-01-092818	0.7	0.0	158%	0	M11-XSG2-01-092818	1810122-4	1.3		63%
Trip 9	Blue	M11-XSG25-01-092818	1.7	1.6	65%	0	M11-XSG25-01-092818	1810122-5	1.4		18%
Trip 9	Red	M11-XSG33-01-092818	0.5	0.0	155%	0	M11-XSG33-01-092818	1810122-7	1.2		88%
Trip 9	Red	M12-XSG26-01-092818	0.0	0.0	0%	0	M12-XSG26-01-092818	1810122-8	1.5		200%
Trip 9	Blue	M14-XSR1-01-093018	0.5	0.0	155%	0	M14-XSR1-01-093018	1810072-21	1.2		80%
Trip 9	White	M15-XSR1-01-093018	0.6	0.0	161%	0	M15-XSR1-01-093018	1810072-22	1.1		52%
Trip 9	White	M16-XSR6-01-093018	0.8	0.7	116%	0	M16-XSR6-01-093018	1810072-24	1.3		43%
Trip 9	Blue	M17-XSR1-01-093018	0.7	0.0	160%	0	M17-XSR1-01-093018	1810072-25	1.2		50%
Trip 9	Red	M19-XSR2-01-093018	0.0	0.0	0%	0	M19-XSR2-01-093018	1810072-26	1.3		200%
Trip 9	Blue	M19-XSR2-02-093018	0.5	0.0	156%	0	M19-XSR2-02-093018	1810072-27	1.2		76%
Trip 9	Red	M1-XSG4-01-092818	0.0	0.0	0%	0	M1-XSG4-01-092818	1810072-1	1.5		200%
Trip 9	Blue	M20-XSR2-01-093018	0.5	0.0	156%	0	M20-XSR2-01-093018	1810072-28	1.3		86%
Trip 9	Red	M24-XS112-01-092518	2.5	2.8	52%	0	M24-XS112-01-092518	1810032-1	3.0		18%
Trip 9	Red	M24-XSG32-01-092518	0.9	0.7	116%	0	M24-XSG32-01-092518	1810032-5	1.9		68%
Trip 9	Blue	M25-XSG12-01-092818	0.3	0.0	245%	0	M25-XSG12-01-092818	1810122-10	1.6		145%
Trip 9	Blue	M25-XSG19-01-092818	1.0	0.8	116%	0	M25-XSG19-01-092818	1810122-11	1.5		37%
Trip 9	Blue	M25-XSG19-02-092818	1.4	1.7	81%	0	M25-XSG19-02-092818	1810122-12	1.5		8%

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Arsenic: Average Ex Situ XRF (ppm)	XRF - Arsenic: Median Ex Situ XRF (ppm)	XRF - Arsenic: Relative Standard Deviation	XRF - Arsenic: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 9	Blue	M25-XSG5-01-092818	0.0	0.0	0%	0	M25-XSG5-01-092818	1810122-13	0.6		200%
Trip 9	Red	M27-XS116-01-092618	1.5	1.8	83%	0	M27-XS116-01-092618	1810072-2	2.4		49%
Trip 9	Red	M27-XS149-01-092618	0.0	0.0	0%	0	M27-XS149-01-092618	1810072-3	1.9		200%
Trip 9	Red	M27-XS150-01-092618	0.0	0.0	0%	0	M27-XS150-01-092618	1810072-4	2.1		200%
Trip 9	Red	M27-XSG6-01-092618	1.6	1.9	51%	0	M27-XSG6-01-092618	1810072-9	2.2		33%
Trip 9	White	M28-XS19-01-092918	1.3	1.5	83%	0	M28-XS19-01-092918	1810122-15	1.6		23%
Trip 9	Blue	M28-XSG18-01-092918	1.0	1.4	79%	0	M28-XSG18-01-092918	1810122-16	1.1		6%
Trip 9	Red	M28-XSG49-01-092618	1.5	1.9	82%	0	M28-XSG49-01-092618	1810032-7	2.7		55%
Trip 9	Blue	M28-XSR1-01-093018	0.6	0.0	157%	0	M28-XSR1-01-093018	1810072-31	1.2		63%
Trip 9	Red	M28-XSR1-02-093018	0.0	0.0	0%	0	M28-XSR1-02-093018	1810072-32	1.3		200%
Trip 9	Red	M29-XS42-01-092518	0.6	0.0	155%	0	M29-XS42-01-092518	1810032-10	2.0		107%
Trip 9	Red	M29-XS64-01-092518	0.8	0.6	112%	0	M29-XS64-01-092518	1810032-12	1.6		69%
Trip 9	Red	M29-XSG1-01-092518	0.0	0.0	0%	0	M29-XSG1-01-092518	1810032-13	1.1		200%
Trip 9	Red	M29-XSG25-01-092518	0.5	0.0	160%	0	M29-XSG25-01-092518	1810032-14	1.4		91%
Trip 9	Red	M29-XSG35-01-092518	0.5	0.0	155%	0	M29-XSG35-01-092518	1810032-15	1.7		108%
Trip 9	Blue	M29-XSR4-01-093018	2.0	2.5	81%	0	M29-XSR4-01-093018	1810072-33	2.1		5%
Trip 9	Red	M29-XSR7-01-093018	3.2	3.5	54%	0	M29-XSR7-01-093018	1810072-34	3.7		13%
Trip 9	White	M2-XSR3-01-093018	1.5	1.5	57%	0	M2-XSR3-01-093018	1810072-35	1.8		20%
Trip 9	White	M30-XSG43-01-092918	1.4	1.5	52%	0	M30-XSG43-01-092918	1810122-24	1.2		14%
Trip 9	White	M30-XSG45-01-092918	0.8	0.8	110%	0	M30-XSG45-01-092918	1810122-25	0.8		3%
Trip 9	Red, White	M30-XSG6-01-092918	1.9	2.0	85%	0	M30-XSG6-01-092918	1810122-26	3.1		50%
Trip 9	Blue	M30-XSG61-01-092918	0.3	0.0	245%	0	M30-XSG61-01-092918	1810122-27	0.7		88%
Trip 9	White	M31-XSG1-01-092918	0.0	0.0	0%	0	M31-XSG1-01-092918	1810122-31	0.9		200%
Trip 9	White	M31-XSG17-01-092918	0.8	0.7	112%	0	M31-XSG17-01-092918	1810122-33	0.9		10%
Trip 9	Red	M31-XSG9-01-092918	0.0	0.0	0%	0	M31-XSG9-01-092918	1810122-34	0.8		200%
Trip 9	Red	M32-XSG26-01-092918	1.4	1.9	79%	0	M32-XSG26-01-092918	1810072-11	2.7		62%
Trip 9	Red	M32-XSG46-01-092918	0.8	0.0	161%	0	M32-XSG46-01-092918	1810072-13	1.8		73%
Trip 9	Red	M32-XSG9-01-092918	1.3	1.6	83%	0	M32-XSG9-01-092918	1810072-14	2.3		58%
Trip 9	Red	M35-XSG20-01-092718	1.7	1.8	56%	0	M35-XSG20-01-092718	1810072-16	2.7		43%
Trip 9	Red	M35-XSG4-01-092718	0.7	0.0	156%	0	M35-XSG4-01-092718	1810072-17	2.1		97%
Trip 9	White	M6-XSR1-01-093018	1.2	1.5	83%	0	M6-XSR1-01-093018	1810072-37	1.2		2%
Trip 9	Blue	M8-XSR1-01-093018	2.6	3.1	52%	0	M8-XSR1-01-093018	1810072-40	3.0		14%
Trip 9	White	T17-XSR1-01-093018	0.7	0.0	155%	0	T17-XSR1-01-093018	1810072-41	1.9		94%
Trip 9	Red	T30-XS20-01-092518	1.5	1.9	82%	0	T30-XS20-01-092518	1810032-16	2.4		48%
Trip 9	Red	T30-XS28-01-092518	1.4	1.8	83%	0	T30-XS28-01-092518	1810032-17	2.2		46%
Trip 9	Red	T30-XS8-01-092518	1.0	0.9	110%	0	T30-XS8-01-092518	1810032-18	1.7		55%
Trip 9	Red	T31-XSG7-01-092518	1.1	1.6	78%	0	T31-XSG7-01-092518	1810032-19	1.5		32%
Trip 9	Red	T31-XSG9-01-092518	0.4	0.0	245%	0	T31-XSG9-01-092518	1810032-20	1.8		131%
Trip 9	Red	T5-XSG3-01-092818	1.3	1.9	78%	0	T5-XSG3-01-092818	1810072-19	2.2		51%
Trip 9	Red	T5-XSG3-02-092818	0.9	0.0	164%	0	T5-XSG3-02-092818	1810072-20	2.2		84%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Arsenic: Average Ex Situ XRF (ppm)	XRF - Arsenic: Median Ex Situ XRF (ppm)	XRF - Arsenic: Relative Standard Deviation	XRF - Arsenic: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 8	Red	M16-XSG24-01-091118	3.7	3.5	58%	0	M16-XSG24-01-091118	1809473-23	28.0		153%
Trip 8	Red	M21-XSG16-01-091218	21.3	21.7	17%	14	M21-XSG16-01-091218	1809473-31	7.2		99%
Trip 8	Red	M6-XS224-01-091118	0.0	0.0	0%	0	M6-XS224-01-091118	1809473-34	17.0		200%
Trip 9	Red	M12-XSG3-01-092818	25.4	3.7	212%	2	M12-XSG3-01-092818	1810122-9	2.2		168%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

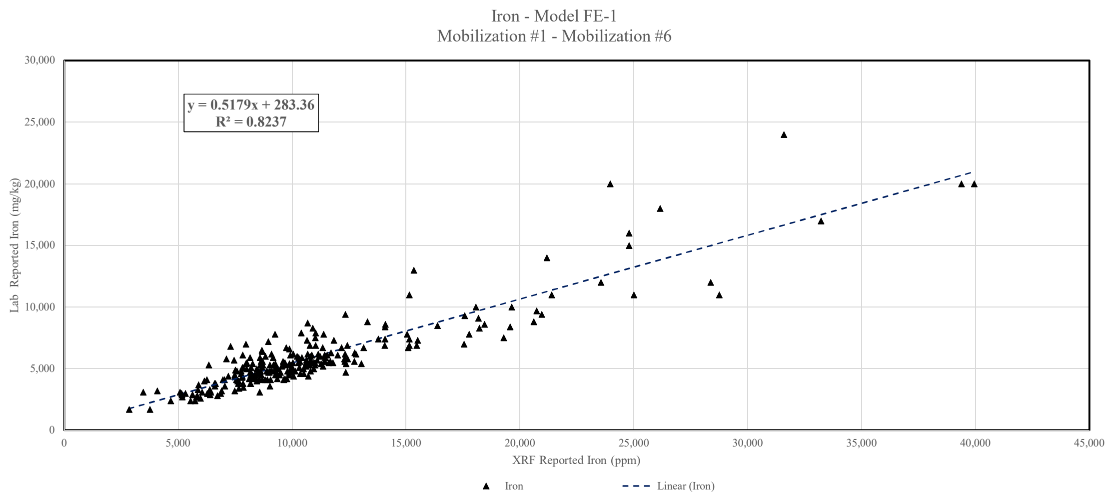
ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model FE-1											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	5,165	5,161.9	10%	4,523	M2-XS15-01-042418	1805041-1	2,900		56%
Trip 1	Pink	M2-XS15-02-042418	5,313	5,209.9	7%	4,942	M2-XS15-02-042418	1805041-2	3,000		56%
Trip 1	Pink	M2-XS32-01-042418	6,048	6,034.2	2%	5,839	M2-XS32-01-042418	1805041-3	3,100		64%
Trip 1	Pink	M2-XS59-01-042418	5,173	5,142.4	16%	4,280	M2-XS59-01-042418	1805041-4	2,700		63%
Trip 1	Pink	M2-XS73-01-042418	5,150	5,109.2	5%	4,854	M2-XS73-01-042418	1805041-5	3,000		53%
Trip 1	Pink	M3-XS34-01-043018	10,705	10,449.6	9%	9,785	M3-XS34-01-043018	1805042-1	4,400		83%
Trip 1	Pink	M3-XS36-01-043018	11,428	11,393.3	3%	10,936	M3-XS36-01-043018	1805042-2	6,100		61%
Trip 1	Pink	M6-XS140-01-042818	8,591	8,633.5	2%	8,334	M6-XS140-01-042818	1805041-6	4,800		57%
Trip 1	Orange	M6-XS159-01-04262018	9,106	8,988.5	13%	7,724	M6-XS159-01-04262018	1805039-1	4,800		62%
Trip 1	Pink	M6-XS251-01-04272018	15,151	15,040.2	6%	14,258	M6-XS251-01-04272018	1805039-2	6,900		75%
Trip 1	Pink	M6-XS269-01-04262018	11,449	11,541.5	6%	10,591	M6-XS269-01-04262018	1805039-3	5,900		64%
Trip 1	Pink	M6-XS269-02-04262018	11,701	11,563.1	2%	11,470	M6-XS269-02-04262018	1805039-4	6,300		60%
Trip 1	Pink	M6-XS285-01-04272018	8,831	8,831.0	3%	8,377	M6-XS285-01-04272018	1805039-5	6,000		38%
Trip 1	Pink	T10-XS1-01-042518	12,366	12,428.8	1%	11,543	T10-XS1-01-042518	1805036-1	5,400		78%
Trip 1	Pink	T10-XS20-01-042518	8,908	8,941.9	4%	8,448	T10-XS20-01-042518	1805036-2	4,100		74%
Trip 1	Pink	T10-XS33-01-042518	9,766	9,686.9	5%	9,332	T10-XS33-01-042518	1805036-3	4,200		80%
Trip 1	Pink	T10-XS56-01-042518	12,329	12,194.4	4%	11,995	T10-XS56-01-042518	1805036-4	5,800		72%
Trip 1	Pink	T10-XS78-01-042518	12,438	12,503.6	3%	11,704	T10-XS78-01-042518	1805036-5	5,800		73%
Trip 1	Pink	T11-XS1-01-042518	12,807	12,739.5	2%	12,531	T11-XS1-01-042518	1805036-6	6,200		70%
Trip 1	Pink	T11-XS20-01-042518	11,996	11,996.5	1%	11,740	T11-XS20-01-042518	1805036-7	6,100		65%
Trip 1	Pink	T11-XS60-01-042518	7,866	7,976.6	4%	7,228	T11-XS60-01-042518	1805036-8	3,500		77%
Trip 1	Pink	T17-XS1-01-04262018	7,819	7,862.8	6%	7,256	T17-XS1-01-04262018	1805039-6	4,400		56%
Trip 1	Pink	T17-XS1-02-04262018	8,257	7,960.8	10%	7,619	T17-XS1-02-04262018	1805039-7	4,300		63%
Trip 1	Pink	T17-XS143-01-04262018	11,107	10,961.7	5%	10,395	T17-XS143-01-04262018	1805039-8	5,700		64%
Trip 1	Orange	T17-XS144-01-04262018	9,224	9,095.1	4%	8,840	T17-XS144-01-04262018	1805039-9	4,800		63%
Trip 1	Pink	T17-XS194-01-04272018	9,448	9,305.6	3%	9,176	T17-XS194-01-04272018	1805039-10	4,500		71%
Trip 1	Pink	T17-XS194-02-04272018	9,302	9,303.9	10%	8,276	T17-XS194-02-04272018	1805039-11	4,600		68%
Trip 1	Pink	T17-XS20-01-04262018	8,886	8,761.0	10%	7,710	T17-XS20-01-04262018	1805039-12	4,800		60%
Trip 1	Pink	T17-XS208-01-042818	9,275	9,293.7	4%	8,774	T17-XS208-01-042818	1805041-7	4,800		64%
Trip 1	Pink	T17-XS251-01-04272018	10,621	10,664.9	4%	10,018	T17-XS251-01-04272018	1805039-13	5,700		60%
Trip 1	Pink	T17-XS257-01-04272018	10,598	10,592.2	2%	10,367	T17-XS257-01-04272018	1805039-14	5,200		68%
Trip 1	Pink	T17-XS273-01-042818	8,682	8,697.7	2%	8,430	T17-XS273-01-042818	1805041-8	4,100		72%
Trip 1	Pink	T17-XS287-01-04272018	15,149	15,112.5	7%	13,686	T17-XS287-01-04272018	1805039-15	11,000		32%
Trip 1	Pink	T17-XS304-01-042818	8,371	8,454.8	4%	7,847	T17-XS304-01-042818	1805041-9	4,200		66%
Trip 1	Pink	T17-XS317-01-04272018	10,790	10,795.3	4%	10,313	T17-XS317-01-04272018	1805039-16	6,000		57%
Trip 1	Pink	T17-XS328-01-04272018	11,794	11,976.8	6%	10,604	T17-XS328-01-04272018	1805039-17	5,500		73%
Trip 1	Pink	T17-XS369-01-043018	11,406	11,413.9	3%	10,900	T17-XS369-01-043018	1805042-4	5,600		68%
Trip 1	Pink	T17-XS377-01-042818	12,314	12,038.3	6%	11,721	T17-XS377-01-042818	1805041-10	5,600		75%
Trip 1	Pink	T17-XS393-01-043018	9,047	9,039.2	5%	8,571	T17-XS393-01-043018	1805042-5	4,100		75%
Trip 1	Pink	T17-XS417-01-04272018	13,047	13,030.2	2%	12,735	T17-XS417-01-04272018	1805039-18	5,400		83%
Trip 1	Pink	T17-XS438-01-042818	6,857	6,847.8	2%	6,694	T17-XS438-01-042818	1805041-11	3,000		78%
Trip 1	Pink	T17-XS44-01-04262018	10,844	10,592.2	5%	10,420	T17-XS44-01-04262018	1805039-19	5,600		64%
Trip 1	Pink	T17-XS442-01-04272018	10,998	11,026.7	2%	10,683	T17-XS442-01-04272018	1805039-20	5,500		67%
Trip 1	Pink	T17-XS46-01-042618	10,952	10,983.3	5%	10,372	T17-XS46-01-042618	1805041-12	5,500		66%
Trip 1	Pink	T17-XS473-01-042818	11,604	11,767.9	4%	10,803	T17-XS473-01-042818	1805041-13	5,500		71%
Trip 1	Pink	T17-XS479-01-042818	10,614	10,559.9	1%	10,452	T17-XS479-01-042818	1805041-14	5,500		63%
Trip 1	Pink	T17-XS479-02-042818	10,620	10,584.6	3%	10,224	T17-XS479-02-042818	1805041-15	5,300		67%
Trip 1	Pink	T17-XS603-01-042818	12,359	12,283.0	2%	12,099	T17-XS603-01-042818	1805041-16	4,700		90%
Trip 1	Pink	T17-XS659-01-043018	9,030	9,002.1	6%	8,284	T17-XS659-01-043018	1805042-6	3,600		86%
Trip 1	Pink	T17-XS679-01-043018	10,134	10,375.6	5%	9,226	T17-XS679-01-043018	1805042-7	4,800		71%

Data Included in Model FE-1												
			XRF - Iron						ALS Results			
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	T17-XS704-01-043018	8,582	8,638.9	4%	8,139	T17-XS704-01-043018	1805042-8	3,100		94%
Trip 1	Pink	T7-XS11-01-042418	6,267	6,125.8	2%	5,536	T7-XS11-01-042418	1805036-9	3,000		71%
Trip 1	Pink	T7-XS5-01-042418	5,620	5,521.4	7%	5,247	T7-XS5-01-042418	1805036-10	2,900		64%
Trip 1	Pink	T7-XS58-01-042418	5,794	5,697.6	8%	5,213	T7-XS58-01-042418	1805036-11	2,700		73%
Trip 1	Pink	T7-XS7-01-042418	4,665	4,586.3	9%	4,040	T7-XS7-01-042418	1805036-12	2,400		64%
Trip 1	Pink	T7-XS9-01-042418	5,624	5,564.2	8%	5,108	T7-XS9-01-042418	1805036-13	2,900		64%
Trip 1	Pink	T8-XS15-01-042418	6,610	6,496.6	4%	6,413	T8-XS15-01-042418	1805036-14	3,600		59%
Trip 1	Pink	T8-XS23-01-042418	7,651	7,676.3	3%	7,222	T8-XS23-01-042418	1805036-15	4,000		63%
Trip 1	Pink	T8-XS6-01-042418	6,412	6,471.1	4%	5,957	T8-XS6-01-042418	1805036-16	3,200		67%
Trip 1	Pink	T9-XS217-01-042518	11,441	11,457.2	4%	10,815	T9-XS217-01-042518	1805036-17	5,600		69%
Trip 1	Pink	T9-XS61-01-042518	14,068	14,104.4	3%	13,645	T9-XS61-01-042518	1805036-18	6,900		68%
Trip 1	Orange	T9-XS61-02-042518	13,784	13,780.1	3%	13,307	T9-XS61-02-042518	1805041-17	7,400		60%
Trip 1	Pink	T9-XS86-01-042518	10,319	10,309.2	2%	10,001	T9-XS86-01-042518	1805036-19	5,100		68%
Trip 1	Pink	T9-XS93-01-042518	10,360	10,514.2	5%	9,572	T9-XS93-01-042518	1805036-20	4,600		77%
Trip 2	Orange	M1-XS31-01-051218	6,324	6,384.7	5%	5,888	M1-XS31-01-051218	1805328-1	3,000		71%
Trip 2	Pink	M1-XS32-01-051218	5,545	5,701.1	10%	4,748	M1-XS32-01-051218	1805328-2	2,400		79%
Trip 2	Pink	M4-XS136-01-050918	7,843	7,935.5	4%	7,293	M4-XS136-01-050918	1805322-1	5,100		42%
Trip 2	Pink	M4-XS18-01-050718	21,192	20,954.9	3%	20,651	M4-XS18-01-050718	1805322-2	14,000		41%
Trip 2	Orange	M4-XS219-01-051018	12,753	12,740.3	4%	11,958	M4-XS219-01-051018	1805322-3	6,300		68%
Trip 2	Pink	M4-XS238-01-051018	31,596	32,560.9	12%	25,124	M4-XS238-01-051018	1805322-4	24,000		27%
Trip 2	Pink	M4-XS4-01-050718	8,185	8,067.5	5%	7,758	M4-XS4-01-050718	1805322-5	4,500		58%
Trip 2	Pink	M4-XS45-01-050718	7,482	7,424.1	4%	6,966	M4-XS45-01-050718	1805322-6	4,500		50%
Trip 2	Pink	M4-XS63-01-050718	11,033	11,267.5	4%	10,268	M4-XS63-01-050718	1805322-7	7,900		33%
Trip 2	Pink	M4-XS63-02-050718	10,904	11,310.1	10%	9,542	M4-XS63-02-050718	1805322-8	8,300		27%
Trip 2	Pink	M4-XS78-01-051018	13,144	12,584.0	19%	11,026	M4-XS78-01-051018	1805322-9	6,700		65%
Trip 2	Orange	M5-XS115-01-051118	9,259	9,139.9	6%	8,620	M5-XS115-01-051118	1805322-10	4,500		69%
Trip 2	Pink	M5-XS385-01-051118	7,030	6,818.4	8%	6,654	M5-XS385-01-051118	1805322-11	4,100		53%
Trip 2	Pink	M5-XS69-01-051118	9,207	9,275.8	3%	8,849	M5-XS69-01-051118	1805322-12	4,800		63%
Trip 2	Orange	M6-XS41-01-051118	5,865	5,943.3	7%	5,270	M6-XS41-01-051118	1805322-13	3,300		56%
Trip 2	Pink	M6-XS44-01-051018	8,268	8,163.2	6%	7,556	M6-XS44-01-051018	1805322-14	5,400		42%
Trip 2	Pink	M6-XS81-01-051018	6,426	6,245.9	13%	5,292	M6-XS81-01-051018	1805322-15	3,100		70%
Trip 2	Pink	M7-XS181-01-051018	8,584	8,471.7	6%	7,768	M7-XS181-01-051018	1805322-16	5,900		37%
Trip 2	Orange	M7-XS181-02-051018	8,634	8,536.2	3%	8,383	M7-XS181-02-051018	1805322-17	5,600		43%
Trip 2	Orange	M7-XS39-01-051018	7,548	7,611.2	5%	6,886	M7-XS39-01-051018	1805322-18	4,100		59%
Trip 2	Orange	M7-XS74-01-051018	12,176	11,915.6	14%	10,980	M7-XS74-01-051018	1805322-19	6,700		58%
Trip 2	Orange	M7-XS77-01-051018	15,147	15,078.8	3%	14,368	M7-XS77-01-051018	1805322-20	7,400		69%
Trip 2	Pink	M8-XS100-01-050918	8,183	8,111.8	3%	7,923	M8-XS100-01-050918	1805328-3	3,800		73%
Trip 2	Pink	M8-XS102-01-050918	39,954	39,891.3	2%	38,861	M8-XS102-01-050918	1805328-4	20,000		67%
Trip 2	Pink	M8-XS102-02-050918	39,391	39,887.1	5%	35,830	M8-XS102-02-050918	1805328-5	20,000		65%
Trip 2	Pink	M8-XS110-01-050918	8,961	9,174.9	8%	7,853	M8-XS110-01-050918	1805328-6	4,700		62%
Trip 2	Orange	M8-XS19-01-051018	12,291	11,971.4	8%	11,408	M8-XS19-01-051018	1805328-7	5,800		72%
Trip 2	Orange	M8-XS32-01-051018	18,187	18,045.8	4%	17,610	M8-XS32-01-051018	1805328-8	9,100		67%
Trip 2	Pink	M8-XS94-01-050918	10,295	9,948.5	16%	8,411	M8-XS94-01-050918	1805328-9	5,900		54%
Trip 2	Pink	T13-XS12-01-050818	11,826	11,864.3	3%	11,389	T13-XS12-01-050818	1805322-21	7,300		47%
Trip 2	Pink	T13-XS24-01-050818	6,382	6,353.3	4%	6,071	T13-XS24-01-050818	1805322-22	3,300		64%
Trip 2	Pink	T14-XS12-01-050818	11,151	11,035.0	4%	10,671	T14-XS12-01-050818	1805322-23	6,200		57%
Trip 2	Pink	T14-XS27-01-050818	9,179	9,185.3	6%	8,531	T14-XS27-01-050818	1805322-24	5,300		54%
Trip 2	Pink	T15-XS2-01-050818	11,228	11,184.6	2%	10,966	T15-XS2-01-050818	1805322-25	6,000		61%
Trip 2	Pink	T15-XS45-01-050818	9,374	9,482.6	3%	8,973	T15-XS45-01-050818	1805322-26	5,000		61%
Trip 2	Pink	T17-XS122-01-050718	9,605	9,646.5	3%	9,304	T17-XS122-01-050718	1805322-27	5,600		53%
Trip 2	Pink	T17-XS176-01-050718	9,683	9,933.1	8%	8,263	T17-XS176-01-050718	1805322-28	5,500		55%
Trip 2	Pink	T17-XS178-01-050718	8,615	8,580.2	3%	8,235	T17-XS178-01-050718	1805322-29	4,800		57%
Trip 2	Pink	T17-XS619-01-050718	9,691	9,763.0	3%	9,208	T17-XS619-01-050718	1805322-30	5,300		59%
Trip 2	Pink	T17-XS619-02-050718	9,626	9,482.9	5%	9,124	T17-XS619-02-050718	1805322-31	5,500		55%
Trip 2	Pink	T17-XS645-01-050718	9,547	9,430.9	5%	9,102	T17-XS645-01-050718	1805322-32	5,200		59%
Trip 2	Pink	T17-XS669-01-050718	8,510	8,514.9	2%	8,275	T17-XS669-01-050718	1805322-33	4,800		56%
Trip 2	Pink	T1-XS104-01-051318	25,010	24,978.9	10%	22,065	T1-XS104-01-051318	1805328-10	11,000		78%
Trip 2	Pink	T1-XS20-01-051318	11,265	11,184.3	6%	10,543	T1-XS20-01-051318	1805328-11	5,400		70%
Trip 2	Pink	T1-XS54-01-051318	9,634	9,523.1	6%	9,085	T1-XS54-01-051318	1805328-12	4,100		81%
Trip 2	Pink	T1-XS54-02-051318	9,684	9,657.3	4%	9,209	T1-XS54-02-051318	1805328-13	4,200		79%
Trip 2	Pink	T1-XS69-01-051318	9,795	9,797.8	5%	9,064	T1-XS69-01-051318	1805328-14	4,800		68%
Trip 2	Orange	T3-XS10-01-051218	7,480	7,474.7	4%	7,112	T3-XS10-01-051218	1805328-15	3,200		80%
Trip 2	Orange	T3-XS5-01-051218	6,903	6,929.7	3%	6,647	T3-XS5-01-051218	1805328-16	3,200		73%
Trip 2	Pink	T4-XS23-01-051218	5,841	5,776.9	6%	5,484	T4-XS23-01-051218	1805328-17	2,800		70%
Trip 2	Orange	T4-XS32-01-051218	6,720	6,704.1	5%	6,386	T4-XS32-01-051218	1805328-18	2,800		82%
Trip 2	Pink	T4-XS43-01-051218	8,446	8,383.4	2%	8,272	T4-XS43-01-051218	1805328-19	5,000		51%
Trip 2	Pink	T5-XS18-01-051418	7,659	7,689.9	6%	6,983	T5-XS18-01-051418	1805328-20	3,400		77%
Trip 2	Pink	T6-XS2-01-051218	5,739	5,605.6	7%	5,318	T6-XS2-01-051218	1805328-21	2,400		82%
Trip 2	Orange	T6-XS25-01-051218	5,980	5,981.0	4%	5,711	T6-XS25-01-051218	1805328-22	2,600		79%
Trip 3	Pink	M14-XS36-01-052418	6,262	6,290	2%	5,970	M14-XS36-01-052418	1805632-1	4,100		42%
Trip 3	Pink	M14-XS40-01-052418	8,172	7,381	24%	6,898	M14-XS40-01-052418	1805632-2	3,800		73%
Trip 3	Pink	M14-XS64-01-052418	8,148	8,163	5%	7,379	M14-XS64-01-052418	1805632-3	4,700		54%
Trip 3	Pink	M14-XS67-01-052418	6,636	6,283	16%	5,677	M14-XS67-01-052418	1805632-4	3,800		54%
Trip 3	Pink	M15-XS3-01-052118	10,046	10,045	4%	9,428	M15-XS3-01-052118	1805589-2	6,200		47%

Data Included in Model FE-1											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Pink	M15-XS22-01-052118	8,697	8,589	5%	8,315	M15-XS22-01-052118	1805589-1	5,600		43%
Trip 3	Pink	M15-XS46-01-052118	10,859	10,664	11%	9,621	M15-XS46-01-052118	1805589-3	6,100		56%
Trip 3	Pink	M15-XS46-02-052118	10,348	10,181	11%	9,330	M15-XS46-02-052118	1805589-4	5,600		60%
Trip 3	Pink	M15-XS82-01-052118	26,158	26,252	5%	24,358	M15-XS82-01-052118	1805589-6	18,000		37%
Trip 3	Pink	M15-XS93-01-052118	9,882	9,825	4%	9,435	M15-XS93-01-052118	1805589-7	6,600		40%
Trip 3	Pink	M16-XS4-01-052118	9,925	10,055	4%	9,210	M16-XS4-01-052118	1805589-12	6,100		48%
Trip 3	Pink	M16-XS30-01-052118	10,423	10,344	8%	9,615	M16-XS30-01-052118	1805589-10	5,900		55%
Trip 3	Pink	M16-XS31-01-052118	6,593	6,564	4%	6,238	M16-XS31-01-052118	1805589-11	3,800		54%
Trip 3	Pink	M16-XS128-01-052118	16,390	16,265	8%	14,461	M16-XS128-01-052118	1805589-8	8,500		63%
Trip 3	Pink	M16-XS154-01-052618	12,733	12,499	13%	10,520	M16-XS154-01-052618	1806235-2	5,600		78%
Trip 3	Pink	M16-XS177-01-052618	9,343	9,131	5%	8,953	M16-XS177-01-052618	1806235-3	4,200		76%
Trip 3	Pink	M16-XS191-01-052618	10,036	10,094	4%	9,533	M16-XS191-01-052618	1806235-4	5,500		58%
Trip 3	Pink	M16-XS191-02-052618	10,812	10,944	6%	9,827	M16-XS191-02-052618	1806235-5	4,800		77%
Trip 3	Pink	M17-XS55-01-052618	7,808	7,600	8%	7,195	M17-XS55-01-052618	1806235-6	4,300		58%
Trip 3	Pink	M17-XS83-01-052618	7,997	7,942	9%	7,236	M17-XS83-01-052618	1806235-7	5,000		46%
Trip 3	Pink	M17-XS83-02-052618	7,198	7,145	5%	6,796	M17-XS83-02-052618	1806235-8	4,400		48%
Trip 3	Pink	M18-XS155-01-052518	6,397	6,202	10%	5,888	M18-XS155-01-052518	1805632-5	2,900		75%
Trip 3	Pink	M18-XS161-01-052518	12,328	11,889	9%	10,955	M18-XS161-01-052518	1805632-6	6,200		66%
Trip 3	Pink	M19-XS22-02-052318	7,507	7,314	7%	7,032	M19-XS22-02-052318	1805632-8	4,900		42%
Trip 3	Pink	M19-XS22-01-052318	7,582	7,477	5%	7,256	M19-XS22-01-052318	1805632-7	4,800		45%
Trip 3	Pink	M19-XS43-01-052318	10,063	10,139	6%	9,295	M19-XS43-01-052318	1805632-9	4,900		69%
Trip 3	Pink	T21-XS55-02-052118	10,682	10,761	4%	9,979	T21-XS55-02-052118	1805589-16	6,200		53%
Trip 3	Pink	T22-XS64-01-052218	10,779	11,000	6%	9,732	T22-XS64-01-052218	1805632-11	5,600		63%
Trip 3	Pink	T23-XS23-01-052118	11,338	11,327	4%	10,765	T23-XS23-01-052118	1805589-19	6,700		51%
Trip 3	Pink	T23-XS40-01-052118	10,213	10,139	3%	9,921	T23-XS40-01-052118	1805589-20	6,000		52%
Trip 3	Pink	T24-XS48-01-052418	24,801	24,149	11%	22,670	T24-XS48-01-052418	1805632-12	16,000		43%
Trip 4	Pink	M13-XS72-01-060618	33,226	32,993.2	5%	31,081	M13-XS72-01-060618	1806235-1	17,000		65%
Trip 4	Pink	M20-XS5-01-060518	20,604	20,752.2	6%	19,102	M20-XS5-01-060518	1806235-20	8,800		80%
Trip 4	Pink	M20-XS11-01-060618	8,448	8,421.4	8%	7,566	M20-XS11-01-060618	1806235-9	4,000		71%
Trip 4	Pink	M20-XS18-01-060618	10,058	9,955.3	9%	8,835	M20-XS18-01-060618	1806235-12	4,400		78%
Trip 4	Pink	M20-XS86-01-060618	9,162	8,976.2	6%	8,774	M20-XS86-01-060618	1806235-21	5,900		43%
Trip 4	Pink	M20-XS130-01-060418	10,514	10,592.9	3%	10,011	M20-XS130-01-060418	1806235-10	4,600		78%
Trip 4	Pink	M20-XS166-01-060518	15,095	15,220.7	7%	13,601	M20-XS166-01-060518	1806235-11	6,700		77%
Trip 4	Pink	M20-XS185-01-060418	8,542	8,481.7	6%	8,082	M20-XS185-01-060418	1806235-13	4,200		68%
Trip 4	Pink	M20-XS231-01-060418	11,355	10,974.6	15%	9,613	M20-XS231-01-060418	1806235-14	5,200		74%
Trip 4	Pink	M20-XS278-01-060418	28,755	28,946.1	6%	25,812	M20-XS278-01-060418	1806235-15	11,000		89%
Trip 4	Pink	M20-XS306-01-060518	19,291	19,346.0	11%	16,661	M20-XS306-01-060518	1806235-16	7,500		88%
Trip 4	Pink	M20-XS312-01-060518	9,968	9,717.1	7%	9,130	M20-XS312-01-060518	1806235-17	5,100		65%
Trip 4	Pink	M20-XS365-01-060618	7,638	7,175.0	16%	6,577	M20-XS365-01-060618	1806235-18	3,800		67%
Trip 4	Pink	M20-XS365-02-060618	7,042	6,920.2	6%	6,600	M20-XS365-02-060618	1806235-19	3,600		65%
Trip 4	Pink	M21-XS14-01-060818	20,965	20,428.2	11%	18,804	M21-XS14-01-060818	1806234-3	9,400		76%
Trip 4	Pink	M21-XS27-01-060818	8,557	8,580.2	6%	7,657	M21-XS27-01-060818	1806234-7	4,600		60%
Trip 4	Pink	M21-XS27-02-060818	9,021	8,911.2	7%	8,284	M21-XS27-02-060818	1806234-8	4,800		61%
Trip 4	Pink	M21-XS40-01-060818	19,642	19,572.1	2%	19,161	M21-XS40-01-060818	1806234-15	10,000		65%
Trip 4	Pink	M21-XS46-01-060818	10,947	10,763.5	8%	10,306	M21-XS46-01-060818	1806234-18	5,000		75%
Trip 4	Pink	M21-XS122-01-060818	28,378	28,492.1	3%	27,140	M21-XS122-01-060818	1806234-1	12,000		81%
Trip 4	Pink	M21-XS126-01-060818	15,471	15,490.3	14%	13,045	M21-XS126-01-060818	1806234-2	6,900		77%
Trip 4	Pink	M21-XS175-01-060818	15,051	14,954.6	3%	14,513	M21-XS175-01-060818	1806234-4	7,800		63%
Trip 4	Pink	M21-XS225-01-060518	18,454	18,932.9	15%	13,687	M21-XS225-01-060518	1806235-22	8,600		73%
Trip 4	Pink	M21-XS259-01-060918	12,427	12,209.5	9%	11,341	M21-XS259-01-060918	1806234-5	6,900		57%
Trip 4	Pink	M21-XS260-01-060918	15,514	15,423.9	3%	15,088	M21-XS260-01-060918	1806234-6	7,300		72%
Trip 4	Pink	M21-XS282-01-060918	8,681	8,570.6	6%	8,177	M21-XS282-01-060918	1806234-9	5,100		52%
Trip 4	Pink	M21-XS290-01-060918	23,563	23,668.1	3%	22,608	M21-XS290-01-060918	1806234-10	12,000		65%
Trip 4	Pink	M21-XS292-01-060518	11,676	11,677.6	9%	9,819	M21-XS292-01-060518	1806235-23	5,600		70%
Trip 4	Pink	M21-XS302-02-060918	10,762	10,646.9	7%	9,950	M21-XS302-02-060918	1806234-12	5,300		68%
Trip 4	Pink	M21-XS302-01-060918	10,276	10,421.8	8%	8,913	M21-XS302-01-060918	1806234-11	5,500		61%
Trip 4	Pink	M21-XS334-01-060918	19,578	19,670.1	4%	18,376	M21-XS334-01-060918	1806234-13	8,400		80%
Trip 4	Pink	M21-XS377-01-060918	9,952	9,602.5	11%	9,304	M21-XS377-01-060918	1806234-14	4,700		72%
Trip 4	Pink	M21-XS403-01-060818	8,111	8,218.2	15%	6,050	M21-XS403-01-060818	1806234-16	4,200		64%
Trip 4	Pink	M21-XS419-01-060818	18,065	18,107.9	5%	16,805	M21-XS419-01-060818	1806234-17	10,000		57%
Trip 4	Pink	M21-XS477-01-060818	17,547	17,881.9	12%	13,825	M21-XS477-01-060818	1806234-19	7,000		86%
Trip 4	Pink	M21-XS541-01-060818	8,821	8,730.7	5%	8,290	M21-XS541-01-060818	1806234-20	4,100		73%
Trip 4	Pink	M21-XS596-01-060518	10,043	9,955.0	5%	9,395	M21-XS596-01-060518	1806235-24	4,800		71%
Trip 4	Pink	M21-XS615-01-060518	8,715	8,622.4	4%	8,212	M21-XS615-01-060518	1806235-25	5,300		49%
Trip 4	Pink	M21-XS619-01-060618	14,088	14,797.8	15%	11,131	M21-XS619-01-060618	1806235-26	8,600		48%
Trip 4	Pink	M22-XS14-01-060418	17,777	17,503.3	11%	15,325	M22-XS14-01-060418	1806235-27	7,800		78%
Trip 4	Pink	M22-XS30-01-060418	9,302	9,207.0	12%	8,179	M22-XS30-01-060418	1806235-28	5,200		57%
Trip 4	Pink	M22-XS40-01-060518	20,744	21,168.3	10%	17,178	M22-XS40-01-060518	1806235-29	9,700		73%
Trip 4	Pink	M22-XS60-01-060418	7,817	7,338.0	12%	7,071	M22-XS60-01-060418	1806235-30	5,100		42%
Trip 4	Pink	M22-XS87-01-060418	18,226	18,287.9	7%	16,645	M22-XS87-01-060418	1806235-31	8,300		75%
Trip 4	Pink	M23-XS20-01-061018	9,984	10,002.8	6%	8,989	M23-XS20-01-061018	1806233-3	5,100		65%
Trip 4	Pink	M23-XS48-01-061018	8,367	8,220.9	7%	7,932	M23-XS48-01-061018	1806233-4	4,500		60%
Trip 4	Pink	M23-XS54-01-061118	7,450	6,960.7	16%	6,516	M23-XS54-01-061118	1806312-1	5,700		27%
Trip 4	Pink	M23-XS64-01-061018	6,962	7,088.5	6%	6,375	M23-XS64-01-061018	1806233-5	4,100		52%

Data Included in Model FE-1											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M23-XS70-01-061018	9,881	10,161.3	7%	8,933	M23-XS70-01-061018	1806233-6	4,700		71%
Trip 4	Pink	M23-XS79-01-061018	10,505	10,469.9	5%	9,925	M23-XS79-01-061018	1806233-7	5,000		71%
Trip 4	Pink	M23-XS102-01-061018	17,584	18,273.3	10%	15,178	M23-XS102-01-061018	1806233-1	9,300		62%
Trip 4	Pink	M23-XS123-01-061018	7,495	7,459.6	5%	7,053	M23-XS123-01-061018	1806233-2	4,400		52%
Trip 4	Pink	M24-XS100-01-061118	9,023	9,081.9	13%	7,661	M24-XS100-01-061118	1806312-3	5,300		52%
Trip 4	Pink	M24-XS128-01-061118	15,345	15,280.2	5%	14,290	M24-XS128-01-061118	1806312-4	13,000		17%
Trip 4	Pink	T18-XS14-01-061118	9,947	10,033.5	7%	8,808	T18-XS14-01-061118	1806312-5	5,300		61%
Trip 4	Pink	T18-XS27-01-061118	2,839	2,788.4	11%	2,525	T18-XS27-01-061118	1806312-6	1,700		50%
Trip 4	Pink	T25-XS2-01-060618	11,533	11,639.3	5%	10,523	T25-XS2-01-060618	1806235-32	6,100		62%
Trip 4	Pink	T26-XS1-01-061018	9,878	9,666.9	8%	9,173	T26-XS1-01-061018	1806233-8	4,500		75%
Trip 4	Pink	T26-XS8-01-061018	9,489	9,531.6	9%	8,290	T26-XS8-01-061018	1806233-9	4,700		68%
Trip 4	Pink	T27-XS6-01-061018	8,998	9,094.3	4%	8,488	T27-XS6-01-061018	1806233-11	4,700		63%
Trip 4	Pink	T27-XS19-01-061018	7,612	7,415.6	9%	6,892	T27-XS19-01-061018	1806233-10	4,000		62%
Trip 5	Pink	M26-XS13-01-061818	5,080	4,981.8	6%	4,837	M26-XS13-01-061818	1806558-1	3,100		48%
Trip 5	Pink	M26-XS25-01-061818	7,830	7,835.5	6%	7,201	M26-XS25-01-061818	1806558-2	6,100		25%
Trip 5	Pink	M27-XS21-01-061918	12,335	11,225.9	24%	9,510	M27-XS21-01-061918	1806558-10	9,400		27%
Trip 5	Pink	M27-XS29-01-061818	8,668	8,398.2	9%	7,862	M27-XS29-01-061818	1806558-14	6,500		29%
Trip 5	Pink	M27-XS38-01-061918	7,969	7,887.5	6%	7,377	M27-XS38-01-061918	1806558-15	5,400		38%
Trip 5	Pink	M27-XS108-01-061918	10,781	10,966.1	5%	9,694	M27-XS108-01-061918	1806558-3	6,900		44%
Trip 5	Pink	M27-XS109-01-061918	9,743	9,694.1	6%	9,206	M27-XS109-01-061918	1806558-4	6,700		37%
Trip 5	Pink	M27-XS123-01-061818	6,343	6,418.3	6%	5,828	M27-XS123-01-061818	1806558-5	5,300		18%
Trip 5	Pink	M27-XS188-01-061918	11,380	11,138.2	5%	10,850	M27-XS188-01-061918	1806558-6	7,800		37%
Trip 5	Pink	M27-XS197-01-061918	8,683	8,435.9	7%	8,061	M27-XS197-01-061918	1806558-7	6,400		30%
Trip 5	Pink	M27-XS210-02-061818	8,189	8,260.7	4%	7,518	M27-XS210-02-061818	1806558-9	5,100		46%
Trip 5	Pink	M27-XS210-01-061818	7,115	7,154.8	7%	6,518	M27-XS210-01-061818	1806558-8	5,800		20%
Trip 5	Pink	M27-XS239-01-061818	4,082	4,184.0	10%	3,404	M27-XS239-01-061818	1806558-11	3,200		24%
Trip 5	Pink	M27-XS275-01-061918	10,408	10,135.1	11%	9,436	M27-XS275-01-061918	1806558-12	7,900		27%
Trip 5	Pink	M27-XS283-01-061818	10,687	10,188.9	14%	9,118	M27-XS283-01-061818	1806558-13	8,700		20%
Trip 5	Pink	M28-XS8-01-062018	5,891	5,827.3	4%	5,595	M28-XS8-01-062018	1806558-21	3,700		46%
Trip 5	Pink	M28-XS43-01-062018	7,299	7,311.8	8%	6,305	M28-XS43-01-062018	1806558-20	6,800		7%
Trip 5	Pink	M28-XS105-01-062018	9,265	9,371.3	6%	8,393	M28-XS105-01-062018	1806558-16	5,400		53%
Trip 5	Pink	M28-XS148-01-062018	13,304	12,854.9	14%	11,430	M28-XS148-01-062018	1806558-17	8,800		41%
Trip 5	Pink	M28-XS155-01-062018	8,604	8,630.0	17%	6,539	M28-XS155-01-062018	1806558-18	5,300		48%
Trip 5	Pink	M28-XS170-01-062018	24,801	24,271.0	15%	20,326	M28-XS170-01-062018	1806558-19	15,000		49%
Trip 5	Pink	M30-XS138-01-062218	10,648	10,792.4	7%	9,428	M30-XS138-01-062218	1806693-1	7,300		37%
Trip 5	Pink	M30-XS222-01-062218	14,078	13,763.2	7%	13,186	M30-XS222-01-062218	1806693-2	8,400		51%
Trip 5	Pink	T32-XS5-01-062018	6,140	6,044.6	5%	5,825	T32-XS5-01-062018	1806558-22	4,000		42%
Trip 6	Orange	M10-XS10A-01-071118	9,886	9,794.3	7%	9,067	M10-XS10A-01-071118	1807369-1	5,400		59%
Trip 6	Orange	M10-XS31-01-071118	8,641	8,455.9	11%	7,752	M10-XS31-01-071118	1807369-2	4,500		63%
Trip 6	Orange	M10-XS31-02-071118	8,218	8,201.8	3%	7,793	M10-XS31-02-071118	1807369-3	4,600		56%
Trip 6	Orange	M11-XS11-01-071118	7,973	7,924.8	4%	7,505	M11-XS11-01-071118	1807369-4	7,000		13%
Trip 6	Red	M11-XS7-01-071118	9,090	8,996.0	3%	8,919	M11-XS7-01-071118	1807369-5	6,200		38%
Trip 6	Red	M12-XS27-01-071518	3,765	3,710.8	7%	3,480	M12-XS27-01-071518	1807369-6	1,700		76%
Trip 6	Orange	M24-XS115-01-071418	23,964	23,968.2	9%	21,553	M24-XS115-01-071418	1807369-7	20,000		18%
Trip 6	Red	M25-XS16-01-071718	8,147	8,279.6	6%	7,345	M25-XS16-01-071718	1807452-1	5,900		32%
Trip 6	Red	M25-XS23-01-071718	11,003	10,406.2	20%	9,002	M25-XS23-01-071718	1807452-2	5,300		70%
Trip 6	Red	M25-XS47-01-071718	7,762	7,414.0	13%	6,752	M25-XS47-01-071718	1807452-3	4,800		47%
Trip 6	Red	M25-XS88-01-071718	8,472	8,596.1	6%	7,698	M25-XS88-01-071718	1807452-4	4,700		57%
Trip 6	Orange	M30-XS127-01-071618	3,464	3,503.1	7%	3,153	M30-XS127-01-071618	1807369-9	3,100		11%
Trip 6	Orange	M30-XS170-01-071618	8,010	8,072.1	9%	6,980	M30-XS170-01-071618	1807369-10	5,500		37%
Trip 6	Red	M30-XS95-01-071618	8,954	9,085.0	6%	8,103	M30-XS95-01-071618	1807369-11	7,200		22%
Trip 6	Red	M31-XS9-01-071018	7,844	7,711.3	9%	7,116	M31-XS9-01-071018	1807369-12	3,800		69%
Trip 6	Orange	M32-XS58-01-071018	7,756	7,700.1	13%	6,589	M32-XS58-01-071018	1807369-13	4,600		51%
Trip 6	Red	M32-XS89-01-071018	14,087	15,055.7	16%	11,106	M32-XS89-01-071018	1807369-14	7,400		62%
Trip 6	Orange	M33-XS22-01-071218	11,015	10,465.1	12%	9,857	M33-XS22-01-071218	1807369-15	7,500		38%
Trip 6	Orange	M33-XS85-01-071218	9,253	9,218.5	5%	8,548	M33-XS85-01-071218	1807369-16	7,800		17%
Trip 6	Red	M33-XS93-01-071218	11,040	11,171.1	5%	10,377	M33-XS93-01-071218	1807369-17	6,900		46%
Trip 6	Red	T33-XS43-01-071718	21,394	21,035.4	7%	20,177	T33-XS43-01-071718	1807452-5	11,000		64%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

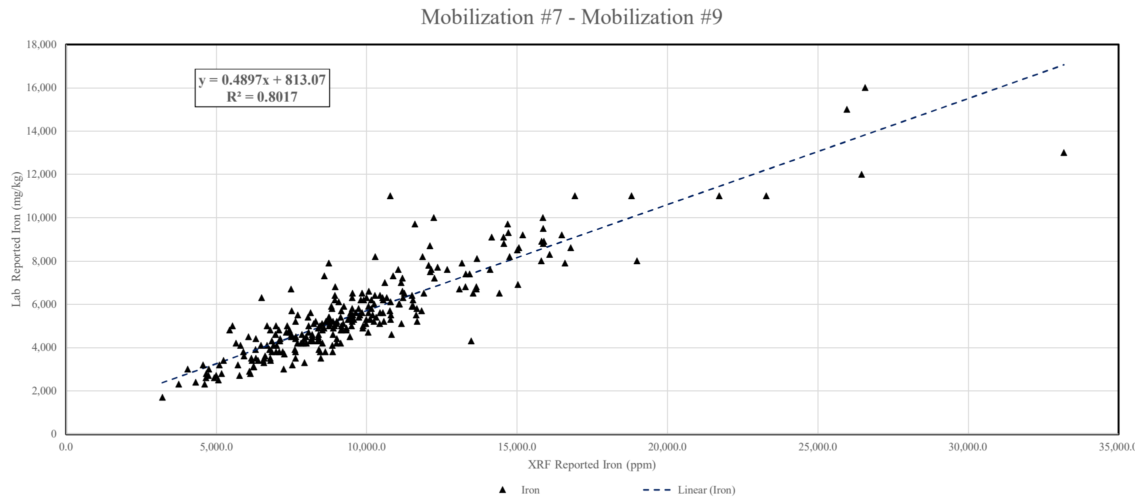
mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Instrument Setting											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Blue	M15-XS73-01-052118	1,660	1,658	2%	1,608	M15-XS73-01-052118	1805589-5	6,800		122%
Trip 3	Blue	M16-XS45-01-052118	1,832	1,817	9%	1,676	M16-XS45-01-052118	1805589-13	7,100		118%
Trip 3	Blue	M16-XS166-01-052118	1,359	1,362	1%	1,333	M16-XS166-01-052118	1805589-9	6,700		133%
Trip 3	Blue	T20-XS14-01-052218	1,211	1,203	2%	1,189	T20-XS14-01-052218	1805632-10	4,300		112%
Trip 3	Blue	T21-XS6-01-052118	3,938	1,181	171%	1,170	T21-XS6-01-052118	1805589-17	4,400		11%
Trip 3	Blue	T21-XS35-01-052118	1,231	1,223	2%	1,202	T21-XS35-01-052118	1805589-14	5,900		131%
Trip 3	Blue	T21-XS55-01-052118	1,222	1,220	2%	1,203	T21-XS55-01-052118	1805589-15	6,000		132%
Trip 3	Blue	T22-XS17-01-052118	1,416	1,414	2%	1,387	T22-XS17-01-052118	1805589-18	6,200		126%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence



Data Included											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M10-XS22-01-082118	8,200.9	8,075.7	10%	7,302	M10-XS22-01-082118	1808494-1	4,300	J	62%
Trip 7	Red	M10-XS39-01-082118	8,744.0	8,852.3	6%	7,781	M10-XS39-01-082118	1808494-2	5,000		54%
Trip 7	Red	M10-XS43-01-082118	8,178.4	7,913.5	15%	7,238	M10-XS43-01-082118	1808494-3	4,600		56%
Trip 7	Red	M1-XSG2-01-081918	10,429.8	10,274.5	3%	10,162	M1-XSG2-01-081918	1808483-1	5,100		69%
Trip 7	Pink	M34-XS110-01-081218	9,875.7	9,342.9	16%	8,346	M34-XS110-01-081218	1808303-1	5,000		66%
Trip 7	Pink	M34-XS22-01-081218	10,763.9	10,793.0	5%	9,871	M34-XS22-01-081218	1808303-2	5,700		62%
Trip 7	Pink	M34-XS43-01-081218	9,317.4	9,309.3	5%	8,696	M34-XS43-01-081218	1808303-3	4,900		62%
Trip 7	Pink	M34-XS50-01-081218	16,078.3	16,370.7	8%	13,672	M34-XS50-01-081218	1808303-4	8,300		64%
Trip 7	Pink	M34-XS68-01-081218	23,277.9	24,251.8	9%	20,013	M34-XS68-01-081218	1808303-5	11,000		72%
Trip 7	Pink	M35-XS11-01-081218	33,181.4	33,999.7	20%	24,085	M35-XS11-01-081218	1808303-6	13,000		87%
Trip 7	Pink	M35-XS20-01-081318	21,715.0	21,832.1	7%	19,896	M35-XS20-01-081318	1808303-7	11,000		66%
Trip 7	Pink	M35-XS31-01-081218	13,641.3	13,488.0	5%	12,926	M35-XS31-01-081218	1808303-8	6,700		68%
Trip 7	Pink	M35-XS63-01-081218	7,257.7	7,254.8	8%	6,402	M35-XS63-01-081218	1808303-9	3,700		65%
Trip 7	Pink	M35-XS74-01-081318	6,304.4	6,297.9	7%	5,755	M35-XS74-01-081318	1808303-10	4,400		36%
Trip 7	Pink	M35-XS74-02-081318	6,550.5	6,444.3	6%	6,098	M35-XS74-02-081318	1808303-11	3,400		63%
Trip 7	Pink	M36-XS20-01-081218	8,444.7	8,247.0	11%	7,505	M36-XS20-01-081218	1808303-12	3,800		76%
Trip 7	Pink	M36-XS2-01-081218	10,821.2	10,409.1	16%	9,521	M36-XS2-01-081218	1808303-13	4,600	J	81%
Trip 7	Pink	M36-XS3-01-081218	5,100.0	4,981.0	13%	4,441	M36-XS3-01-081218	1808303-14	3,200		46%
Trip 7	Pink	M36-XS31-01-081218	11,531.6	11,168.4	10%	10,170	M36-XS31-01-081218	1808303-15	6,200		60%
Trip 7	Pink	M37-XS124A-01-081318	15,869.6	16,125.7	6%	14,524	M37-XS124A-01-081318	1808303-16	9,500		50%
Trip 7	Pink	M37-XS144-01-081318	14,749.4	14,296.4	11%	13,159	M37-XS144-01-081318	1808303-17	8,200		57%
Trip 7	Pink	M37-XS2-01-081318	15,061.3	15,843.6	11%	11,887	M37-XS2-01-081318	1808303-18	8,600		55%
Trip 7	Pink	M37-XS23-01-081318	7,624.8	7,362.1	8%	7,071	M37-XS23-01-081318	1808303-19	4,400		54%
Trip 7	Pink	M37-XS31-01-081318	3,745.8	3,686.1	8%	3,377	M37-XS31-01-081318	1808303-20	2,300		48%
Trip 7	Pink	M37-XS38-01-081318	7,423.2	7,220.7	11%	6,610	M37-XS38-01-081318	1808356-1	4,800		43%
Trip 7	Pink	M37-XS44-01-081318	11,146.2	11,138.5	9%	10,010	M37-XS44-01-081318	1808356-2	5,100		74%
Trip 7	Pink	M37-XS50-01-081318	15,186.0	15,233.6	10%	13,060	M37-XS50-01-081318	1808356-3	9,200		49%
Trip 7	Pink	M37-XS7-01-081318	15,861.4	15,446.9	10%	13,878	M37-XS7-01-081318	1808356-4	8,800		57%
Trip 7	Red	M38-XS20-01-081818	10,442.1	10,161.8	10%	9,270	M38-XS20-01-081818	1808483-2	5,600		60%
Trip 7	Red	M3-XS19-01-081718	6,840.5	6,864.0	10%	5,993	M3-XS19-01-081718	1808476-1	4,300		46%
Trip 7	Red	M3-XS41-01-081718	8,767.0	8,632.5	14%	7,570	M3-XS41-01-081718	1808476-2	5,100		53%
Trip 7	Red	M4-XS210-01-081818	4,605.2	4,557.5	5%	4,289	M4-XS210-01-081818	1808483-3	2,300		67%
Trip 7	Red	M4-XSG11-01-081818	5,762.3	5,553.7	9%	5,421	M4-XSG11-01-081818	1808483-4	2,700		72%
Trip 7	Red	M4-XSG2-01-081818	6,245.4	6,280.4	8%	5,490	M4-XSG2-01-081818	1808483-5	3,100		67%
Trip 7	Red	M5-XS131-01-082018	7,488.7	7,366.8	5%	7,003	M5-XS131-01-082018	1808487-1	4,500		50%
Trip 7	Red	M5-XS15-01-081818	5,170.6	4,960.9	11%	4,670	M5-XS15-01-081818	1808483-6	2,800		59%
Trip 7	Red	M5-XS192-01-081818	14,093.8	13,827.8	6%	12,945	M5-XS192-01-081818	1808483-7	7,600		60%
Trip 7	Red	M5-XS199-01-082018	6,891.4	6,938.2	7%	6,232	M5-XS199-01-082018	1808487-2	4,100		51%
Trip 7	Red	M5-XS207A-01-082018	6,505.0	6,631.8	10%	5,410	M5-XS207A-01-082018	1808487-3	6,300		3%
Trip 7	Red	M5-XS261-01-082018	7,316.1	7,301.3	7%	6,684	M5-XS261-01-082018	1808487-4	4,700		44%
Trip 7	Red	M5-XS263-01-082018	6,681.5	6,540.9	15%	5,534	M5-XS263-01-082018	1808487-5	5,000		29%
Trip 7	Red	M5-XS305-01-082018	6,764.0	6,627.1	8%	6,099	M5-XS305-01-082018	1808487-6	3,900		54%
Trip 7	Red	M5-XS476-01-082018	9,515.1	9,458.7	4%	9,118	M5-XS476-01-082018	1808487-7	5,200		59%
Trip 7	Red	M5-XS488-01-082018	9,633.7	9,699.4	7%	8,554	M5-XS488-01-082018	1808487-8	5,600		53%
Trip 7	Red	M6-XS108-01-081618	9,514.6	9,134.5	13%	8,660	M6-XS108-01-081618	1808476-3	5,800		49%
Trip 7	Red	M6-XS108-02-081618	8,952.9	9,055.1	5%	8,178	M6-XS108-02-081618	1808476-4	6,800		27%

Data Included											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M6-XS198-01-081618	11,896.4	12,004.5	12%	10,324	M6-XS198-01-081618	1808476-5	6,500		59%
Trip 7	Red	M6-XS249-01-081618	11,640.4	10,971.2	25%	8,840	M6-XS249-01-081618	1808476-6	5,500		72%
Trip 7	Red	M6-XS289-01-081618	7,691.3	7,636.8	7%	7,020	M6-XS289-01-081618	1808476-7	4,200		59%
Trip 7	Red	M6-XS324-01-081618	8,387.7	8,459.3	11%	7,179	M6-XS324-01-081618	1808476-8	4,900		52%
Trip 7	Red	M6-XS60-01-081618	7,117.5	7,077.4	4%	6,738	M6-XS60-01-081618	1808476-9	4,400		47%
Trip 7	Red	M6-XS72-01-081618	8,640.7	8,299.8	10%	7,964	M6-XS72-01-081618	1808476-10	5,200		50%
Trip 7	Pink	M7-XS162A-01-081518	12,102.7	11,826.5	21%	9,219	M7-XS162A-01-081518	1808356-5	8,700		33%
Trip 7	Pink	M7-XS203-01-081418	12,673.5	12,655.7	9%	11,467	M7-XS203-01-081418	1808356-6	7,600		50%
Trip 7	Pink	M7-XS213-01-081518	8,039.8	8,044.6	15%	6,596	M7-XS213-01-081518	1808356-7	5,400		39%
Trip 7	Pink	M7-XS214-01-081518	8,735.2	8,755.6	2%	8,402	M7-XS214-01-081518	1808356-8	5,400		47%
Trip 7	Pink	M7-XS235A-01-081418	14,148.5	13,921.3	7%	13,234	M7-XS235A-01-081418	1808356-9	9,100		43%
Trip 7	Pink	M7-XS244-01-081518	8,997.6	8,942.4	7%	8,327	M7-XS244-01-081518	1808356-10	5,200		53%
Trip 7	Pink	M8-XS55-01-081418	13,474.8	12,586.7	13%	11,992	M8-XS55-01-081418	1808356-20	4,300		103%
Trip 7	Red	M8-XS83-01-081418	8,820.7	8,987.0	6%	8,167	M8-XS83-01-081418	1808476-12	5,900		40%
Trip 7	Pink	M8-XSG16-01-081518	8,231.3	8,333.3	6%	7,202	M8-XSG16-01-081518	1808356-11	5,100		47%
Trip 7	Pink	M8-XSG28-01-081418	10,150.0	10,298.1	5%	9,250	M8-XSG28-01-081418	1808356-12	6,200		48%
Trip 7	Pink	M8-XSG31-01-081518	9,795.3	9,454.6	7%	9,262	M8-XSG31-01-081518	1808356-13	6,200		45%
Trip 7	Pink	M8-XSG37-01-081418	11,242.4	11,018.7	7%	10,422	M8-XSG37-01-081418	1808356-14	6,500		53%
Trip 7	Pink	M8-XSG40-01-081418	8,931.8	8,700.3	6%	8,525	M8-XSG40-01-081418	1808356-15	6,400		33%
Trip 7	Pink	M8-XSG4-01-081518	10,526.3	10,629.6	6%	9,404	M8-XSG4-01-081518	1808356-16	6,300		50%
Trip 7	Pink	M8-XSG44-01-081418	9,493.1	8,667.9	19%	7,793	M8-XSG44-01-081418	1808356-17	5,000		62%
Trip 7	Pink	M8-XSG44-02-081418	9,863.4	9,975.6	15%	8,177	M8-XSG44-02-081418	1808356-18	4,900		67%
Trip 7	Pink	M8-XSG47-01-081418	13,077.7	13,184.2	14%	10,653	M8-XSG47-01-081418	1808356-19	6,700		64%
Trip 7	Red	M8-XSG6-01-081518	10,543.7	10,433.6	8%	9,683	M8-XSG6-01-081518	1808476-11	6,200		52%
Trip 7	Red	M9-XS19A-01-081718	4,554.1	4,508.2	12%	3,860	M9-XS19A-01-081718	1808483-8	3,200		35%
Trip 7	Red	M9-XS28A-01-081718	10,281.9	9,486.0	16%	8,814	M9-XS28A-01-081718	1808483-9	8,200		23%
Trip 7	Red	T10-XSG1-01-081818	9,215.3	9,302.9	8%	8,317	T10-XSG1-01-081818	1808483-10	5,100		57%
Trip 7	Red	T13-XSG16-01-081618	8,740.8	8,531.4	11%	7,761	T13-XSG16-01-081618	1808476-13	5,400		47%
Trip 7	Red	T13-XSG26-01-081618	11,179.9	11,126.4	3%	10,839	T13-XSG26-01-081618	1808476-14	7,200		43%
Trip 7	Red	T13-XSG7-01-081618	9,729.1	9,586.2	6%	9,086	T13-XSG7-01-081618	1808476-15	5,800		51%
Trip 7	Red	T15-XS20-01-081718	5,918.0	5,959.4	11%	5,095	T15-XS20-01-081718	1808483-11	3,600		49%
Trip 7	Red	T15-XSG5-01-081718	10,095.2	9,895.2	6%	9,495	T15-XSG5-01-081718	1808483-12	5,300		62%
Trip 7	Red	T17-XSG17-01-081618	7,706.2	7,507.0	7%	7,277	T17-XSG17-01-081618	1808476-16	5,500		33%
Trip 7	Red	T17-XSG27-01-081618	9,508.9	9,590.3	8%	8,466	T17-XSG27-01-081618	1808476-17	6,300		41%
Trip 7	Red	T17-XSG31-01-081518	7,434.8	7,505.3	10%	6,521	T17-XSG31-01-081518	1808476-18	4,700		45%
Trip 7	Red	T17-XSG7-01-081618	10,441.0	10,315.2	8%	9,685	T17-XSG7-01-081618	1808476-19	6,400		48%
Trip 7	Red	T17-XSG7-02-081618	10,788.7	10,644.6	4%	10,264	T17-XSG7-02-081618	1808476-20	6,100		56%
Trip 7	Red	T1-XSG38-01-081918	8,433.4	8,420.3	6%	7,839	T1-XSG38-01-081918	1808483-13	5,000		51%
Trip 7	Red	T1-XSG49A-01-081918	7,636.7	7,286.9	12%	6,970	T1-XSG49A-01-081918	1808483-14	4,500		52%
Trip 7	Red	T4-XS15A-01-081918	25,963.7	26,443.1	11%	21,816	T4-XS15A-01-081918	1808487-9	15,000		54%
Trip 7	Red	T4-XSG10-01-081918	5,228.9	5,224.0	8%	4,765	T4-XSG10-01-081918	1808483-16	3,400		42%
Trip 7	Red	T4-XSG39-01-081918	4,929.7	4,839.8	6%	4,679	T4-XSG39-01-081918	1808483-17	2,600		62%
Trip 7	Red	T4-XSG50A-01-081918	26,454.4	27,098.2	9%	23,067	T4-XSG50A-01-081918	1808483-18	12,000		75%
Trip 7	Red	T5-XSG10-01-081918	12,107.9	11,913.3	6%	11,518	T5-XSG10-01-081918	1808483-19	7,500		47%
Trip 7	Red	T6-XSG6-01-081918	4,662.3	4,522.2	8%	4,407	T6-XSG6-01-081918	1808487-10	2,800		50%
Trip 7	Red	T6-XSG6-02-081918	4,734.7	4,665.9	8%	4,332	T6-XSG6-02-081918	1808487-11	2,700		55%
Trip 7	Red	T9-XSG12-01-081818	11,504.1	11,452.8	4%	10,898	T9-XSG12-01-081818	1808483-20	6,400		57%
Trip 8	Red	M13-XS112-01-091518	7,631.7	7,141.4	20%	6,247	M13-XS112-01-091518	1809475-1	5,200		38%
Trip 8	Red	M13-XS258-01-091518	4,984.1	4,738.7	16%	4,418	M13-XS258-01-091518	1809475-2	2,700		59%
Trip 8	Red	M14-XS62-01-091818	6,590.3	6,520.9	6%	6,063	M14-XS62-01-091818	1809475-21	3,500		61%
Trip 8	Red	M14-XSG14A-01-091818	6,307.3	6,275.9	9%	5,510	M14-XSG14A-01-091818	1809475-22	3,500		57%
Trip 8	Red	M14-XSG27A-01-091818	7,895.3	7,983.9	5%	7,120	M14-XSG27A-01-091818	1809475-23	4,200		61%
Trip 8	Red	M14-XSG41-01-091818	13,537.1	13,437.1	8%	12,028	M14-XSG41-01-091818	1809475-24	6,500		70%
Trip 8	Red	M14-XSG49-01-091818	11,067.5	11,050.6	3%	10,591	M14-XSG49-01-091818	1809475-25	6,000		59%
Trip 8	Red	M14-XSG58-01-091818	15,888.1	15,338.5	14%	13,728	M14-XSG58-01-091818	1809475-26	8,900		56%
Trip 8	Red	M14-XSG6-01-091818	8,875.5	8,770.0	2%	8,719	M14-XSG6-01-091818	1809475-27	5,200		52%
Trip 8	Red	M15-XSG20-01-091118	10,062.1	9,835.9	8%	9,551	M15-XSG20-01-091118	1809473-20	6,600		42%
Trip 8	Red	M15-XSG2-01-091118	9,142.2	9,085.9	4%	8,654	M15-XSG2-01-091118	1809473-21	4,800		62%
Trip 8	Red	M16-XSG13-01-091118	15,850.5	15,785.9	7%	14,656	M16-XSG13-01-091118	1809473-22	10,000		45%
Trip 8	Red	M16-XSG30-01-091518	5,715.5	5,722.9	10%	4,967	M16-XSG30-01-091518	1809475-3	3,200		56%
Trip 8	Red	M16-XSG38-01-091518	3,197.1	3,204.0	11%	2,713	M16-XSG38-01-091518	1809475-4	1,700		61%
Trip 8	Red	M17-XS79-01-091318	8,194.5	8,043.4	6%	7,682	M17-XS79-01-091318	1809473-1	4,500		58%
Trip 8	Red	M17-XSG1-01-091318	13,422.6	13,024.3	11%	11,838	M17-XSG1-01-091318	1809473-2	7,400		58%
Trip 8	Red	M17-XSG27-01-091318	7,805.2	7,987.1	6%	6,845	M17-XSG27-01-091318	1809473-3	4,200		60%
Trip 8	Red	M17-XSG36-01-091318	6,182.9	6,132.1	5%	5,743	M17-XSG36-01-091318	1809473-4	3,400		58%
Trip 8	Red	M17-XSG36-02-091318	6,157.7	6,151.9	5%	5,779	M17-XSG36-02-091318	1809473-5	3,500		55%
Trip 8	Red	M18-XSG16-01-091318	9,561.0	9,429.6	8%	8,741	M18-XSG16-01-091318	1809473-6	5,300		57%
Trip 8	Red	M18-XSG30-01-091318	9,838.5	9,565.5	12%	8,389	M18-XSG30-01-091318	1809473-7	6,500		41%
Trip 8	Red	M18-XSG32-01-091318	9,423.8	9,352.6	7%	8,501	M18-XSG32-01-091318	1809473-8	5,300		56%
Trip 8	Red	M19-XSG11-01-091318	11,548.2	11,562.4	4%	10,638	M19-XSG11-01-091318	1809473-9	5,900		65%

Data Included											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M19-XSG19-01-091318	8,782.6	8,473.2	21%	6,973	M19-XSG19-01-091318	1809473-10	5,300		49%
Trip 8	Red	M19-XSG25-01-091318	10,193.2	10,096.2	5%	9,564	M19-XSG25-01-091318	1809473-11	5,500		60%
Trip 8	Red	M19-XSG29-01-091318	8,121.1	8,198.0	9%	6,950	M19-XSG29-01-091318	1809473-12	4,300		62%
Trip 8	Red	M19-XSG39-01-091318	9,154.6	9,167.2	6%	8,441	M19-XSG39-01-091318	1809473-13	5,000		59%
Trip 8	Red	M19-XSG43-01-091318	9,440.9	9,256.3	13%	7,712	M19-XSG43-01-091318	1809473-14	4,500		71%
Trip 8	Red	M20-XS146-01-091718	5,433.1	5,137.9	14%	4,517	M20-XS146-01-091718	1809475-28	4,800		12%
Trip 8	Red	M20-XS243-01-091718	6,060.4	6,094.4	8%	5,295	M20-XS243-01-091718	1809475-29	4,500		30%
Trip 8	Red	M20-XS247-01-091718	8,865.5	8,742.4	6%	8,318	M20-XS247-01-091718	1809475-30	3,800		80%
Trip 8	Red	M20-XS267-01-091718	7,496.3	7,461.9	14%	6,094	M20-XS267-01-091718	1809475-31	5,700		27%
Trip 8	Red	M20-XS271-01-091718	6,613.3	6,641.7	5%	6,157	M20-XS271-01-091718	1809475-32	3,600		59%
Trip 8	Red	M20-XS30-01-091718	9,006.0	9,142.9	7%	8,162	M20-XS30-01-091718	1809475-33	4,400		69%
Trip 8	Red	M20-XS335-01-091418	7,624.9	7,714.2	10%	6,557	M20-XS335-01-091418	1809475-5	3,800		67%
Trip 8	Red	M20-XS422-01-091418	10,533.7	10,203.7	14%	9,272	M20-XS422-01-091418	1809475-6	5,600		61%
Trip 8	Red	M20-XS58-01-091718	9,181.6	9,109.9	5%	8,554	M20-XS58-01-091718	1809475-34	4,800		63%
Trip 8	Red	M20-XS60-01-091718	10,569.3	10,694.7	7%	9,658	M20-XS60-01-091718	1809475-35	5,200		68%
Trip 8	Red	M20-XSG15-01-091418	13,157.8	13,074.2	5%	12,111	M20-XSG15-01-091418	1809475-7	7,900		50%
Trip 8	Red	M20-XSG28-01-091418	9,967.6	9,764.7	11%	9,002	M20-XSG28-01-091418	1809475-8	5,100		65%
Trip 8	Red	M20-XSG7-01-091418	5,888.5	5,846.5	4%	5,583	M20-XSG7-01-091418	1809475-9	3,800		43%
Trip 8	Red	M21-XS1-01-091218	10,877.0	10,668.4	12%	9,435	M21-XS1-01-091218	1809473-24	7,300		39%
Trip 8	Red	M21-XS317-01-091218	11,507.1	11,871.2	11%	9,933	M21-XS317-01-091218	1809473-25	5,900		64%
Trip 8	Red	M21-XS323-01-091218	10,053.6	9,796.2	11%	8,824	M21-XS323-01-091218	1809473-26	5,600		57%
Trip 8	Red	M21-XS366-01-091418	5,644.9	5,606.4	11%	4,752	M21-XS366-01-091418	1809475-10	4,200		29%
Trip 8	Red	M21-XS366-02-091418	5,802.8	5,747.5	6%	5,471	M21-XS366-02-091418	1809475-11	4,100		34%
Trip 8	Red	M21-XS465-01-091218	12,141.2	12,034.4	9%	10,930	M21-XS465-01-091218	1809473-27	7,600		46%
Trip 8	Red	M21-XS503-01-091218	6,676.4	6,682.4	6%	6,203	M21-XS503-01-091218	1809473-28	4,100		48%
Trip 8	Red	M21-XS511-01-091218	9,132.0	9,187.4	8%	7,881	M21-XS511-01-091218	1809473-29	5,400		51%
Trip 8	Red	M21-XS536-01-091218	16,487.6	16,531.0	9%	14,533	M21-XS536-01-091218	1809473-30	9,200		57%
Trip 8	Red	M21-XSG16-01-091218	16,585.3	16,462.2	10%	14,094	M21-XSG16-01-091218	1809473-31	7,900		71%
Trip 8	Red	M21-XSG38-01-091418	14,999.6	14,584.8	8%	13,895	M21-XSG38-01-091418	1809475-12	8,500		55%
Trip 8	Red	M21-XSG43-01-091418	6,294.0	6,219.0	8%	5,750	M21-XSG43-01-091418	1809475-13	3,900		47%
Trip 8	Red	M21-XSG7-01-091218	7,491.7	7,336.8	6%	6,989	M21-XSG7-01-091218	1809473-32	4,600		48%
Trip 8	Red	M22-XS112-01-091418	9,837.4	9,509.5	8%	9,297	M22-XS112-01-091418	1809475-14	5,600		55%
Trip 8	Red	M22-XS115-01-091418	11,084.8	11,487.5	6%	9,992	M22-XS115-01-091418	1809475-15	6,000		60%
Trip 8	Red	M22-XS121-01-091418	10,118.8	9,913.5	7%	9,557	M22-XS121-01-091418	1809475-16	5,300		63%
Trip 8	Red	M22-XS94-01-091418	8,403.5	8,279.1	7%	7,671	M22-XS94-01-091418	1809475-17	3,900		73%
Trip 8	Red	M23-XSG1-01-091418	10,596.2	10,498.2	11%	9,392	M23-XSG1-01-091418	1809475-18	7,000		41%
Trip 8	Red	M23-XSG20-01-091418	10,311.2	10,143.7	8%	9,262	M23-XSG20-01-091418	1809475-19	5,400		63%
Trip 8	Red	M23-XSG5-01-091418	8,392.3	8,302.2	6%	7,756	M23-XSG5-01-091418	1809475-20	4,600		58%
Trip 8	Red	M6-XS164-01-091118	4,310.5	4,202.1	11%	3,771	M6-XS164-01-091118	1809473-33	2,400		57%
Trip 8	Red	M6-XS224-01-091118	11,855.8	11,713.4	8%	10,705	M6-XS224-01-091118	1809473-34	8,200		36%
Trip 8	Red	M6-XS353A-01-091618	14,702.6	14,294.9	12%	12,956	M6-XS353A-01-091618	1809475-36	9,300		45%
Trip 8	Red	M6-XS369-01-091618	6,126.4	6,158.5	9%	5,492	M6-XS369-01-091618	1809475-37	2,800		75%
Trip 8	Red	M6-XS52-01-091118	8,888.0	8,925.5	3%	8,368	M6-XS52-01-091118	1809473-35	4,900		58%
Trip 8	Red	M6-XSG13A-01-091618	12,058.0	11,961.7	4%	11,421	M6-XSG13A-01-091618	1809475-38	7,800		43%
Trip 8	Red	M6-XSG22-01-091618	8,360.5	8,349.1	4%	7,988	M6-XSG22-01-091618	1809475-39	4,300		64%
Trip 8	Red	M7-XSG34-01-091618	10,045.3	10,202.9	4%	9,280	M7-XSG34-01-091618	1809475-40	4,700		73%
Trip 8	Red	M7-XSG41-01-091618	7,610.5	7,510.4	8%	6,911	M7-XSG41-01-091618	1809475-41	3,900		64%
Trip 8	Red	T18-XSG7-01-091518	8,621.6	8,667.5	7%	7,690	T18-XSG7-01-091518	1809475-42	3,800		78%
Trip 8	Red	T19-XS9-01-091118	9,063.9	9,085.8	5%	8,584	T19-XS9-01-091118	1809473-36	6,100		39%
Trip 8	Red	T20-XSG3-01-091118	9,316.9	9,131.1	6%	8,697	T20-XSG3-01-091118	1809473-37	4,800		64%
Trip 8	Red	T21-XSG13-01-091118	10,267.6	10,261.3	7%	9,506	T21-XSG13-01-091118	1809473-38	6,400		46%
Trip 8	Red	T21-XSG26-01-091118	8,506.8	8,165.9	10%	7,974	T21-XSG26-01-091118	1809473-39	5,100		50%
Trip 8	Red	T22-XS20-01-091118	8,123.5	8,004.8	4%	7,803	T22-XS20-01-091118	1809473-15	5,600		37%
Trip 8	Red	T23-XSG26-01-091118	7,975.6	7,537.8	16%	6,631	T23-XSG26-01-091118	1809473-16	4,500		56%
Trip 8	Red	T23-XSG7-01-091118	9,985.8	9,974.4	5%	9,080	T23-XSG7-01-091118	1809473-17	6,300		45%
Trip 8	Red	T24-XSG2-01-091118	8,297.3	8,503.4	8%	7,520	T24-XSG2-01-091118	1809473-18	5,200		46%
Trip 8	Red	T24-XSG26-01-091118	5,533.9	5,537.5	6%	5,027	T24-XSG26-01-091118	1809473-19	5,000		10%
Trip 8	Red	T26-XSG2-01-091518	8,518.0	8,972.5	9%	7,422	T26-XSG2-01-091518	1809475-43	4,200		68%
Trip 8	Red	T26-XSG9-01-091518	8,430.2	8,468.6	5%	7,776	T26-XSG9-01-091518	1809475-44	4,300		65%
Trip 9	Red	M10-XSG2-01-092818	9,740.1	9,824.0	9%	8,453	M10-XSG2-01-092818	1810122-1	5,400		57%
Trip 9	Blue	M10-XSG4-01-092818	11,822.8	12,032.3	9%	10,571	M10-XSG4-01-092818	1810122-2	5,700		70%
Trip 9	Red	M11-XS47-01-092818	9,368.8	9,048.8	10%	8,493	M11-XS47-01-092818	1810122-3	5,300		55%
Trip 9	Blue	M11-XSG2-01-092818	7,837.7	7,886.9	8%	6,754	M11-XSG2-01-092818	1810122-4	4,600		52%
Trip 9	Blue	M11-XSG25-01-092818	8,868.0	8,493.8	17%	7,087	M11-XSG25-01-092818	1810122-5	4,600		63%
Trip 9	Blue	M11-XSG28-01-092818	18,983.5	18,424.2	21%	14,750	M11-XSG28-01-092818	1810122-6	8,000		81%
Trip 9	Red	M11-XSG33-01-092818	8,523.1	8,358.9	5%	8,199	M11-XSG33-01-092818	1810122-7	4,800		56%
Trip 9	Red	M12-XSG26-01-092818	8,842.4	8,566.6	8%	8,244	M12-XSG26-01-092818	1810122-8	5,800		42%
Trip 9	Blue	M14-XSR1-01-093018	8,060.4	8,110.4	4%	7,486	M14-XSR1-01-093018	1810072-21	4,700		53%
Trip 9	White	M15-XSR1-01-093018	6,973.7	6,998.8	4%	6,645	M15-XSR1-01-093018	1810072-22	3,800		59%
Trip 9	White	M16-XSR1-01-093018	7,920.3	7,742.3	11%	7,102	M16-XSR1-01-093018	1810072-23	4,400		57%

Data Included											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	White	M16-XSR6-01-093018	8,466.3	8,513.2	4%	8,002	M16-XSR6-01-093018	1810072-24	3,500		83%
Trip 9	Blue	M17-XSR1-01-093018	9,130.4	8,844.4	12%	8,036	M17-XSR1-01-093018	1810072-25	4,200		74%
Trip 9	Red	M19-XSR2-01-093018	10,793.5	10,564.2	5%	10,320	M19-XSR2-01-093018	1810072-26	5,300		68%
Trip 9	Blue	M19-XSR2-02-093018	11,677.1	11,613.1	12%	10,160	M19-XSR2-02-093018	1810072-27	5,200		77%
Trip 9	Red	M1-XSG4-01-092818	7,107.2	7,173.3	6%	6,555	M1-XSG4-01-092818	1810072-1	4,300		49%
Trip 9	Blue	M20-XSR2-01-093018	8,848.3	8,230.5	21%	7,232	M20-XSR2-01-093018	1810072-28	4,100		73%
Trip 9	White	M23-XSR4-01-093018	10,660.0	10,718.1	7%	9,599	M23-XSR4-01-093018	1810072-29	6,300		51%
Trip 9	Red	M24-XS112-01-092518	12,241.6	12,224.9	11%	10,171	M24-XS112-01-092518	1810032-1	7,200		52%
Trip 9	Red	M24-XS114-01-092518	9,977.6	10,034.9	8%	8,511	M24-XS114-01-092518	1810032-2	5,300		61%
Trip 9	Red	M24-XSG15-01-092518	11,046.0	10,253.5	20%	9,549	M24-XSG15-01-092518	1810032-3	7,600		37%
Trip 9	Red	M24-XSG3-01-092518	7,353.2	6,846.1	18%	6,196	M24-XSG3-01-092518	1810032-4	5,000		38%
Trip 9	Red	M24-XSG32-01-092518	6,844.0	6,848.5	9%	6,151	M24-XSG32-01-092518	1810032-5	3,800		57%
Trip 9	Red	M24-XSR1-01-093018	10,051.8	9,826.6	8%	9,365	M24-XSR1-01-093018	1810072-30	5,900		52%
Trip 9	Blue	M25-XSG12-01-092818	4,038.6	4,073.2	9%	3,509	M25-XSG12-01-092818	1810122-10	3,000		30%
Trip 9	Blue	M25-XSG19-01-092818	9,538.0	9,466.7	6%	8,996	M25-XSG19-01-092818	1810122-11	5,500		54%
Trip 9	Blue	M25-XSG19-02-092818	9,772.4	9,318.2	16%	8,382	M25-XSG19-02-092818	1810122-12	5,500		56%
Trip 9	Blue	M25-XSG5-01-092818	4,646.2	4,492.4	8%	4,283	M25-XSG5-01-092818	1810122-13	2,600		56%
Trip 9	Red	M27-XS116-01-092618	8,059.3	8,126.1	6%	7,245	M27-XS116-01-092618	1810072-2	5,000		47%
Trip 9	Red	M27-XS149-01-092618	6,783.1	6,792.9	10%	6,004	M27-XS149-01-092618	1810072-3	4,800		34%
Trip 9	Red	M27-XS150-01-092618	6,970.6	6,985.3	6%	6,444	M27-XS150-01-092618	1810072-4	4,600		41%
Trip 9	Red	M27-XS163-01-092618	11,183.9	10,790.7	10%	9,930	M27-XS163-01-092618	1810072-5	6,600		52%
Trip 9	Red	M27-XSG28-01-092618	8,731.3	8,666.4	6%	8,070	M27-XSG28-01-092618	1810072-6	7,900		10%
Trip 9	Red	M27-XSG28-02-092618	8,589.5	8,733.0	8%	7,447	M27-XSG28-02-092618	1810072-7	7,300		16%
Trip 9	Red	M27-XSG48-01-092618	16,922.4	16,523.7	10%	15,312	M27-XSG48-01-092618	1810072-8	11,000		42%
Trip 9	Red	M27-XSG6-01-092618	6,956.2	6,962.7	2%	6,780	M27-XSG6-01-092618	1810072-9	4,600		41%
Trip 9	Red, Blue	M28-XS162-01-092818	26,567.0	27,091.1	16%	20,752	M28-XS162-01-092818	1810122-14	16,000		50%
Trip 9	White	M28-XS19-01-092918	13,282.5	11,572.7	27%	11,094	M28-XS19-01-092918	1810122-15	6,800		65%
Trip 9	Red	M28-XS29-01-092618	7,482.5	7,453.5	11%	6,345	M28-XS29-01-092618	1810032-6	6,700		11%
Trip 9	Blue	M28-XSG18-01-092918	7,200.6	7,098.5	9%	6,545	M28-XSG18-01-092918	1810122-16	3,800		62%
Trip 9	Red	M28-XSG49-01-092618	12,348.1	13,073.6	28%	5,793	M28-XSG49-01-092618	1810032-7	7,700		46%
Trip 9	Red, White	M28-XSG54-01-092918	16,776.3	16,430.1	9%	14,335	M28-XSG54-01-092918	1810122-17	8,600		64%
Trip 9	Red	M28-XSG7-01-092618	6,474.0	6,400.5	13%	5,470	M28-XSG7-01-092618	1810032-8	4,100		45%
Trip 9	White	M28-XSG76-01-092918	9,524.1	9,495.9	6%	8,920	M28-XSG76-01-092918	1810122-18	6,500		38%
Trip 9	Blue	M28-XSR1-01-093018	7,928.5	7,942.8	6%	7,220	M28-XSR1-01-093018	1810072-31	3,300		82%
Trip 9	Red	M28-XSR1-02-093018	7,626.8	7,631.7	5%	7,057	M28-XSR1-02-093018	1810072-32	3,500		74%
Trip 9	Red	M29-XS19-01-092518	14,559.1	14,821.2	10%	12,720	M29-XS19-01-092518	1810032-9	8,800		49%
Trip 9	Red	M29-XS42-01-092518	8,574.6	8,503.3	6%	8,060	M29-XS42-01-092518	1810032-10	4,900		55%
Trip 9	Red	M29-XS59-01-092518	10,781.1	9,672.7	27%	8,025	M29-XS59-01-092518	1810032-11	11,000		2%
Trip 9	Red	M29-XS64-01-092518	6,379.1	6,471.9	8%	5,595	M29-XS64-01-092518	1810032-12	3,400		61%
Trip 9	Red	M29-XSG1-01-092518	5,061.6	4,982.4	9%	4,574	M29-XSG1-01-092518	1810032-13	2,500		68%
Trip 9	Red	M29-XSG25-01-092518	6,222.7	6,102.3	8%	5,526	M29-XSG25-01-092518	1810032-14	3,100		67%
Trip 9	Red	M29-XSG35-01-092518	10,238.5	10,060.6	8%	9,430	M29-XSG35-01-092518	1810032-15	5,200		65%
Trip 9	Blue	M29-XSR4-01-093018	14,412.2	13,978.7	20%	10,679	M29-XSR4-01-093018	1810072-33	6,500		76%
Trip 9	Red	M29-XSR7-01-093018	14,542.3	14,124.6	16%	11,443	M29-XSR7-01-093018	1810072-34	9,100		46%
Trip 9	White	M2-XSR3-01-093018	4,747.3	4,728.1	14%	3,940	M2-XSR3-01-093018	1810072-35	3,000		45%
Trip 9	White	M30-XS144-01-092918	11,205.0	11,116.5	7%	10,135	M30-XS144-01-092918	1810122-19	6,300		56%
Trip 9	White	M30-XS185-01-092918	18,805.3	19,200.5	12%	14,882	M30-XS185-01-092918	1810122-20	11,000		52%
Trip 9	White	M30-XS62-01-092918	9,446.2	9,495.9	9%	8,288	M30-XS62-01-092918	1810122-21	5,400		55%
Trip 9	White	M30-XSG18-01-092918	15,801.9	15,289.5	18%	11,847	M30-XSG18-01-092918	1810122-22	8,000		66%
Trip 9	White	M30-XSG29-01-092918	13,666.9	13,686.8	5%	12,850	M30-XSG29-01-092918	1810122-23	8,100		51%
Trip 9	White	M30-XSG43-01-092918	7,985.5	8,027.7	1%	7,756	M30-XSG43-01-092918	1810122-24	4,200		62%
Trip 9	White	M30-XSG45-01-092918	7,002.8	7,269.4	11%	5,807	M30-XSG45-01-092918	1810122-25	4,100		52%
Trip 9	Red, White	M30-XSG6-01-092918	8,928.5	9,217.9	10%	7,540	M30-XSG6-01-092918	1810122-26	5,000		56%
Trip 9	Blue	M30-XSG61-01-092918	6,098.3	6,161.7	14%	4,828	M30-XSG61-01-092918	1810122-27	2,900		71%
Trip 9	White	M30-XSR5-01-093018	11,657.6	11,541.4	8%	10,850	M30-XSR5-01-093018	1810072-36	5,800		67%
Trip 9	Red	M31-XS1-01-092918	13,287.4	12,949.0	15%	10,512	M31-XS1-01-092918	1810122-28	7,400		57%
Trip 9	Blue	M31-XS39-01-092918	9,238.2	8,902.9	11%	8,400	M31-XS39-01-092918	1810122-29	5,900		44%
Trip 9	White	M31-XS8-01-092918	15,020.3	15,200.1	15%	10,969	M31-XS8-01-092918	1810122-30	6,900		74%
Trip 9	White	M31-XSG1-01-092918	6,801.9	6,801.9	10%	5,940	M31-XSG1-01-092918	1810122-31	3,400		67%
Trip 9	White	M31-XSG12-01-092918	13,640.5	13,754.2	11%	11,347	M31-XSG12-01-092918	1810122-32	6,800		67%
Trip 9	White	M31-XSG17-01-092918	8,985.9	8,884.8	7%	8,188	M31-XSG17-01-092918	1810122-33	4,200		73%
Trip 9	Red	M31-XSG9-01-092918	6,782.6	6,806.6	5%	6,340	M31-XSG9-01-092918	1810122-34	3,500		64%
Trip 9	Red	M32-XSG23-01-092918	14,684.8	14,712.1	3%	14,011	M32-XSG23-01-092918	1810072-10	9,700		41%
Trip 9	Red	M32-XSG26-01-092918	9,152.7	9,229.4	5%	8,473	M32-XSG26-01-092918	1810072-11	5,700		46%
Trip 9	Red	M32-XSG34-01-092918	15,808.9	16,029.7	8%	13,804	M32-XSG34-01-092918	1810072-12	8,900		56%
Trip 9	Red	M32-XSG46-01-092918	9,437.4	9,634.0	9%	8,065	M32-XSG46-01-092918	1810072-13	5,300		56%
Trip 9	Red	M32-XSG9-01-092918	8,941.9	9,009.6	6%	7,931	M32-XSG9-01-092918	1810072-14	6,200		36%
Trip 9	Red	M34-XSG15-01-092718	11,594.4	11,551.2	5%	10,873	M34-XSG15-01-092718	1810072-15	9,700		18%
Trip 9	Red	M35-XSG20-01-092718	12,224.4	11,846.4	21%	9,493	M35-XSG20-01-092718	1810072-16	10,000		20%
Trip 9	Red	M35-XSG4-01-092718	9,897.2	8,343.0	38%	7,232	M35-XSG4-01-092718	1810072-17	6,200		46%

Data Included												
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	Red	M36-XSG1-01-092718	11,143.3	11,048.1	5%	10,425	M36-XSG1-01-092718	1810072-18	7,000		46%
Trip 9	White	M6-XSR1-01-093018	7,235.8	7,190.0	11%	6,100	M6-XSR1-01-093018	1810072-37	3,000		83%
Trip 9	White	M7-XSR1-01-093018	10,804.4	10,894.7	4%	10,242	M7-XSR1-01-093018	1810072-38	5,500		65%
Trip 9	White	M7-XSR1-02-093018	10,152.2	10,311.6	5%	9,470	M7-XSR1-02-093018	1810072-39	5,800		55%
Trip 9	Blue	M8-XSR1-01-093018	10,242.6	10,833.8	18%	6,893	M8-XSR1-01-093018	1810072-40	6,000		52%
Trip 9	White	T17-XSR1-01-093018	7,524.2	7,559.2	11%	6,273	T17-XSR1-01-093018	1810072-41	3,200		81%
Trip 9	Red	T30-XS20-01-092518	9,456.9	9,304.6	4%	9,091	T30-XS20-01-092518	1810032-16	5,600		51%
Trip 9	Red	T30-XS28-01-092518	8,985.2	9,200.9	5%	8,412	T30-XS28-01-092518	1810032-17	5,100		55%
Trip 9	Red	T30-XS8-01-092518	8,379.4	8,291.8	8%	7,480	T30-XS8-01-092518	1810032-18	4,500		60%
Trip 9	Red	T31-XSG7-01-092518	6,574.4	6,645.0	8%	5,833	T31-XSG7-01-092518	1810032-19	3,300		66%
Trip 9	Red	T31-XSG9-01-092518	7,081.8	6,996.9	7%	6,553	T31-XSG9-01-092518	1810032-20	3,800		60%
Trip 9	Red	T5-XSG3-01-092818	6,982.4	6,992.1	5%	6,601	T5-XSG3-01-092818	1810072-19	5,000		33%
Trip 9	Red	T5-XSG3-02-092818	7,074.4	7,142.3	4%	6,573	T5-XSG3-02-092818	1810072-20	4,800		38%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Outliers											
			XRF - Iron						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	T1-XSG5A-01-081918	25,488.7	6,540.5	195%	5,892	T1-XSG5A-01-081918	1808483-15	3,800		148%
Trip 8	Red	M16-XSG24-01-091118	11,877.2	12,144.5	12%	10,230	M16-XSG24-01-091118	1809473-23	14,000		16%
Trip 9	Red	M12-XSG3-01-092818	49,456.1	14,762.0	174%	12,589	M12-XSG3-01-092818	1810122-9	6,000		157%

Notes:

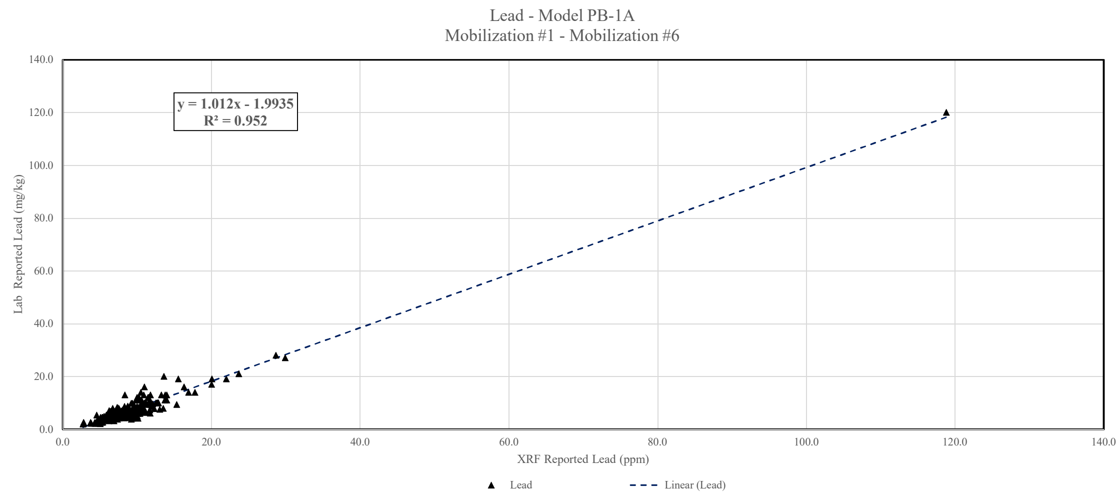
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model PB-1A												
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	4.3	4.3	23%	3	M2-XS15-01-042418	1805041-1	2.5		53%
Trip 1	Pink	M2-XS15-02-042418	3.7	3.6	18%	3	M2-XS15-02-042418	1805041-2	2.4		44%
Trip 1	Pink	M2-XS32-01-042418	5.6	5.9	15%	4	M2-XS32-01-042418	1805041-3	3.6		44%
Trip 1	Pink	M2-XS59-01-042418	4.3	4.4	17%	3	M2-XS59-01-042418	1805041-4	2.2		64%
Trip 1	Pink	M2-XS73-01-042418	4.9	4.8	14%	4	M2-XS73-01-042418	1805041-5	2.5		64%
Trip 1	Pink	M3-XS34-01-043018	7.2	7.2	10%	6	M3-XS34-01-043018	1805042-1	4.7		42%
Trip 1	Pink	M3-XS36-01-043018	7.6	7.7	12%	7	M3-XS36-01-043018	1805042-2	6.4		18%
Trip 1	Pink	M6-XS140-01-042818	7.4	7.3	14%	6	M6-XS140-01-042818	1805041-6	5.0		38%
Trip 1	Orange	M6-XS159-01-04262018	6.9	6.7	17%	5	M6-XS159-01-04262018	1805039-1	6.4		7%
Trip 1	Pink	M6-XS251-01-04272018	8.2	8.0	15%	7	M6-XS251-01-04272018	1805039-2	7.1		14%
Trip 1	Pink	M6-XS269-01-04262018	7.3	7.2	15%	6	M6-XS269-01-04262018	1805039-3	8.2		11%
Trip 1	Pink	M6-XS269-02-04262018	7.4	7.1	15%	6	M6-XS269-02-04262018	1805039-4	5.8		24%
Trip 1	Pink	M6-XS285-01-04272018	10.5	10.7	11%	9	M6-XS285-01-04272018	1805039-5	14.0		29%
Trip 1	Pink	T10-XS1-01-042518	10.4	10.5	1%	9	T10-XS1-01-042518	1805036-1	6.6		45%
Trip 1	Pink	T10-XS20-01-042518	8.8	8.7	5%	8	T10-XS20-01-042518	1805036-2	4.4		66%
Trip 1	Pink	T10-XS33-01-042518	10.0	9.9	4%	9	T10-XS33-01-042518	1805036-3	5.0		67%
Trip 1	Pink	T10-XS56-01-042518	9.4	9.3	8%	8	T10-XS56-01-042518	1805036-4	6.0		45%
Trip 1	Pink	T10-XS78-01-042518	9.4	9.5	6%	9	T10-XS78-01-042518	1805036-5	5.7		49%
Trip 1	Pink	T11-XS1-01-042518	9.6	9.3	12%	8	T11-XS1-01-042518	1805036-6	6.3		42%
Trip 1	Pink	T11-XS20-01-042518	10.1	10.0	9%	9	T11-XS20-01-042518	1805036-7	6.0		51%
Trip 1	Pink	T11-XS60-01-042518	6.9	6.8	11%	6	T11-XS60-01-042518	1805036-8	3.2		73%
Trip 1	Pink	T17-XS1-01-04262018	5.0	4.8	21%	4	T17-XS1-01-04262018	1805039-6	2.4		70%
Trip 1	Pink	T17-XS1-02-04262018	4.8	4.9	11%	4	T17-XS1-02-04262018	1805039-7	2.2		74%
Trip 1	Pink	T17-XS143-01-04262018	20.0	19.4	8%	18	T17-XS143-01-04262018	1805039-8	17.0		16%
Trip 1	Orange	T17-XS144-01-04262018	118.8	115.5	11%	106	T17-XS144-01-04262018	1805039-9	120.0		1%
Trip 1	Pink	T17-XS194-01-04272018	7.1	7.1	8%	7	T17-XS194-01-04272018	1805039-10	4.3		50%
Trip 1	Pink	T17-XS194-02-04272018	7.4	7.0	11%	6	T17-XS194-02-04272018	1805039-11	3.8		64%
Trip 1	Pink	T17-XS20-01-04262018	6.1	6.0	14%	5	T17-XS20-01-04262018	1805039-12	3.7		49%
Trip 1	Pink	T17-XS208-01-042818	8.6	8.4	10%	8	T17-XS208-01-042818	1805041-7	4.8		57%
Trip 1	Pink	T17-XS251-01-04272018	9.1	8.9	9%	8	T17-XS251-01-04272018	1805039-13	7.1		24%
Trip 1	Pink	T17-XS257-01-04272018	10.8	10.8	9%	10	T17-XS257-01-04272018	1805039-14	6.7		47%
Trip 1	Pink	T17-XS273-01-042818	9.8	9.8	9%	9	T17-XS273-01-042818	1805041-8	7.2		31%
Trip 1	Pink	T17-XS287-01-04272018	11.1	11.7	10%	10	T17-XS287-01-04272018	1805039-15	9.7		14%
Trip 1	Pink	T17-XS304-01-042818	8.8	8.8	7%	8	T17-XS304-01-042818	1805041-9	4.4		67%
Trip 1	Pink	T17-XS317-01-04272018	9.1	9.2	6%	8	T17-XS317-01-04272018	1805039-16	6.5		33%
Trip 1	Pink	T17-XS328-01-04272018	11.1	11.0	4%	11	T17-XS328-01-04272018	1805039-17	6.6		51%
Trip 1	Pink	T17-XS369-01-043018	9.2	9.1	5%	9	T17-XS369-01-043018	1805042-4	5.0		60%
Trip 1	Pink	T17-XS377-01-042818	10.6	10.7	6%	10	T17-XS377-01-042818	1805041-10	7.3		37%
Trip 1	Pink	T17-XS393-01-043018	10.1	9.7	12%	9	T17-XS393-01-043018	1805042-5	4.3		80%
Trip 1	Pink	T17-XS417-01-04272018	9.4	9.4	4%	9	T17-XS417-01-04272018	1805039-18	6.3		40%
Trip 1	Pink	T17-XS438-01-042818	4.4	4.5	11%	4	T17-XS438-01-042818	1805041-11	2.4		59%
Trip 1	Pink	T17-XS44-01-04262018	8.6	8.3	10%	8	T17-XS44-01-04262018	1805039-19	5.2		50%
Trip 1	Pink	T17-XS442-01-04272018	7.3	7.1	6%	7	T17-XS442-01-04272018	1805039-20	5.6		26%
Trip 1	Pink	T17-XS46-01-042618	8.3	8.3	7%	8	T17-XS46-01-042618	1805041-12	4.9		52%
Trip 1	Pink	T17-XS473-01-042818	11.9	11.9	11%	11	T17-XS473-01-042818	1805041-13	8.6		32%
Trip 1	Pink	T17-XS479-01-042818	13.7	13.8	7%	12	T17-XS479-01-042818	1805041-14	11.0		22%
Trip 1	Pink	T17-XS479-02-042818	12.5	12.5	6%	12	T17-XS479-02-042818	1805041-15	10.0		22%
Trip 1	Pink	T17-XS603-01-042818	8.1	8.1	11%	7	T17-XS603-01-042818	1805041-16	4.5		57%
Trip 1	Pink	T17-XS659-01-043018	9.4	9.3	7%	9	T17-XS659-01-043018	1805042-6	4.1		78%
Trip 1	Pink	T17-XS679-01-043018	13.0	13.1	7%	12	T17-XS679-01-043018	1805042-7	7.5		54%

Data Included in Model PB-1A											
Trip	XRF Color	XRF ID	XRF - Lead Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	T17-XS704-01-043018	9.2	9.2	9%	8	T17-XS704-01-043018	1805042-8	3.8		83%
Trip 1	Pink	T7-XS11-01-042418	5.0	5.0	1%	4	T7-XS11-01-042418	1805036-9	2.6		63%
Trip 1	Pink	T7-XS5-01-042418	5.3	5.2	15%	4	T7-XS5-01-042418	1805036-10	2.7		65%
Trip 1	Pink	T7-XS58-01-042418	5.1	5.3	18%	4	T7-XS58-01-042418	1805036-11	2.7		61%
Trip 1	Pink	T7-XS7-01-042418	4.4	4.4	13%	4	T7-XS7-01-042418	1805036-12	2.2		68%
Trip 1	Pink	T7-XS9-01-042418	5.4	5.7	18%	4	T7-XS9-01-042418	1805036-13	2.7		67%
Trip 1	Pink	T8-XS15-01-042418	6.7	6.5	11%	6	T8-XS15-01-042418	1805036-14	3.6		61%
Trip 1	Pink	T8-XS23-01-042418	6.6	6.5	13%	5	T8-XS23-01-042418	1805036-15	3.8		53%
Trip 1	Pink	T8-XS6-01-042418	5.3	5.4	12%	4	T8-XS6-01-042418	1805036-16	2.7		65%
Trip 1	Pink	T9-XS217-01-042518	8.8	8.8	7%	8	T9-XS217-01-042518	1805036-17	5.7		42%
Trip 1	Pink	T9-XS61-01-042518	7.9	7.7	12%	7	T9-XS61-01-042518	1805036-18	5.5		35%
Trip 1	Orange	T9-XS61-02-042518	7.7	7.5	8%	7	T9-XS61-02-042518	1805041-17	5.7		29%
Trip 1	Pink	T9-XS86-01-042518	8.0	8.1	12%	6	T9-XS86-01-042518	1805036-19	4.5		56%
Trip 1	Pink	T9-XS93-01-042518	6.6	6.8	12%	5	T9-XS93-01-042518	1805036-20	5.0		27%
Trip 2	Orange	M1-XS31-01-051218	6.2	6.0	18%	5	M1-XS31-01-051218	1805328-1	4.9		23%
Trip 2	Pink	M1-XS32-01-051218	6.5	6.6	5%	6	M1-XS32-01-051218	1805328-2	4.9		29%
Trip 2	Pink	M4-XS136-01-050918	8.1	7.6	25%	6	M4-XS136-01-050918	1805322-1	7.3		10%
Trip 2	Pink	M4-XS18-01-050718	10.9	10.7	10%	10	M4-XS18-01-050718	1805322-2	10.0		9%
Trip 2	Orange	M4-XS219-01-051018	7.8	7.7	11%	6	M4-XS219-01-051018	1805322-3	5.9		28%
Trip 2	Pink	M4-XS238-01-051018	16.3	13.1	58%	8	M4-XS238-01-051018	1805322-4	16.0		2%
Trip 2	Pink	M4-XS4-01-050718	8.0	7.9	12%	7	M4-XS4-01-050718	1805322-5	4.4		58%
Trip 2	Pink	M4-XS45-01-050718	6.2	6.0	13%	5	M4-XS45-01-050718	1805322-6	7.1		13%
Trip 2	Pink	M4-XS63-01-050718	22.0	22.8	14%	17	M4-XS63-01-050718	1805322-7	19.0		15%
Trip 2	Pink	M4-XS63-02-050718	13.6	12.5	21%	11	M4-XS63-02-050718	1805322-8	20.0		38%
Trip 2	Pink	M4-XS78-01-051018	10.4	10.3	8%	9	M4-XS78-01-051018	1805322-9	7.7		30%
Trip 2	Orange	M5-XS115-01-051118	9.3	9.1	8%	9	M5-XS115-01-051118	1805322-10	6.1		41%
Trip 2	Pink	M5-XS385-01-051118	6.1	5.8	12%	6	M5-XS385-01-051118	1805322-11	3.7		48%
Trip 2	Pink	M5-XS69-01-051118	12.9	12.7	14%	11	M5-XS69-01-051118	1805322-12	9.9		26%
Trip 2	Orange	M6-XS41-01-051118	3.7	3.9	16%	3	M6-XS41-01-051118	1805322-13	2.6		36%
Trip 2	Pink	M6-XS44-01-051018	6.2	6.3	8%	5	M6-XS44-01-051018	1805322-14	4.8		26%
Trip 2	Pink	M6-XS81-01-051018	5.0	4.4	25%	3	M6-XS81-01-051018	1805322-15	3.5		35%
Trip 2	Pink	M7-XS181-01-051018	7.4	7.5	11%	6	M7-XS181-01-051018	1805322-16	5.9		23%
Trip 2	Orange	M7-XS181-02-051018	7.7	7.7	7%	7	M7-XS181-02-051018	1805322-17	5.7		30%
Trip 2	Orange	M7-XS39-01-051018	4.6	4.6	6%	4	M7-XS39-01-051018	1805322-18	3.4		31%
Trip 2	Orange	M7-XS74-01-051018	6.6	6.8	15%	5	M7-XS74-01-051018	1805322-19	5.7		15%
Trip 2	Orange	M7-XS77-01-051018	7.5	7.3	13%	6	M7-XS77-01-051018	1805322-20	7.1		6%
Trip 2	Pink	M8-XS100-01-050918	10.1	10.1	13%	8	M8-XS100-01-050918	1805328-3	4.1		85%
Trip 2	Pink	M8-XS102-01-050918	28.7	27.9	8%	26	M8-XS102-01-050918	1805328-4	28.0		2%
Trip 2	Pink	M8-XS102-02-050918	29.9	30.5	7%	26	M8-XS102-02-050918	1805328-5	27.0		10%
Trip 2	Pink	M8-XS110-01-050918	10.7	10.1	13%	10	M8-XS110-01-050918	1805328-6	7.6		33%
Trip 2	Orange	M8-XS19-01-051018	9.0	9.0	11%	8	M8-XS19-01-051018	1805328-7	6.2		37%
Trip 2	Orange	M8-XS32-01-051018	10.7	10.9	7%	10	M8-XS32-01-051018	1805328-8	10.0		7%
Trip 2	Pink	M8-XS94-01-050918	13.8	13.3	22%	10	M8-XS94-01-050918	1805328-9	13.0		6%
Trip 2	Pink	T13-XS12-01-050818	11.8	11.5	11%	11	T13-XS12-01-050818	1805322-21	9.7		19%
Trip 2	Pink	T13-XS24-01-050818	6.2	6.2	13%	5	T13-XS24-01-050818	1805322-22	3.2		64%
Trip 2	Pink	T14-XS12-01-050818	9.0	9.0	7%	8	T14-XS12-01-050818	1805322-23	7.0		24%
Trip 2	Pink	T14-XS27-01-050818	7.2	7.2	8%	6	T14-XS27-01-050818	1805322-24	4.3		50%
Trip 2	Pink	T15-XS2-01-050818	10.4	10.2	9%	9	T15-XS2-01-050818	1805322-25	6.0		54%
Trip 2	Pink	T15-XS45-01-050818	7.6	7.8	14%	6	T15-XS45-01-050818	1805322-26	4.7		47%
Trip 2	Pink	T17-XS122-01-050718	12.3	11.9	13%	11	T17-XS122-01-050718	1805322-27	7.8		45%
Trip 2	Pink	T17-XS176-01-050718	8.9	8.8	5%	8	T17-XS176-01-050718	1805322-28	5.8		42%
Trip 2	Pink	T17-XS178-01-050718	8.5	8.4	8%	8	T17-XS178-01-050718	1805322-29	5.5		43%
Trip 2	Pink	T17-XS619-01-050718	9.9	10.1	11%	9	T17-XS619-01-050718	1805322-30	6.1		48%
Trip 2	Pink	T17-XS619-02-050718	9.1	9.1	6%	8	T17-XS619-02-050718	1805322-31	5.8		44%
Trip 2	Pink	T17-XS645-01-050718	8.9	9.0	10%	8	T17-XS645-01-050718	1805322-32	5.1		54%
Trip 2	Pink	T17-XS669-01-050718	8.2	8.3	6%	8	T17-XS669-01-050718	1805322-33	4.3		63%
Trip 2	Pink	T1-XS104-01-051318	9.7	9.2	13%	9	T1-XS104-01-051318	1805328-10	7.6		24%
Trip 2	Pink	T1-XS20-01-051318	6.6	6.7	23%	5	T1-XS20-01-051318	1805328-11	5.0		27%
Trip 2	Pink	T1-XS54-01-051318	7.8	8.1	11%	6	T1-XS54-01-051318	1805328-12	6.2		23%
Trip 2	Pink	T1-XS54-02-051318	8.1	8.0	8%	8	T1-XS54-02-051318	1805328-13	6.3		26%
Trip 2	Pink	T1-XS69-01-051318	13.2	13.6	12%	11	T1-XS69-01-051318	1805328-14	13.0		2%
Trip 2	Orange	T3-XS10-01-051218	6.5	6.1	20%	5	T3-XS10-01-051218	1805328-15	3.8		52%
Trip 2	Orange	T3-XS5-01-051218	5.5	5.6	7%	5	T3-XS5-01-051218	1805328-16	3.8		37%
Trip 2	Pink	T4-XS23-01-051218	6.4	6.4	16%	5	T4-XS23-01-051218	1805328-17	4.0		47%
Trip 2	Orange	T4-XS32-01-051218	5.0	4.8	10%	5	T4-XS32-01-051218	1805328-18	3.5		36%
Trip 2	Pink	T4-XS43-01-051218	14.0	13.8	9%	13	T4-XS43-01-051218	1805328-19	11.0		24%
Trip 2	Pink	T5-XS18-01-051418	2.8	2.8	22%	2	T5-XS18-01-051418	1805328-20	2.3		20%
Trip 2	Pink	T6-XS2-01-051218	5.0	5.0	12%	4	T6-XS2-01-051218	1805328-21	2.1		82%
Trip 2	Orange	T6-XS25-01-051218	5.2	5.5	14%	4	T6-XS25-01-051218	1805328-22	2.5		71%
Trip 3	Pink	M14-XS36-01-052418	11.7	12.1	6%	11	M14-XS36-01-052418	1805632-1	9.8		18%
Trip 3	Pink	M14-XS40-01-052418	10.6	10.6	5%	10	M14-XS40-01-052418	1805632-2	8.7		20%
Trip 3	Pink	M14-XS64-01-052418	6.7	6.5	15%	6	M14-XS64-01-052418	1805632-3	5.4		22%
Trip 3	Pink	M14-XS67-01-052418	12.0	11.6	16%	10	M14-XS67-01-052418	1805632-4	9.2		26%
Trip 3	Pink	M15-XS22-01-052118	7.9	7.8	6%	7	M15-XS22-01-052118	1805589-1	6.1		26%

Data Included in Model PB-1A											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Pink	M15-XS3-01-052118	8.2	8.2	8%	7	M15-XS3-01-052118	1805589-2	5.9		33%
Trip 3	Pink	M15-XS46-01-052118	5.6	5.5	10%	5	M15-XS46-01-052118	1805589-3	4.3		27%
Trip 3	Pink	M15-XS46-02-052118	5.6	5.7	12%	4	M15-XS46-02-052118	1805589-4	4		33%
Trip 3	Pink	M15-XS82-01-052118	10.9	10.9	7%	10	M15-XS82-01-052118	1805589-6	13		18%
Trip 3	Pink	M15-XS93-01-052118	11.8	11.9	11%	10	M15-XS93-01-052118	1805589-7	9.3		24%
Trip 3	Pink	M16-XS128-01-052118	10.3	10.7	24%	6	M16-XS128-01-052118	1805589-8	11		6%
Trip 3	Pink	M16-XS154-01-052618	7.9	7.8	8%	7	M16-XS154-01-052618	1806235-2	6.2		24%
Trip 3	Pink	M16-XS177-01-052618	6.2	6.1	13%	5	M16-XS177-01-052618	1806235-3	4.6		29%
Trip 3	Pink	M16-XS191-01-052618	5.8	5.9	4%	5	M16-XS191-01-052618	1806235-4	5.4		8%
Trip 3	Pink	M16-XS191-02-052618	7.5	7.5	8%	7	M16-XS191-02-052618	1806235-5	5.4		32%
Trip 3	Pink	M16-XS30-01-052118	6.5	7.0	17%	5	M16-XS30-01-052118	1805589-10	5.6		15%
Trip 3	Pink	M16-XS31-01-052118	5.6	5.4	20%	5	M16-XS31-01-052118	1805589-11	3.5		46%
Trip 3	Pink	M16-XS4-01-052118	8.3	8.6	13%	7	M16-XS4-01-052118	1805589-12	5.7		38%
Trip 3	Pink	M17-XS55-01-052618	9.7	9.4	8%	9	M17-XS55-01-052618	1806235-6	8.5		13%
Trip 3	Pink	M17-XS83-01-052618	11.7	11.7	7%	11	M17-XS83-01-052618	1806235-7	11		6%
Trip 3	Pink	M17-XS83-02-052618	12.8	13.1	9%	11	M17-XS83-02-052618	1806235-8	10		25%
Trip 3	Pink	M18-XS155-01-052518	4.9	4.6	12%	4	M18-XS155-01-052518	1805632-5	3.4		35%
Trip 3	Pink	M18-XS161-01-052518	23.7	23.1	16%	19	M18-XS161-01-052518	1805632-6	21		12%
Trip 3	Pink	M19-XS22-01-052318	12.7	12.8	6%	12	M19-XS22-01-052318	1805632-7	10		24%
Trip 3	Pink	M19-XS22-02-052318	11.2	11.1	9%	10	M19-XS22-02-052318	1805632-8	10		11%
Trip 3	Pink	M19-XS43-01-052318	9.6	9.4	11%	8	M19-XS43-01-052318	1805632-9	6.2		43%
Trip 3	Pink	T21-XS55-02-052118	11.0	10.7	8%	10	T21-XS55-02-052118	1805589-16	6.3		54%
Trip 3	Pink	T22-XS64-01-052218	8.4	8.4	11%	7	T22-XS64-01-052218	1805632-11	4.6		59%
Trip 3	Pink	T23-XS23-01-052118	11.7	11.6	9%	11	T23-XS23-01-052118	1805589-19	7.3		46%
Trip 3	Pink	T23-XS40-01-052118	10.9	11.0	4%	10	T23-XS40-01-052118	1805589-20	7.8		34%
Trip 3	Pink	T24-XS48-01-052418	10.2	9.8	15%	9	T24-XS48-01-052418	1805632-12	12		16%
Trip 4	Pink	M13-XS72-01-060618	9.9	9.9	9%	9	M13-XS72-01-060618	1806235-1	11.0		11%
Trip 4	Pink	M20-XS11-01-060618	5.9	5.7	14%	5	M20-XS11-01-060618	1806235-9	3.9		41%
Trip 4	Pink	M20-XS130-01-060418	17.8	18.3	10%	14	M20-XS130-01-060418	1806235-10	14.0		24%
Trip 4	Pink	M20-XS166-01-060518	6.2	6.2	13%	5	M20-XS166-01-060518	1806235-11	6.0		2%
Trip 4	Pink	M20-XS18-01-060618	7.1	6.8	12%	6	M20-XS18-01-060618	1806235-12	5.3		29%
Trip 4	Pink	M20-XS185-01-060418	9.8	9.8	8%	9	M20-XS185-01-060418	1806235-13	5.4		58%
Trip 4	Pink	M20-XS231-01-060418	9.7	9.2	12%	9	M20-XS231-01-060418	1806235-14	5.5		55%
Trip 4	Pink	M20-XS278-01-060418	4.6	4.7	28%	3	M20-XS278-01-060418	1806235-15	5.3		15%
Trip 4	Pink	M20-XS306-01-060518	8.7	8.8	16%	7	M20-XS306-01-060518	1806235-16	7.9		10%
Trip 4	Pink	M20-XS312-01-060518	6.8	6.8	16%	5	M20-XS312-01-060518	1806235-17	5.3		25%
Trip 4	Pink	M20-XS365-01-060618	9.4	10.2	19%	6	M20-XS365-01-060618	1806235-18	8.3		13%
Trip 4	Pink	M20-XS365-02-060618	9.1	9.1	9%	8	M20-XS365-02-060618	1806235-19	6.5		33%
Trip 4	Pink	M20-XS5-01-060518	10.6	10.6	10%	9	M20-XS5-01-060518	1806235-20	8.6		20%
Trip 4	Pink	M20-XS86-01-060618	5.4	5.2	17%	5	M20-XS86-01-060618	1806235-21	4.5		17%
Trip 4	Pink	M21-XS122-01-060818	11.4	11.5	8%	10	M21-XS122-01-060818	1806234-1	12.0		5%
Trip 4	Pink	M21-XS126-01-060818	7.3	7.8	17%	6	M21-XS126-01-060818	1806234-2	6.0		19%
Trip 4	Pink	M21-XS14-01-060818	8.6	8.8	13%	7	M21-XS14-01-060818	1806234-3	7.8		10%
Trip 4	Pink	M21-XS175-01-060818	9.2	9.6	12%	8	M21-XS175-01-060818	1806234-4	7.2		25%
Trip 4	Pink	M21-XS225-01-060518	7.6	7.5	16%	6	M21-XS225-01-060518	1806235-22	6.7		13%
Trip 4	Pink	M21-XS259-01-060918	7.9	7.7	11%	7	M21-XS259-01-060918	1806234-5	6.8		15%
Trip 4	Pink	M21-XS260-01-060918	8.9	8.8	8%	8	M21-XS260-01-060918	1806234-6	7.9		12%
Trip 4	Pink	M21-XS27-01-060818	5.3	5.1	13%	5	M21-XS27-01-060818	1806234-7	4.5		16%
Trip 4	Pink	M21-XS27-02-060818	5.8	5.8	16%	5	M21-XS27-02-060818	1806234-8	4.6		23%
Trip 4	Pink	M21-XS282-01-060918	5.9	6.0	17%	4	M21-XS282-01-060918	1806234-9	4.2		33%
Trip 4	Pink	M21-XS290-01-060918	11.8	11.8	11%	10	M21-XS290-01-060918	1806234-10	13.0		10%
Trip 4	Pink	M21-XS292-01-060518	5.7	5.8	19%	4	M21-XS292-01-060518	1806235-23	4.7		19%
Trip 4	Pink	M21-XS302-01-060918	7.9	7.8	9%	7	M21-XS302-01-060918	1806234-11	6.2		25%
Trip 4	Pink	M21-XS302-02-060918	7.9	7.8	12%	7	M21-XS302-02-060918	1806234-12	6.7		16%
Trip 4	Pink	M21-XS334-01-060918	20.1	19.3	11%	18	M21-XS334-01-060918	1806234-13	19.0		5%
Trip 4	Pink	M21-XS377-01-060918	8.1	8.0	14%	7	M21-XS377-01-060918	1806234-14	5.2		44%
Trip 4	Pink	M21-XS40-01-060818	8.3	8.2	10%	7	M21-XS40-01-060818	1806234-15	8.6		4%
Trip 4	Pink	M21-XS403-01-060818	10.1	10.8	18%	7	M21-XS403-01-060818	1806234-16	8.2		21%
Trip 4	Pink	M21-XS419-01-060818	10.5	10.8	13%	8	M21-XS419-01-060818	1806234-17	9.7		8%
Trip 4	Pink	M21-XS46-01-060818	11.9	11.5	14%	10	M21-XS46-01-060818	1806234-18	9.6		21%
Trip 4	Pink	M21-XS477-01-060818	11.3	11.2	11%	10	M21-XS477-01-060818	1806234-19	9.3		19%
Trip 4	Pink	M21-XS541-01-060818	8.1	8.3	7%	7	M21-XS541-01-060818	1806234-20	5.9		31%
Trip 4	Pink	M21-XS596-01-060518	7.0	7.4	15%	6	M21-XS596-01-060518	1806235-24	5.5		24%
Trip 4	Pink	M21-XS615-01-060518	6.5	6.5	3%	6	M21-XS615-01-060518	1806235-25	4.8		31%
Trip 4	Pink	M21-XS619-01-060618	7.4	7.9	13%	6	M21-XS619-01-060618	1806235-26	8.0		7%
Trip 4	Pink	M22-XS14-01-060418	8.0	8.0	11%	7	M22-XS14-01-060418	1806235-27	6.9		15%
Trip 4	Pink	M22-XS30-01-060418	5.5	6.1	24%	4	M22-XS30-01-060418	1806235-28	4.9		12%
Trip 4	Pink	M22-XS40-01-060518	10.6	11.1	19%	7	M22-XS40-01-060518	1806235-29	11.0		4%
Trip 4	Pink	M22-XS60-01-060418	6.4	5.9	15%	5	M22-XS60-01-060418	1806235-30	6.8		6%
Trip 4	Pink	M22-XS87-01-060418	8.6	9.0	13%	7	M22-XS87-01-060418	1806235-31	7.9		9%
Trip 4	Pink	M23-XS102-01-061018	10.0	9.9	10%	8	M23-XS102-01-061018	1806233-1	8.6		15%
Trip 4	Pink	M23-XS123-01-061018	8.2	8.2	12%	7	M23-XS123-01-061018	1806233-2	5.2		45%
Trip 4	Pink	M23-XS20-01-061018	16.9	16.2	11%	14	M23-XS20-01-061018	1806233-3	14.0		19%
Trip 4	Pink	M23-XS48-01-061018	9.8	10.0	9%	8	M23-XS48-01-061018	1806233-4	4.2		80%

Data Included in Model PB-1A											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M23-XS54-01-061118	9.4	9.5	10%	8	M23-XS54-01-061118	1806312-1	7.8		18%
Trip 4	Pink	M23-XS64-01-061018	8.2	7.7	13%	7	M23-XS64-01-061018	1806233-5	5.2		44%
Trip 4	Pink	M23-XS70-01-061018	11.8	11.8	4%	11	M23-XS70-01-061018	1806233-6	6.1		63%
Trip 4	Pink	M23-XS79-01-061018	8.1	8.1	14%	7	M23-XS79-01-061018	1806233-7	5.1		46%
Trip 4	Pink	M24-XS100-01-061118	8.5	8.7	10%	7	M24-XS100-01-061118	1806312-3	7.4		14%
Trip 4	Pink	T18-XS14-01-061118	6.0	5.9	9%	5	T18-XS14-01-061118	1806312-5	4.1		37%
Trip 4	Pink	T18-XS27-01-061118	2.7	2.7	16%	2	T18-XS27-01-061118	1806312-6	1.9		36%
Trip 4	Pink	T25-XS2-01-060618	7.6	7.3	8%	7	T25-XS2-01-060618	1806235-32	4.3		55%
Trip 4	Pink	T26-XS1-01-061018	6.0	6.0	18%	5	T26-XS1-01-061018	1806233-8	4.9		19%
Trip 4	Pink	T26-XS8-01-061018	5.1	5.0	11%	4	T26-XS8-01-061018	1806233-9	4.5		12%
Trip 4	Pink	T27-XS19-01-061018	9.8	9.9	6%	9	T27-XS19-01-061018	1806233-10	4.3		78%
Trip 4	Pink	T27-XS6-01-061018	13.5	13.3	6%	13	T27-XS6-01-061018	1806233-11	7.9		52%
Trip 5	Pink	M26-XS13-01-061818	2.8	2.7	16%	2	M26-XS13-01-061818	1806558-1	2.6		8%
Trip 5	Pink	M26-XS25-01-061818	7.4	7.5	18%	6	M26-XS25-01-061818	1806558-2	6.8		9%
Trip 5	Pink	M27-XS108-01-061918	7.3	7.4	7%	7	M27-XS108-01-061918	1806558-3	5.8		23%
Trip 5	Pink	M27-XS109-01-061918	7.7	7.9	10%	6	M27-XS109-01-061918	1806558-4	5.7		30%
Trip 5	Pink	M27-XS123-01-061818	5.1	5.0	15%	4	M27-XS123-01-061818	1806558-5	3.2		46%
Trip 5	Pink	M27-XS188-01-061918	7.7	7.6	6%	7	M27-XS188-01-061918	1806558-6	6.5		17%
Trip 5	Pink	M27-XS197-01-061918	6.1	5.9	10%	6	M27-XS197-01-061918	1806558-7	5.2		16%
Trip 5	Pink	M27-XS210-01-061818	6.4	6.4	11%	5	M27-XS210-01-061818	1806558-8	4.8		29%
Trip 5	Pink	M27-XS210-02-061818	6.1	6.5	17%	5	M27-XS210-02-061818	1806558-9	4.5		30%
Trip 5	Pink	M27-XS21-01-061918	7.9	7.5	39%	5	M27-XS21-01-061918	1806558-10	6.9		13%
Trip 5	Pink	M27-XS239-01-061818	4.6	4.6	9%	4	M27-XS239-01-061818	1806558-11	2.4		62%
Trip 5	Pink	M27-XS275-01-061918	7.6	7.5	18%	5	M27-XS275-01-061918	1806558-12	7.8		3%
Trip 5	Pink	M27-XS283-01-061818	8.7	8.9	18%	7	M27-XS283-01-061818	1806558-13	8.7		0%
Trip 5	Pink	M27-XS29-01-061818	5.9	5.9	10%	5	M27-XS29-01-061818	1806558-14	5.1		15%
Trip 5	Pink	M27-XS38-01-061918	7.6	7.6	11%	6	M27-XS38-01-061918	1806558-15	5.8		26%
Trip 5	Pink	M28-XS105-01-062018	6.3	6.1	15%	5	M28-XS105-01-062018	1806558-16	4.6		31%
Trip 5	Pink	M28-XS148-01-062018	8.8	8.6	10%	8	M28-XS148-01-062018	1806558-17	7.4		17%
Trip 5	Pink	M28-XS155-01-062018	5.9	5.7	9%	5	M28-XS155-01-062018	1806558-18	4.5		28%
Trip 5	Pink	M28-XS170-01-062018	10.0	9.9	9%	9	M28-XS170-01-062018	1806558-19	12		18%
Trip 5	Pink	M28-XS43-01-062018	9.4	9.6	16%	8	M28-XS43-01-062018	1806558-20	9.8		5%
Trip 5	Pink	M28-XS8-01-062018	5.8	6.1	13%	5	M28-XS8-01-062018	1806558-21	3.3		55%
Trip 5	Pink	M30-XS138-01-062218	7.2	7.0	18%	6	M30-XS138-01-062218	1806693-1	6		18%
Trip 5	Pink	M30-XS222-01-062218	7.6	7.6	11%	6	M30-XS222-01-062218	1806693-2	7.3		4%
Trip 5	Pink	T32-XS5-01-062018	6.7	6.8	8%	6	T32-XS5-01-062018	1806558-22	4.2		47%
Trip 6	Orange	M10-XS10A-01-071118	8.3	8.1	16%	7	M10-XS10A-01-071118	1807369-1	13.0		44%
Trip 6	Orange	M10-XS31-01-071118	8.2	7.9	8%	8	M10-XS31-01-071118	1807369-2	5.9		33%
Trip 6	Orange	M10-XS31-02-071118	8.5	8.6	12%	7	M10-XS31-02-071118	1807369-3	5.9		36%
Trip 6	Orange	M11-XS11-01-071118	15.5	15.5	10%	14	M11-XS11-01-071118	1807369-4	19.0		20%
Trip 6	Red	M11-XS7-01-071118	11.5	11.7	9%	10	M11-XS7-01-071118	1807369-5	12.0		4%
Trip 6	Red	M12-XS27-01-071518	3.8	3.8	11%	3	M12-XS27-01-071518	1807369-6	2.2		54%
Trip 6	Orange	M24-XS115-01-071418	11.0	10.7	9%	10	M24-XS115-01-071418	1807369-7	16.0		37%
Trip 6	Red	M25-XS16-01-071718	14.0	13.7	10%	13	M25-XS16-01-071718	1807452-1	13.0		7%
Trip 6	Red	M25-XS23-01-071718	15.3	14.4	26%	12	M25-XS23-01-071718	1807452-2	9.4		48%
Trip 6	Red	M25-XS47-01-071718	6.1	5.8	20%	5	M25-XS47-01-071718	1807452-3	4.5		31%
Trip 6	Red	M25-XS88-01-071718	8.1	8.1	3%	8	M25-XS88-01-071718	1807452-4	6.2		27%
Trip 6	Orange	M30-XS127-01-071618	9.2	8.9	9%	8	M30-XS127-01-071618	1807369-9	9.8		6%
Trip 6	Orange	M30-XS170-01-071618	6.4	6.6	13%	5	M30-XS170-01-071618	1807369-10	6.7		5%
Trip 6	Red	M30-XS95-01-071618	7.0	6.9	8%	6	M30-XS95-01-071618	1807369-11	6.9		2%
Trip 6	Red	M31-XS9-01-071018	6.4	6.2	7%	6	M31-XS9-01-071018	1807369-12	4.2		41%
Trip 6	Orange	M32-XS58-01-071018	6.0	6.2	12%	5	M32-XS58-01-071018	1807369-13	5.5		9%
Trip 6	Red	M32-XS89-01-071018	9.7	9.7	7%	9	M32-XS89-01-071018	1807369-14	7.2		30%
Trip 6	Orange	M33-XS22-01-071218	7.5	7.4	7%	7	M33-XS22-01-071218	1807369-15	6.5		14%
Trip 6	Orange	M33-XS85-01-071218	6.7	6.7	7%	6	M33-XS85-01-071218	1807369-16	7.9		16%
Trip 6	Red	M33-XS93-01-071218	9.6	9.5	11%	9	M33-XS93-01-071218	1807369-17	8.9		8%
Trip 6	Red	T33-XS43-01-071718	12.1	11.6	13%	11	T33-XS43-01-071718	1807452-5	9.6		23%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Lead: Average Ex Situ XRF (ppm)	XRF - Lead: Median Ex Situ XRF (ppm)	XRF - Lead: Relative Standard Deviation	XRF - Lead: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 3	Blue	M15-XS73-01-052118	0.2	0.0	245%	0	M15-XS73-01-052118	1805589-5	6.9		188%
Trip 3	Blue	M16-XS166-01-052118	0.2	0.0	245%	0	M16-XS166-01-052118	1805589-9	7.8		191%
Trip 3	Blue	T20-XS14-01-052218	0.0	0.0	0%	0	T20-XS14-01-052218	1805632-10	4.2		200%
Trip 3	Blue	T21-XS6-01-052118	0.6	0.5	110%	0	T21-XS6-01-052118	1805589-17	5.5		162%
Trip 3	Blue	T21-XS35-01-052118	1.7	1.8	53%	0	T21-XS35-01-052118	1805589-14	8.6		135%
Trip 3	Blue	T21-XS55-01-052118	0.7	0.6	112%	0	T21-XS55-01-052118	1805589-15	6.3		161%
Trip 3	Blue	T22-XS17-01-052118	0.9	1.3	78%	0	T22-XS17-01-052118	1805589-18	5.7		146%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Lead: Average Ex Situ XRF (ppm)	XRF - Lead: Median Ex Situ XRF (ppm)	XRF - Lead: Relative Standard Deviation	XRF - Lead: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M24-XS128-01-061118	7.9	7.8	13%	7	M24-XS128-01-061118	1806312-4	20.0		87%
Trip 3	Blue	M16-XS45-01-052118	1.7	1.6	25%	1	M16-XS45-01-052118	1805589-13	7.5		126%

Notes:

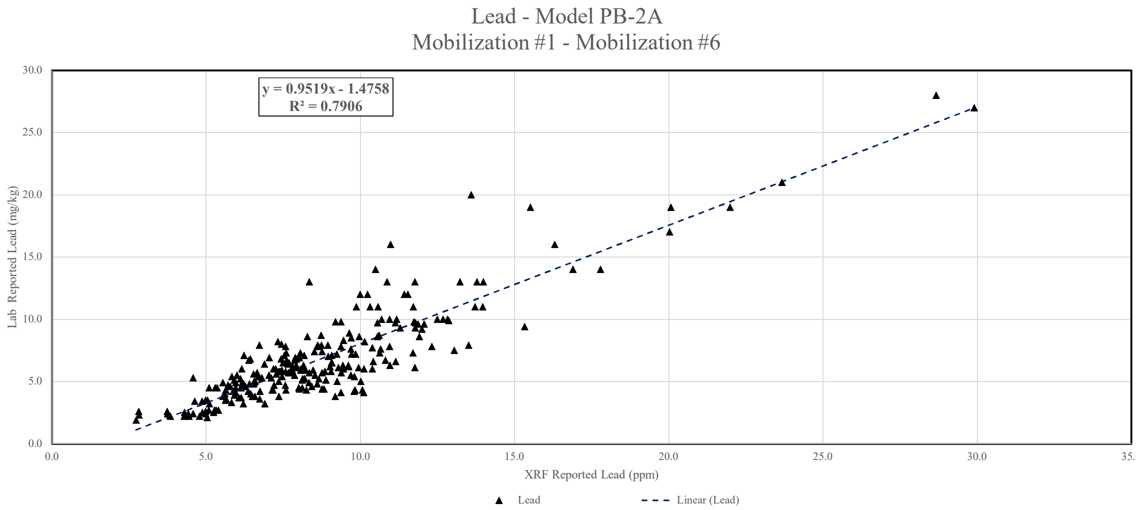
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model PB-2A											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	4.3	4.3	23%	3	M2-XS15-01-042418	1805041-1	2.5		53%
Trip 1	Pink	M2-XS15-02-042418	3.7	3.6	18%	3	M2-XS15-02-042418	1805041-2	2.4		44%
Trip 1	Pink	M2-XS32-01-042418	5.6	5.9	15%	4	M2-XS32-01-042418	1805041-3	3.6		44%
Trip 1	Pink	M2-XS59-01-042418	4.3	4.4	17%	3	M2-XS59-01-042418	1805041-4	2.2		64%
Trip 1	Pink	M2-XS73-01-042418	4.9	4.8	14%	4	M2-XS73-01-042418	1805041-5	2.5		64%
Trip 1	Pink	M3-XS34-01-043018	7.2	7.2	10%	6	M3-XS34-01-043018	1805042-1	4.7		42%
Trip 1	Pink	M3-XS36-01-043018	7.6	7.7	12%	7	M3-XS36-01-043018	1805042-2	6.4		18%
Trip 1	Pink	M6-XS140-01-042818	7.4	7.3	14%	6	M6-XS140-01-042818	1805041-6	5.0		38%
Trip 1	Orange	M6-XS159-01-04262018	6.9	6.7	17%	5	M6-XS159-01-04262018	1805039-1	6.4		7%
Trip 1	Pink	M6-XS251-01-04272018	8.2	8.0	15%	7	M6-XS251-01-04272018	1805039-2	7.1		14%
Trip 1	Pink	M6-XS269-01-04262018	7.3	7.2	15%	6	M6-XS269-01-04262018	1805039-3	8.2		11%
Trip 1	Pink	M6-XS269-02-04262018	7.4	7.1	15%	6	M6-XS269-02-04262018	1805039-4	5.8		24%
Trip 1	Pink	M6-XS285-01-04272018	10.5	10.7	11%	9	M6-XS285-01-04272018	1805039-5	14.0		29%
Trip 1	Pink	T10-XS1-01-042518	10.4	10.5	1%	9	T10-XS1-01-042518	1805036-1	6.6		45%
Trip 1	Pink	T10-XS20-01-042518	8.8	8.7	5%	8	T10-XS20-01-042518	1805036-2	4.4		66%
Trip 1	Pink	T10-XS33-01-042518	10.0	9.9	4%	9	T10-XS33-01-042518	1805036-3	5.0		67%
Trip 1	Pink	T10-XS56-01-042518	9.4	9.3	8%	8	T10-XS56-01-042518	1805036-4	6.0		45%
Trip 1	Pink	T10-XS78-01-042518	9.4	9.5	6%	9	T10-XS78-01-042518	1805036-5	5.7		49%
Trip 1	Pink	T11-XS1-01-042518	9.6	9.3	12%	8	T11-XS1-01-042518	1805036-6	6.3		42%
Trip 1	Pink	T11-XS20-01-042518	10.1	10.0	9%	9	T11-XS20-01-042518	1805036-7	6.0		51%
Trip 1	Pink	T11-XS60-01-042518	6.9	6.8	11%	6	T11-XS60-01-042518	1805036-8	3.2		73%
Trip 1	Pink	T17-XS1-01-04262018	5.0	4.8	21%	4	T17-XS1-01-04262018	1805039-6	2.4		70%
Trip 1	Pink	T17-XS1-02-04262018	4.8	4.9	11%	4	T17-XS1-02-04262018	1805039-7	2.2		74%
Trip 1	Pink	T17-XS143-01-04262018	20.0	19.4	8%	18	T17-XS143-01-04262018	1805039-8	17.0		16%
Trip 1	Pink	T17-XS194-01-04272018	7.1	7.1	8%	7	T17-XS194-01-04272018	1805039-10	4.3		50%
Trip 1	Pink	T17-XS194-02-04272018	7.4	7.0	11%	6	T17-XS194-02-04272018	1805039-11	3.8		64%
Trip 1	Pink	T17-XS20-01-04262018	6.1	6.0	14%	5	T17-XS20-01-04262018	1805039-12	3.7		49%
Trip 1	Pink	T17-XS208-01-042818	8.6	8.4	10%	8	T17-XS208-01-042818	1805041-7	4.8		57%
Trip 1	Pink	T17-XS251-01-04272018	9.1	8.9	9%	8	T17-XS251-01-04272018	1805039-13	7.1		24%
Trip 1	Pink	T17-XS257-01-04272018	10.8	10.8	9%	10	T17-XS257-01-04272018	1805039-14	6.7		47%
Trip 1	Pink	T17-XS273-01-042818	9.8	9.8	9%	9	T17-XS273-01-042818	1805041-8	7.2		31%
Trip 1	Pink	T17-XS287-01-04272018	11.1	11.7	10%	10	T17-XS287-01-04272018	1805039-15	9.7		14%
Trip 1	Pink	T17-XS304-01-042818	8.8	8.8	7%	8	T17-XS304-01-042818	1805041-9	4.4		67%
Trip 1	Pink	T17-XS317-01-04272018	9.1	9.2	6%	8	T17-XS317-01-04272018	1805039-16	6.5		33%
Trip 1	Pink	T17-XS328-01-04272018	11.1	11.0	4%	11	T17-XS328-01-04272018	1805039-17	6.6		51%
Trip 1	Pink	T17-XS369-01-043018	9.2	9.1	5%	9	T17-XS369-01-043018	1805042-4	5.0		60%
Trip 1	Pink	T17-XS377-01-042818	10.6	10.7	6%	10	T17-XS377-01-042818	1805041-10	7.3		37%
Trip 1	Pink	T17-XS393-01-043018	10.1	9.7	12%	9	T17-XS393-01-043018	1805042-5	4.3		80%
Trip 1	Pink	T17-XS417-01-04272018	9.4	9.4	4%	9	T17-XS417-01-04272018	1805039-18	6.3		40%
Trip 1	Pink	T17-XS438-01-042818	4.4	4.5	11%	4	T17-XS438-01-042818	1805041-11	2.4		59%
Trip 1	Pink	T17-XS44-01-04262018	8.6	8.3	10%	8	T17-XS44-01-04262018	1805039-19	5.2		50%
Trip 1	Pink	T17-XS442-01-04272018	7.3	7.1	6%	7	T17-XS442-01-04272018	1805039-20	5.6		26%
Trip 1	Pink	T17-XS46-01-042618	8.3	8.3	7%	8	T17-XS46-01-042618	1805041-12	4.9		52%
Trip 1	Pink	T17-XS473-01-042818	11.9	11.9	11%	11	T17-XS473-01-042818	1805041-13	8.6		32%
Trip 1	Pink	T17-XS479-01-042818	13.7	13.8	7%	12	T17-XS479-01-042818	1805041-14	11.0		22%
Trip 1	Pink	T17-XS479-02-042818	12.5	12.5	6%	12	T17-XS479-02-042818	1805041-15	10.0		22%
Trip 1	Pink	T17-XS603-01-042818	8.1	8.1	11%	7	T17-XS603-01-042818	1805041-16	4.5		57%

Data Included in Model PB-2A

Trip	XRF Color	XRF ID	XRF - Lead				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	T17-XS659-01-043018	9.4	9.3	7%	9	T17-XS659-01-043018	1805042-6	4.1		78%
Trip 1	Pink	T17-XS679-01-043018	13.0	13.1	7%	12	T17-XS679-01-043018	1805042-7	7.5		54%
Trip 1	Pink	T17-XS704-01-043018	9.2	9.2	9%	8	T17-XS704-01-043018	1805042-8	3.8		83%
Trip 1	Pink	T7-XS11-01-042418	5.0	5.0	1%	4	T7-XS11-01-042418	1805036-9	2.6		63%
Trip 1	Pink	T7-XS5-01-042418	5.3	5.2	15%	4	T7-XS5-01-042418	1805036-10	2.7		65%
Trip 1	Pink	T7-XS58-01-042418	5.1	5.3	18%	4	T7-XS58-01-042418	1805036-11	2.7		61%
Trip 1	Pink	T7-XS7-01-042418	4.4	4.4	13%	4	T7-XS7-01-042418	1805036-12	2.2		68%
Trip 1	Pink	T7-XS9-01-042418	5.4	5.7	18%	4	T7-XS9-01-042418	1805036-13	2.7		67%
Trip 1	Pink	T8-XS15-01-042418	6.7	6.5	11%	6	T8-XS15-01-042418	1805036-14	3.6		61%
Trip 1	Pink	T8-XS23-01-042418	6.6	6.5	13%	5	T8-XS23-01-042418	1805036-15	3.8		53%
Trip 1	Pink	T8-XS6-01-042418	5.3	5.4	12%	4	T8-XS6-01-042418	1805036-16	2.7		65%
Trip 1	Pink	T9-XS217-01-042518	8.8	8.8	7%	8	T9-XS217-01-042518	1805036-17	5.7		42%
Trip 1	Pink	T9-XS61-01-042518	7.9	7.7	12%	7	T9-XS61-01-042518	1805036-18	5.5		35%
Trip 1	Orange	T9-XS61-02-042518	7.7	7.5	8%	7	T9-XS61-02-042518	1805041-17	5.7		29%
Trip 1	Pink	T9-XS86-01-042518	8.0	8.1	12%	6	T9-XS86-01-042518	1805036-19	4.5		56%
Trip 1	Pink	T9-XS93-01-042518	6.6	6.8	12%	5	T9-XS93-01-042518	1805036-20	5.0		27%
Trip 2	Orange	M1-XS31-01-051218	6.2	6.0	18%	5	M1-XS31-01-051218	1805328-1	4.9		23%
Trip 2	Pink	M1-XS32-01-051218	6.5	6.6	5%	6	M1-XS32-01-051218	1805328-2	4.9		29%
Trip 2	Pink	M4-XS136-01-050918	8.1	7.6	25%	6	M4-XS136-01-050918	1805322-1	7.3		10%
Trip 2	Pink	M4-XS18-01-050718	10.9	10.7	10%	10	M4-XS18-01-050718	1805322-2	10.0		9%
Trip 2	Orange	M4-XS219-01-051018	7.8	7.7	11%	6	M4-XS219-01-051018	1805322-3	5.9		28%
Trip 2	Pink	M4-XS238-01-051018	16.3	13.1	58%	8	M4-XS238-01-051018	1805322-4	16.0		2%
Trip 2	Pink	M4-XS4-01-050718	8.0	7.9	12%	7	M4-XS4-01-050718	1805322-5	4.4		58%
Trip 2	Pink	M4-XS45-01-050718	6.2	6.0	13%	5	M4-XS45-01-050718	1805322-6	7.1		13%
Trip 2	Pink	M4-XS63-01-050718	22.0	22.8	14%	17	M4-XS63-01-050718	1805322-7	19.0		15%
Trip 2	Pink	M4-XS63-02-050718	13.6	12.5	21%	11	M4-XS63-02-050718	1805322-8	20.0		38%
Trip 2	Pink	M4-XS78-01-051018	10.4	10.3	8%	9	M4-XS78-01-051018	1805322-9	7.7		30%
Trip 2	Orange	M5-XS115-01-051118	9.3	9.1	8%	9	M5-XS115-01-051118	1805322-10	6.1		41%
Trip 2	Pink	M5-XS385-01-051118	6.1	5.8	12%	6	M5-XS385-01-051118	1805322-11	3.7		48%
Trip 2	Pink	M5-XS69-01-051118	12.9	12.7	14%	11	M5-XS69-01-051118	1805322-12	9.9		26%
Trip 2	Orange	M6-XS41-01-051118	3.7	3.9	16%	3	M6-XS41-01-051118	1805322-13	2.6		36%
Trip 2	Pink	M6-XS44-01-051018	6.2	6.3	8%	5	M6-XS44-01-051018	1805322-14	4.8		26%
Trip 2	Pink	M6-XS81-01-051018	5.0	4.4	25%	3	M6-XS81-01-051018	1805322-15	3.5		35%
Trip 2	Pink	M7-XS181-01-051018	7.4	7.5	11%	6	M7-XS181-01-051018	1805322-16	5.9		23%
Trip 2	Orange	M7-XS181-02-051018	7.7	7.7	7%	7	M7-XS181-02-051018	1805322-17	5.7		30%
Trip 2	Orange	M7-XS39-01-051018	4.6	4.6	6%	4	M7-XS39-01-051018	1805322-18	3.4		31%
Trip 2	Orange	M7-XS74-01-051018	6.6	6.8	15%	5	M7-XS74-01-051018	1805322-19	5.7		15%
Trip 2	Orange	M7-XS77-01-051018	7.5	7.3	13%	6	M7-XS77-01-051018	1805322-20	7.1		6%
Trip 2	Pink	M8-XS100-01-050918	10.1	10.1	13%	8	M8-XS100-01-050918	1805328-3	4.1		85%
Trip 2	Pink	M8-XS102-01-050918	28.7	27.9	8%	26	M8-XS102-01-050918	1805328-4	28.0		2%
Trip 2	Pink	M8-XS102-02-050918	29.9	30.5	7%	26	M8-XS102-02-050918	1805328-5	27.0		10%
Trip 2	Pink	M8-XS110-01-050918	10.7	10.1	13%	10	M8-XS110-01-050918	1805328-6	7.6		33%
Trip 2	Orange	M8-XS19-01-051018	9.0	9.0	11%	8	M8-XS19-01-051018	1805328-7	6.2		37%
Trip 2	Orange	M8-XS32-01-051018	10.7	10.9	7%	10	M8-XS32-01-051018	1805328-8	10.0		7%
Trip 2	Pink	M8-XS94-01-050918	13.8	13.3	22%	10	M8-XS94-01-050918	1805328-9	13.0		6%
Trip 2	Pink	T13-XS12-01-050818	11.8	11.5	11%	11	T13-XS12-01-050818	1805322-21	9.7		19%
Trip 2	Pink	T13-XS24-01-050818	6.2	6.2	13%	5	T13-XS24-01-050818	1805322-22	3.2		64%
Trip 2	Pink	T14-XS12-01-050818	9.0	9.0	7%	8	T14-XS12-01-050818	1805322-23	7.0		24%
Trip 2	Pink	T14-XS27-01-050818	7.2	7.2	8%	6	T14-XS27-01-050818	1805322-24	4.3		50%
Trip 2	Pink	T15-XS2-01-050818	10.4	10.2	9%	9	T15-XS2-01-050818	1805322-25	6.0		54%
Trip 2	Pink	T15-XS45-01-050818	7.6	7.8	14%	6	T15-XS45-01-050818	1805322-26	4.7		47%
Trip 2	Pink	T17-XS122-01-050718	12.3	11.9	13%	11	T17-XS122-01-050718	1805322-27	7.8		45%
Trip 2	Pink	T17-XS176-01-050718	8.9	8.8	5%	8	T17-XS176-01-050718	1805322-28	5.8		42%
Trip 2	Pink	T17-XS178-01-050718	8.5	8.4	8%	8	T17-XS178-01-050718	1805322-29	5.5		43%
Trip 2	Pink	T17-XS619-01-050718	9.9	10.1	11%	9	T17-XS619-01-050718	1805322-30	6.1		48%
Trip 2	Pink	T17-XS619-02-050718	9.1	9.1	6%	8	T17-XS619-02-050718	1805322-31	5.8		44%
Trip 2	Pink	T17-XS645-01-050718	8.9	9.0	10%	8	T17-XS645-01-050718	1805322-32	5.1		54%
Trip 2	Pink	T17-XS669-01-050718	8.2	8.3	6%	8	T17-XS669-01-050718	1805322-33	4.3		63%
Trip 2	Pink	T1-XS104-01-051318	9.7	9.2	13%	9	T1-XS104-01-051318	1805328-10	7.6		24%
Trip 2	Pink	T1-XS20-01-051318	6.6	6.7	23%	5	T1-XS20-01-051318	1805328-11	5.0		27%
Trip 2	Pink	T1-XS54-01-051318	7.8	8.1	11%	6	T1-XS54-01-051318	1805328-12	6.2		23%
Trip 2	Pink	T1-XS54-02-051318	8.1	8.0	8%	8	T1-XS54-02-051318	1805328-13	6.3		26%
Trip 2	Pink	T1-XS69-01-051318	13.2	13.6	12%	11	T1-XS69-01-051318	1805328-14	13.0		2%
Trip 2	Orange	T3-XS10-01-051218	6.5	6.1	20%	5	T3-XS10-01-051218	1805328-15	3.8		52%
Trip 2	Orange	T3-XS5-01-051218	5.5	5.6	7%	5	T3-XS5-01-051218	1805328-16	3.8		37%
Trip 2	Pink	T4-XS23-01-051218	6.4	6.4	16%	5	T4-XS23-01-051218	1805328-17	4.0		47%
Trip 2	Orange	T4-XS32-01-051218	5.0	4.8	10%	5	T4-XS32-01-051218	1805328-18	3.5		36%
Trip 2	Pink	T4-XS43-01-051218	14.0	13.8	9%	13	T4-XS43-01-051218	1805328-19	11.0		24%
Trip 2	Pink	T5-XS18-01-051418	2.8	2.8	22%	2	T5-XS18-01-051418	1805328-20	2.3		20%
Trip 2	Pink	T6-XS2-01-051218	5.0	5.0	12%	4	T6-XS2-01-051218	1805328-21	2.1		82%
Trip 2	Orange	T6-XS25-01-051218	5.2	5.5	14%	4	T6-XS25-01-051218	1805328-22	2.5		71%

Data Included in Model PB-2A											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Pink	M14-XS36-01-052418	11.7	12.1	6%	11	M14-XS36-01-052418	1805632-1	9.8		18%
Trip 3	Pink	M14-XS40-01-052418	10.6	10.6	5%	10	M14-XS40-01-052418	1805632-2	8.7		20%
Trip 3	Pink	M14-XS64-01-052418	6.7	6.5	15%	6	M14-XS64-01-052418	1805632-3	5.4		22%
Trip 3	Pink	M14-XS67-01-052418	12.0	11.6	16%	10	M14-XS67-01-052418	1805632-4	9.2		26%
Trip 3	Pink	M15-XS22-01-052118	7.9	7.8	6%	7	M15-XS22-01-052118	1805589-1	6.1		26%
Trip 3	Pink	M15-XS3-01-052118	8.2	8.2	8%	7	M15-XS3-01-052118	1805589-2	5.9		33%
Trip 3	Pink	M15-XS46-01-052118	5.6	5.5	10%	5	M15-XS46-01-052118	1805589-3	4.3		27%
Trip 3	Pink	M15-XS46-02-052118	5.6	5.7	12%	4	M15-XS46-02-052118	1805589-4	4		33%
Trip 3	Pink	M15-XS82-01-052118	10.9	10.9	7%	10	M15-XS82-01-052118	1805589-6	13		18%
Trip 3	Pink	M15-XS93-01-052118	11.8	11.9	11%	10	M15-XS93-01-052118	1805589-7	9.3		24%
Trip 3	Pink	M16-XS128-01-052118	10.3	10.7	24%	6	M16-XS128-01-052118	1805589-8	11		6%
Trip 3	Pink	M16-XS154-01-052618	7.9	7.8	8%	7	M16-XS154-01-052618	1806235-2	6.2		24%
Trip 3	Pink	M16-XS177-01-052618	6.2	6.1	13%	5	M16-XS177-01-052618	1806235-3	4.6		29%
Trip 3	Pink	M16-XS191-01-052618	5.8	5.9	4%	5	M16-XS191-01-052618	1806235-4	5.4		8%
Trip 3	Pink	M16-XS191-02-052618	7.5	7.5	8%	7	M16-XS191-02-052618	1806235-5	5.4		32%
Trip 3	Pink	M16-XS30-01-052118	6.5	7.0	17%	5	M16-XS30-01-052118	1805589-10	5.6		15%
Trip 3	Pink	M16-XS31-01-052118	5.6	5.4	20%	5	M16-XS31-01-052118	1805589-11	3.5		46%
Trip 3	Pink	M16-XS4-01-052118	8.3	8.6	13%	7	M16-XS4-01-052118	1805589-12	5.7		38%
Trip 3	Pink	M17-XS55-01-052618	9.7	9.4	8%	9	M17-XS55-01-052618	1806235-6	8.5		13%
Trip 3	Pink	M17-XS83-01-052618	11.7	11.7	7%	11	M17-XS83-01-052618	1806235-7	11		6%
Trip 3	Pink	M17-XS83-02-052618	12.8	13.1	9%	11	M17-XS83-02-052618	1806235-8	10		25%
Trip 3	Pink	M18-XS155-01-052518	4.9	4.6	12%	4	M18-XS155-01-052518	1805632-5	3.4		35%
Trip 3	Pink	M18-XS161-01-052518	23.7	23.1	16%	19	M18-XS161-01-052518	1805632-6	21		12%
Trip 3	Pink	M19-XS22-01-052318	12.7	12.8	6%	12	M19-XS22-01-052318	1805632-7	10		24%
Trip 3	Pink	M19-XS22-02-052318	11.2	11.1	9%	10	M19-XS22-02-052318	1805632-8	10		11%
Trip 3	Pink	M19-XS43-01-052318	9.6	9.4	11%	8	M19-XS43-01-052318	1805632-9	6.2		43%
Trip 3	Pink	T21-XS55-02-052118	11.0	10.7	8%	10	T21-XS55-02-052118	1805589-16	6.3		54%
Trip 3	Pink	T22-XS64-01-052218	8.4	8.4	11%	7	T22-XS64-01-052218	1805632-11	4.6		59%
Trip 3	Pink	T23-XS23-01-052118	11.7	11.6	9%	11	T23-XS23-01-052118	1805589-19	7.3		46%
Trip 3	Pink	T23-XS40-01-052118	10.9	11.0	4%	10	T23-XS40-01-052118	1805589-20	7.8		34%
Trip 3	Pink	T24-XS48-01-052418	10.2	9.8	15%	9	T24-XS48-01-052418	1805632-12	12		16%
Trip 4	Pink	M13-XS72-01-060618	9.9	9.9	9%	9	M13-XS72-01-060618	1806235-1	11.0		11%
Trip 4	Pink	M20-XS11-01-060618	5.9	5.7	14%	5	M20-XS11-01-060618	1806235-9	3.9		41%
Trip 4	Pink	M20-XS130-01-060418	17.8	18.3	10%	14	M20-XS130-01-060418	1806235-10	14.0		24%
Trip 4	Pink	M20-XS166-01-060518	6.2	6.2	13%	5	M20-XS166-01-060518	1806235-11	6.0		2%
Trip 4	Pink	M20-XS18-01-060618	7.1	6.8	12%	6	M20-XS18-01-060618	1806235-12	5.3		29%
Trip 4	Pink	M20-XS185-01-060418	9.8	9.8	8%	9	M20-XS185-01-060418	1806235-13	5.4		58%
Trip 4	Pink	M20-XS231-01-060418	9.7	9.2	12%	9	M20-XS231-01-060418	1806235-14	5.5		55%
Trip 4	Pink	M20-XS278-01-060418	4.6	4.7	28%	3	M20-XS278-01-060418	1806235-15	5.3		15%
Trip 4	Pink	M20-XS306-01-060518	8.7	8.8	16%	7	M20-XS306-01-060518	1806235-16	7.9		10%
Trip 4	Pink	M20-XS312-01-060518	6.8	6.8	16%	5	M20-XS312-01-060518	1806235-17	5.3		25%
Trip 4	Pink	M20-XS365-01-060618	9.4	10.2	19%	6	M20-XS365-01-060618	1806235-18	8.3		13%
Trip 4	Pink	M20-XS365-02-060618	9.1	9.1	9%	8	M20-XS365-02-060618	1806235-19	6.5		33%
Trip 4	Pink	M20-XS5-01-060518	10.6	10.6	10%	9	M20-XS5-01-060518	1806235-20	8.6		20%
Trip 4	Pink	M20-XS86-01-060618	5.4	5.2	17%	5	M20-XS86-01-060618	1806235-21	4.5		17%
Trip 4	Pink	M21-XS122-01-060818	11.4	11.5	8%	10	M21-XS122-01-060818	1806234-1	12.0		5%
Trip 4	Pink	M21-XS126-01-060818	7.3	7.8	17%	6	M21-XS126-01-060818	1806234-2	6.0		19%
Trip 4	Pink	M21-XS14-01-060818	8.6	8.8	13%	7	M21-XS14-01-060818	1806234-3	7.8		10%
Trip 4	Pink	M21-XS175-01-060818	9.2	9.6	12%	8	M21-XS175-01-060818	1806234-4	7.2		25%
Trip 4	Pink	M21-XS225-01-060518	7.6	7.5	16%	6	M21-XS225-01-060518	1806235-22	6.7		13%
Trip 4	Pink	M21-XS259-01-060918	7.9	7.7	11%	7	M21-XS259-01-060918	1806234-5	6.8		15%
Trip 4	Pink	M21-XS260-01-060918	8.9	8.8	8%	8	M21-XS260-01-060918	1806234-6	7.9		12%
Trip 4	Pink	M21-XS27-01-060818	5.3	5.1	13%	5	M21-XS27-01-060818	1806234-7	4.5		16%
Trip 4	Pink	M21-XS27-02-060818	5.8	5.8	16%	5	M21-XS27-02-060818	1806234-8	4.6		23%
Trip 4	Pink	M21-XS282-01-060918	5.9	6.0	17%	4	M21-XS282-01-060918	1806234-9	4.2		33%
Trip 4	Pink	M21-XS290-01-060918	11.8	11.8	11%	10	M21-XS290-01-060918	1806234-10	13.0		10%
Trip 4	Pink	M21-XS292-01-060518	5.7	5.8	19%	4	M21-XS292-01-060518	1806235-23	4.7		19%
Trip 4	Pink	M21-XS302-01-060918	7.9	7.8	9%	7	M21-XS302-01-060918	1806234-11	6.2		25%
Trip 4	Pink	M21-XS302-02-060918	7.9	7.8	12%	7	M21-XS302-02-060918	1806234-12	6.7		16%
Trip 4	Pink	M21-XS334-01-060918	20.1	19.3	11%	18	M21-XS334-01-060918	1806234-13	19.0		5%
Trip 4	Pink	M21-XS377-01-060918	8.1	8.0	14%	7	M21-XS377-01-060918	1806234-14	5.2		44%
Trip 4	Pink	M21-XS40-01-060818	8.3	8.2	10%	7	M21-XS40-01-060818	1806234-15	8.6		4%
Trip 4	Pink	M21-XS403-01-060818	10.1	10.8	18%	7	M21-XS403-01-060818	1806234-16	8.2		21%
Trip 4	Pink	M21-XS419-01-060818	10.5	10.8	13%	8	M21-XS419-01-060818	1806234-17	9.7		8%
Trip 4	Pink	M21-XS46-01-060818	11.9	11.5	14%	10	M21-XS46-01-060818	1806234-18	9.6		21%
Trip 4	Pink	M21-XS477-01-060818	11.3	11.2	11%	10	M21-XS477-01-060818	1806234-19	9.3		19%
Trip 4	Pink	M21-XS541-01-060818	8.1	8.3	7%	7	M21-XS541-01-060818	1806234-20	5.9		31%
Trip 4	Pink	M21-XS596-01-060518	7.0	7.4	15%	6	M21-XS596-01-060518	1806235-24	5.5		24%
Trip 4	Pink	M21-XS615-01-060518	6.5	6.5	3%	6	M21-XS615-01-060518	1806235-25	4.8		31%
Trip 4	Pink	M21-XS619-01-060618	7.4	7.9	13%	6	M21-XS619-01-060618	1806235-26	8.0		7%
Trip 4	Pink	M22-XS14-01-060418	8.0	8.0	11%	7	M22-XS14-01-060418	1806235-27	6.9		15%

Data Included in Model PB-2A											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M22-XS30-01-060418	5.5	6.1	24%	4	M22-XS30-01-060418	1806235-28	4.9		12%
Trip 4	Pink	M22-XS40-01-060518	10.6	11.1	19%	7	M22-XS40-01-060518	1806235-29	11.0		4%
Trip 4	Pink	M22-XS60-01-060418	6.4	5.9	15%	5	M22-XS60-01-060418	1806235-30	6.8		6%
Trip 4	Pink	M22-XS87-01-060418	8.6	9.0	13%	7	M22-XS87-01-060418	1806235-31	7.9		9%
Trip 4	Pink	M23-XS102-01-061018	10.0	9.9	10%	8	M23-XS102-01-061018	1806233-1	8.6		15%
Trip 4	Pink	M23-XS123-01-061018	8.2	8.2	12%	7	M23-XS123-01-061018	1806233-2	5.2		45%
Trip 4	Pink	M23-XS20-01-061018	16.9	16.2	11%	14	M23-XS20-01-061018	1806233-3	14.0		19%
Trip 4	Pink	M23-XS48-01-061018	9.8	10.0	9%	8	M23-XS48-01-061018	1806233-4	4.2		80%
Trip 4	Pink	M23-XS54-01-061118	9.4	9.5	10%	8	M23-XS54-01-061118	1806312-1	7.8		18%
Trip 4	Pink	M23-XS64-01-061018	8.2	7.7	13%	7	M23-XS64-01-061018	1806233-5	5.2		44%
Trip 4	Pink	M23-XS70-01-061018	11.8	11.8	4%	11	M23-XS70-01-061018	1806233-6	6.1		63%
Trip 4	Pink	M23-XS79-01-061018	8.1	8.1	14%	7	M23-XS79-01-061018	1806233-7	5.1		46%
Trip 4	Pink	M24-XS100-01-061118	8.5	8.7	10%	7	M24-XS100-01-061118	1806312-3	7.4		14%
Trip 4	Pink	T18-XS14-01-061118	6.0	5.9	9%	5	T18-XS14-01-061118	1806312-5	4.1		37%
Trip 4	Pink	T18-XS27-01-061118	2.7	2.7	16%	2	T18-XS27-01-061118	1806312-6	1.9		36%
Trip 4	Pink	T25-XS2-01-060618	7.6	7.3	8%	7	T25-XS2-01-060618	1806235-32	4.3		55%
Trip 4	Pink	T26-XS1-01-061018	6.0	6.0	18%	5	T26-XS1-01-061018	1806233-8	4.9		19%
Trip 4	Pink	T26-XS8-01-061018	5.1	5.0	11%	4	T26-XS8-01-061018	1806233-9	4.5		12%
Trip 4	Pink	T27-XS19-01-061018	9.8	9.9	6%	9	T27-XS19-01-061018	1806233-10	4.3		78%
Trip 4	Pink	T27-XS6-01-061018	13.5	13.3	6%	13	T27-XS6-01-061018	1806233-11	7.9		52%
Trip 5	Pink	M26-XS13-01-061818	2.8	2.7	16%	2	M26-XS13-01-061818	1806558-1	2.6		8%
Trip 5	Pink	M26-XS25-01-061818	7.4	7.5	18%	6	M26-XS25-01-061818	1806558-2	6.8		9%
Trip 5	Pink	M27-XS108-01-061918	7.3	7.4	7%	7	M27-XS108-01-061918	1806558-3	5.8		23%
Trip 5	Pink	M27-XS109-01-061918	7.7	7.9	10%	6	M27-XS109-01-061918	1806558-4	5.7		30%
Trip 5	Pink	M27-XS123-01-061818	5.1	5.0	15%	4	M27-XS123-01-061818	1806558-5	3.2		46%
Trip 5	Pink	M27-XS188-01-061918	7.7	7.6	6%	7	M27-XS188-01-061918	1806558-6	6.5		17%
Trip 5	Pink	M27-XS197-01-061918	6.1	5.9	10%	6	M27-XS197-01-061918	1806558-7	5.2		16%
Trip 5	Pink	M27-XS210-01-061818	6.4	6.4	11%	5	M27-XS210-01-061818	1806558-8	4.8		29%
Trip 5	Pink	M27-XS210-02-061818	6.1	6.5	17%	5	M27-XS210-02-061818	1806558-9	4.5		30%
Trip 5	Pink	M27-XS21-01-061918	7.9	7.5	39%	5	M27-XS21-01-061918	1806558-10	6.9		13%
Trip 5	Pink	M27-XS239-01-061818	4.6	4.6	9%	4	M27-XS239-01-061818	1806558-11	2.4		62%
Trip 5	Pink	M27-XS275-01-061918	7.6	7.5	18%	5	M27-XS275-01-061918	1806558-12	7.8		3%
Trip 5	Pink	M27-XS283-01-061818	8.7	8.9	18%	7	M27-XS283-01-061818	1806558-13	8.7		0%
Trip 5	Pink	M27-XS29-01-061818	5.9	5.9	10%	5	M27-XS29-01-061818	1806558-14	5.1		15%
Trip 5	Pink	M27-XS38-01-061918	7.6	7.6	11%	6	M27-XS38-01-061918	1806558-15	5.8		26%
Trip 5	Pink	M28-XS105-01-062018	6.3	6.1	15%	5	M28-XS105-01-062018	1806558-16	4.6		31%
Trip 5	Pink	M28-XS148-01-062018	8.8	8.6	10%	8	M28-XS148-01-062018	1806558-17	7.4		17%
Trip 5	Pink	M28-XS155-01-062018	5.9	5.7	9%	5	M28-XS155-01-062018	1806558-18	4.5		28%
Trip 5	Pink	M28-XS170-01-062018	10.0	9.9	9%	9	M28-XS170-01-062018	1806558-19	12		18%
Trip 5	Pink	M28-XS43-01-062018	9.4	9.6	16%	8	M28-XS43-01-062018	1806558-20	9.8		5%
Trip 5	Pink	M28-XS8-01-062018	5.8	6.1	13%	5	M28-XS8-01-062018	1806558-21	3.3		55%
Trip 5	Pink	M30-XS138-01-062218	7.2	7.0	18%	6	M30-XS138-01-062218	1806693-1	6		18%
Trip 5	Pink	M30-XS222-01-062218	7.6	7.6	11%	6	M30-XS222-01-062218	1806693-2	7.3		4%
Trip 5	Pink	T32-XS5-01-062018	6.7	6.8	8%	6	T32-XS5-01-062018	1806558-22	4.2		47%
Trip 6	Orange	M10-XS10A-01-071118	8.3	8.1	16%	7	M10-XS10A-01-071118	1807369-1	13.0		44%
Trip 6	Orange	M10-XS31-01-071118	8.2	7.9	8%	8	M10-XS31-01-071118	1807369-2	5.9		33%
Trip 6	Orange	M10-XS31-02-071118	8.5	8.6	12%	7	M10-XS31-02-071118	1807369-3	5.9		36%
Trip 6	Orange	M11-XS11-01-071118	15.5	15.5	10%	14	M11-XS11-01-071118	1807369-4	19.0		20%
Trip 6	Red	M11-XS7-01-071118	11.5	11.7	9%	10	M11-XS7-01-071118	1807369-5	12.0		4%
Trip 6	Red	M12-XS27-01-071518	3.8	3.8	11%	3	M12-XS27-01-071518	1807369-6	2.2		54%
Trip 6	Orange	M24-XS115-01-071418	11.0	10.7	9%	10	M24-XS115-01-071418	1807369-7	16.0		37%
Trip 6	Red	M25-XS16-01-071718	14.0	13.7	10%	13	M25-XS16-01-071718	1807452-1	13.0		7%
Trip 6	Red	M25-XS23-01-071718	15.3	14.4	26%	12	M25-XS23-01-071718	1807452-2	9.4		48%
Trip 6	Red	M25-XS47-01-071718	6.1	5.8	20%	5	M25-XS47-01-071718	1807452-3	4.5		31%
Trip 6	Red	M25-XS88-01-071718	8.1	8.1	3%	8	M25-XS88-01-071718	1807452-4	6.2		27%
Trip 6	Orange	M30-XS127-01-071618	9.2	8.9	9%	8	M30-XS127-01-071618	1807369-9	9.8		6%
Trip 6	Orange	M30-XS170-01-071618	6.4	6.6	13%	5	M30-XS170-01-071618	1807369-10	6.7		5%
Trip 6	Red	M30-XS95-01-071618	7.0	6.9	8%	6	M30-XS95-01-071618	1807369-11	6.9		2%
Trip 6	Red	M31-XS9-01-071018	6.4	6.2	7%	6	M31-XS9-01-071018	1807369-12	4.2		41%
Trip 6	Orange	M32-XS58-01-071018	6.0	6.2	12%	5	M32-XS58-01-071018	1807369-13	5.5		9%
Trip 6	Red	M32-XS89-01-071018	9.7	9.7	7%	9	M32-XS89-01-071018	1807369-14	7.2		30%
Trip 6	Orange	M33-XS22-01-071218	7.5	7.4	7%	7	M33-XS22-01-071218	1807369-15	6.5		14%
Trip 6	Orange	M33-XS85-01-071218	6.7	6.7	7%	6	M33-XS85-01-071218	1807369-16	7.9		16%
Trip 6	Red	M33-XS93-01-071218	9.6	9.5	11%	9	M33-XS93-01-071218	1807369-17	8.9		8%
Trip 6	Red	T33-XS43-01-071718	12.1	11.6	13%	11	T33-XS43-01-071718	1807452-5	9.6		23%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental
ppm = parts per million

mg/kg = milligrams per kilogram
XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Lead				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 3	Blue	M15-XS73-01-052118	0.2	0.0	245%	0	M15-XS73-01-052118	1805589-5	6.9		188%
Trip 3	Blue	M16-XS166-01-052118	0.2	0.0	245%	0	M16-XS166-01-052118	1805589-9	7.8		191%
Trip 3	Blue	T20-XS14-01-052218	0.0	0.0	0%	0	T20-XS14-01-052218	1805632-10	4.2		200%
Trip 3	Blue	T21-XS6-01-052118	0.6	0.5	110%	0	T21-XS6-01-052118	1805589-17	5.5		162%
Trip 3	Blue	T21-XS35-01-052118	1.7	1.8	53%	0	T21-XS35-01-052118	1805589-14	8.6		135%
Trip 3	Blue	T21-XS55-01-052118	0.7	0.6	112%	0	T21-XS55-01-052118	1805589-15	6.3		161%
Trip 3	Blue	T22-XS17-01-052118	0.9	1.3	78%	0	T22-XS17-01-052118	1805589-18	5.7		146%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Lead				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 4	Pink	M24-XS128-01-061118	7.9	7.8	13%	7	M24-XS128-01-061118	1806312-4	20.0		87%
Trip 3	Blue	M16-XS45-01-052118	1.7	1.6	25%	1	M16-XS45-01-052118	1805589-13	7.5		126%

7

Removed Data - Above 40 ppm

Trip	XRF Color	XRF ID	XRF - Lead				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Orange	T17-XS144-01-04262018	118.8	115.5	11%	106	T17-XS144-01-04262018	1805039-9	120.0		1%

Notes:

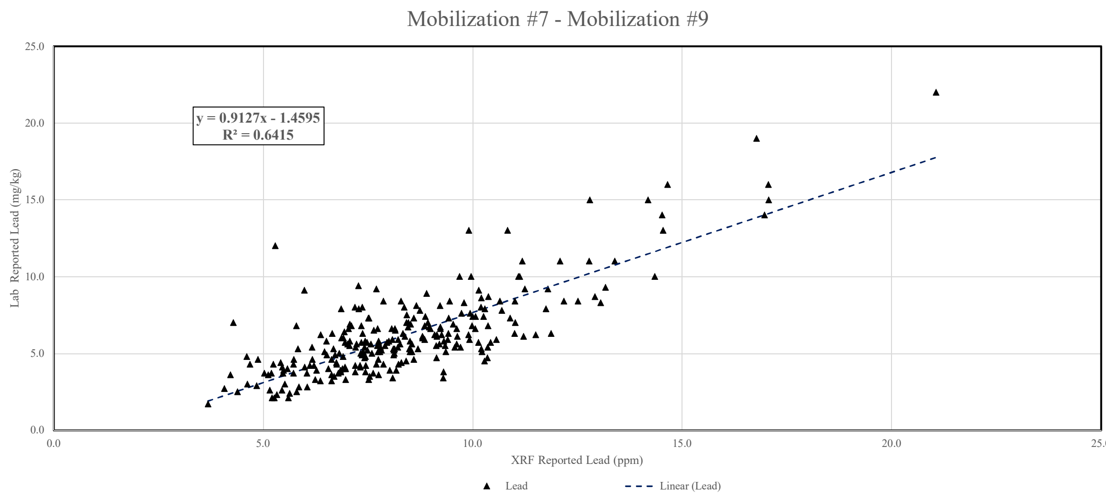
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M10-XS22-01-082118	6.8	7.2	18%	5	M10-XS22-01-082118	1808494-1	4.3		44%
Trip 7	Red	M10-XS39-01-082118	6.7	6.8	7%	6	M10-XS39-01-082118	1808494-2	3.5		63%
Trip 7	Red	M10-XS43-01-082118	8.3	8.4	12%	7	M10-XS43-01-082118	1808494-3	6.3		28%
Trip 7	Red	M1-XSG2-01-081918	7.8	7.6	10%	7	M1-XSG2-01-081918	1808483-1	5.1		42%
Trip 7	Pink	M34-XS110-01-081218	10.0	9.8	6%	9	M34-XS110-01-081218	1808303-1	10.0		0%
Trip 7	Pink	M34-XS22-01-081218	7.2	7.2	5%	7	M34-XS22-01-081218	1808303-2	5.4		29%
Trip 7	Pink	M34-XS43-01-081218	10.7	10.8	8%	9	M34-XS43-01-081218	1808303-3	7.8		31%
Trip 7	Pink	M34-XS50-01-081218	8.4	8.4	17%	7	M34-XS50-01-081218	1808303-4	7.0		18%
Trip 7	Pink	M34-XS68-01-081218	7.2	7.1	28%	5	M34-XS68-01-081218	1808303-5	8.0		11%
Trip 7	Pink	M35-XS11-01-081218	12.1	11.9	21%	8	M35-XS11-01-081218	1808303-6	11.0		9%
Trip 7	Pink	M35-XS20-01-081318	12.8	12.0	24%	9	M35-XS20-01-081318	1808303-7	15.0		16%
Trip 7	Pink	M35-XS31-01-081218	7.6	7.7	12%	6	M35-XS31-01-081218	1808303-8	6.5		16%
Trip 7	Pink	M35-XS63-01-081218	4.2	4.1	25%	3	M35-XS63-01-081218	1808303-9	3.6		16%
Trip 7	Pink	M35-XS74-01-081318	6.7	6.8	9%	6	M35-XS74-01-081318	1808303-10	4.9		31%
Trip 7	Pink	M35-XS74-02-081318	6.2	6.2	12%	5	M35-XS74-02-081318	1808303-11	4.2		39%
Trip 7	Pink	M36-XS20-01-081218	4.7	4.8	10%	4	M36-XS20-01-081218	1808303-12	4.3		9%
Trip 7	Pink	M36-XS2-01-081218	9.3	9.0	9%	8	M36-XS2-01-081218	1808303-13	5.5		52%
Trip 7	Pink	M36-XS3-01-081218	5.7	5.8	11%	5	M36-XS3-01-081218	1808303-14	3.7		43%
Trip 7	Pink	M36-XS31-01-081218	9.5	8.8	16%	8	M36-XS31-01-081218	1808303-15	8.4		12%
Trip 7	Pink	M37-XS124A-01-081318	10.8	10.9	12%	9	M37-XS124A-01-081318	1808303-16	13.0		18%
Trip 7	Pink	M37-XS144-01-081318	8.3	8.2	17%	7	M37-XS144-01-081318	1808303-17	8.4		1%
Trip 7	Pink	M37-XS2-01-081318	6.6	6.8	13%	6	M37-XS2-01-081318	1808303-18	6.3		5%
Trip 7	Pink	M37-XS23-01-081318	5.5	5.2	32%	4	M37-XS23-01-081318	1808303-19	4.1		28%
Trip 7	Pink	M37-XS31-01-081318	5.6	5.8	11%	4	M37-XS31-01-081318	1808303-20	4.0		33%
Trip 7	Pink	M37-XS38-01-081318	4.6	4.6	18%	3	M37-XS38-01-081318	1808356-1	4.8		4%
Trip 7	Pink	M37-XS44-01-081318	7.4	7.3	13%	6	M37-XS44-01-081318	1808356-2	6.3		16%
Trip 7	Pink	M37-XS50-01-081318	7.3	7.6	19%	6	M37-XS50-01-081318	1808356-3	9.4		26%
Trip 7	Pink	M37-XS7-01-081318	7.5	7.7	13%	6	M37-XS7-01-081318	1808356-4	7.3		3%
Trip 7	Red	M38-XS20-01-081818	8.0	7.9	9%	7	M38-XS20-01-081818	1808483-2	5.7		33%
Trip 7	Red	M3-XS19-01-081718	7.0	6.7	13%	6	M3-XS19-01-081718	1808476-1	4.0		54%
Trip 7	Red	M3-XS41-01-081718	7.3	7.6	9%	6	M3-XS41-01-081718	1808476-2	5.0		38%
Trip 7	Red	M4-XS210-01-081818	5.2	5.1	12%	4	M4-XS210-01-081818	1808483-3	2.6		66%
Trip 7	Red	M4-XSG11-01-081818	6.1	6.1	14%	5	M4-XSG11-01-081818	1808483-4	4.2		37%
Trip 7	Red	M4-XSG2-01-081818	9.3	9.6	9%	8	M4-XSG2-01-081818	1808483-5	3.8		84%
Trip 7	Red	M5-XS131-01-082018	8.1	7.9	11%	7	M5-XS131-01-082018	1808487-1	6.6		20%
Trip 7	Red	M5-XS15-01-081818	5.5	5.5	19%	4	M5-XS15-01-081818	1808483-6	3.7		39%
Trip 7	Red	M5-XS192-01-081818	8.4	8.5	7%	8	M5-XS192-01-081818	1808483-7	8.0		4%
Trip 7	Red	M5-XS199-01-082018	6.9	6.8	10%	6	M5-XS199-01-082018	1808487-2	4.0		53%
Trip 7	Red	M5-XS207A-01-082018	7.7	7.5	14%	6	M5-XS207A-01-082018	1808487-3	9.2		18%
Trip 7	Red	M5-XS261-01-082018	8.0	7.8	15%	7	M5-XS261-01-082018	1808487-4	5.8		32%
Trip 7	Red	M5-XS263-01-082018	11.2	7.1	101%	6	M5-XS263-01-082018	1808487-5	9.2		20%
Trip 7	Red	M5-XS305-01-082018	10.3	10.3	8%	9	M5-XS305-01-082018	1808487-6	7.9		26%
Trip 7	Red	M5-XS476-01-082018	7.2	7.2	9%	6	M5-XS476-01-082018	1808487-7	3.8		62%
Trip 7	Red	M5-XS488-01-082018	7.0	6.7	13%	6	M5-XS488-01-082018	1808487-8	4.0		54%
Trip 7	Red	M6-XS108-01-081618	8.4	8.5	7%	8	M6-XS108-01-081618	1808476-3	6.1		32%
Trip 7	Red	M6-XS108-02-081618	9.4	9.3	8%	9	M6-XS108-02-081618	1808476-4	7.3		25%

Data Included											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M6-XS198-01-081618	7.7	7.8	14%	6	M6-XS198-01-081618	1808476-5	6.6		16%
Trip 7	Red	M6-XS249-01-081618	6.5	7.0	22%	4	M6-XS249-01-081618	1808476-6	5.8		11%
Trip 7	Red	M6-XS289-01-081618	6.5	6.8	10%	5	M6-XS289-01-081618	1808476-7	4.9		28%
Trip 7	Red	M6-XS324-01-081618	8.5	8.5	10%	7	M6-XS324-01-081618	1808476-8	5.1		50%
Trip 7	Red	M6-XS60-01-081618	6.0	6.0	6%	6	M6-XS60-01-081618	1808476-9	3.7		48%
Trip 7	Red	M6-XS72-01-081618	7.1	7.2	25%	4	M6-XS72-01-081618	1808476-10	6.9		2%
Trip 7	Pink	M7-XS162A-01-081518	17.1	16.7	15%	14	M7-XS162A-01-081518	1808356-5	16.0		6%
Trip 7	Pink	M7-XS203-01-081418	7.4	7.4	7%	6	M7-XS203-01-081418	1808356-6	8.0		8%
Trip 7	Pink	M7-XS213-01-081518	7.1	6.9	26%	5	M7-XS213-01-081518	1808356-7	5.5		25%
Trip 7	Pink	M7-XS214-01-081518	10.2	10.3	11%	9	M7-XS214-01-081518	1808356-8	8.6		17%
Trip 7	Pink	M7-XS235A-01-081418	9.9	10.1	12%	8	M7-XS235A-01-081418	1808356-9	13.0		27%
Trip 7	Pink	M7-XS244-01-081518	7.1	7.1	6%	7	M7-XS244-01-081518	1808356-10	5.8		20%
Trip 7	Pink	M8-XS55-01-081418	7.2	7.0	16%	6	M8-XS55-01-081418	1808356-20	5.6		25%
Trip 7	Red	M8-XS83-01-081418	14.5	14.2	6%	14	M8-XS83-01-081418	1808476-12	13.0		11%
Trip 7	Pink	M8-XSG16-01-081518	6.4	6.3	8%	6	M8-XSG16-01-081518	1808356-11	6.2		3%
Trip 7	Pink	M8-XSG28-01-081418	8.7	8.3	14%	7	M8-XSG28-01-081418	1808356-12	8.1		7%
Trip 7	Pink	M8-XSG31-01-081518	9.7	9.6	10%	9	M8-XSG31-01-081518	1808356-13	10.0		3%
Trip 7	Pink	M8-XSG37-01-081418	8.2	7.9	12%	7	M8-XSG37-01-081418	1808356-14	5.9		33%
Trip 7	Pink	M8-XSG40-01-081418	6.9	7.3	14%	5	M8-XSG40-01-081418	1808356-15	6.4		8%
Trip 7	Pink	M8-XSG4-01-081518	5.8	5.4	24%	4	M8-XSG4-01-081518	1808356-16	6.8		16%
Trip 7	Pink	M8-XSG44-01-081418	4.9	4.3	30%	4	M8-XSG44-01-081418	1808356-17	4.6		6%
Trip 7	Pink	M8-XSG44-02-081418	5.4	5.5	13%	4	M8-XSG44-02-081418	1808356-18	4.4		21%
Trip 7	Pink	M8-XSG47-01-081418	7.0	7.2	15%	5	M8-XSG47-01-081418	1808356-19	6.6		6%
Trip 7	Red	M8-XSG6-01-081518	7.4	7.2	16%	6	M8-XSG6-01-081518	1808476-11	4.7		45%
Trip 7	Red	M9-XS19A-01-081718	6.6	6.8	17%	5	M9-XS19A-01-081718	1808483-8	3.2		70%
Trip 7	Red	M9-XS28A-01-081718	16.8	16.3	16%	14	M9-XS28A-01-081718	1808483-9	19.0		12%
Trip 7	Red	T10-XSG1-01-081818	10.4	10.9	15%	8	T10-XSG1-01-081818	1808483-10	6.8		42%
Trip 7	Red	T13-XSG16-01-081618	11.8	12.7	22%	8	T13-XSG16-01-081618	1808476-13	9.2		25%
Trip 7	Red	T13-XSG26-01-081618	17.0	16.8	5%	16	T13-XSG26-01-081618	1808476-14	14.0		19%
Trip 7	Red	T13-XSG7-01-081618	13.1	13.0	4%	12	T13-XSG7-01-081618	1808476-15	8.3		45%
Trip 7	Red	T15-XS20-01-081718	7.9	7.9	11%	6	T15-XS20-01-081718	1808483-11	4.3		59%
Trip 7	Red	T15-XSG5-01-081718	11.2	11.3	5%	10	T15-XSG5-01-081718	1808483-12	6.1		59%
Trip 7	Red	T17-XSG17-01-081618	7.3	7.9	24%	5	T17-XSG17-01-081618	1808476-16	5.7		25%
Trip 7	Red	T17-XSG27-01-081618	7.0	7.1	34%	4	T17-XSG27-01-081618	1808476-17	5.6		22%
Trip 7	Red	T17-XSG31-01-081518	9.1	8.9	13%	8	T17-XSG31-01-081518	1808476-18	6.2		38%
Trip 7	Red	T17-XSG7-01-081618	7.9	7.8	12%	7	T17-XSG7-01-081618	1808476-19	5.5		36%
Trip 7	Red	T17-XSG7-02-081618	9.7	9.6	7%	9	T17-XSG7-02-081618	1808476-20	5.4		57%
Trip 7	Red	T1-XSG38-01-081918	9.6	9.8	6%	8	T1-XSG38-01-081918	1808483-13	5.6		53%
Trip 7	Red	T1-XSG49A-01-081918	7.4	7.4	6%	7	T1-XSG49A-01-081918	1808483-14	4.2		56%
Trip 7	Red	T4-XS15A-01-081918	21.1	19.9	12%	19	T4-XS15A-01-081918	1808487-9	22.0		4%
Trip 7	Red	T4-XSG10-01-081918	5.7	6.0	14%	4	T4-XSG10-01-081918	1808483-16	4.3		28%
Trip 7	Red	T4-XSG39-01-081918	5.4	5.6	14%	5	T4-XSG39-01-081918	1808483-17	2.6		71%
Trip 7	Red	T4-XSG50A-01-081918	8.9	8.9	16%	7	T4-XSG50A-01-081918	1808483-18	7.0		24%
Trip 7	Red	T5-XSG10-01-081918	17.1	17.4	5%	16	T5-XSG10-01-081918	1808483-19	15.0		13%
Trip 7	Red	T6-XSG6-01-081918	5.6	5.6	15%	4	T6-XSG6-01-081918	1808487-10	2.1		91%
Trip 7	Red	T6-XSG6-02-081918	5.3	5.1	19%	4	T6-XSG6-02-081918	1808487-11	2.1		86%
Trip 7	Red	T9-XSG12-01-081818	10.6	11.0	11%	9	T9-XSG12-01-081818	1808483-20	5.9		57%
Trip 8	Red	M13-XS112-01-091518	7.5	7.6	6%	7	M13-XS112-01-091518	1809475-1	5.7		27%
Trip 8	Red	M13-XS258-01-091518	5.6	5.3	14%	5	M13-XS258-01-091518	1809475-2	2.4		80%
Trip 8	Red	M14-XS62-01-091818	5.0	5.0	13%	4	M14-XS62-01-091818	1809475-21	3.7		30%
Trip 8	Red	M14-XSG14A-01-091818	7.7	8.0	20%	6	M14-XSG14A-01-091818	1809475-22	5.1		41%
Trip 8	Red	M14-XSG27A-01-091818	9.8	9.6	8%	9	M14-XSG27A-01-091818	1809475-23	8.3		16%
Trip 8	Red	M14-XSG41-01-091818	9.2	9.1	10%	8	M14-XSG41-01-091818	1809475-24	6.6		33%
Trip 8	Red	M14-XSG49-01-091818	11.0	10.8	5%	11	M14-XSG49-01-091818	1809475-25	6.3		54%
Trip 8	Red	M14-XSG58-01-091818	10.2	10.3	5%	9	M14-XSG58-01-091818	1809475-26	8.0		24%
Trip 8	Red	M14-XSG6-01-091818	14.5	14.3	12%	13	M14-XSG6-01-091818	1809475-27	14.0		4%
Trip 8	Red	M15-XSG20-01-091118	7.1	6.9	13%	6	M15-XSG20-01-091118	1809473-20	6.8		4%
Trip 8	Red	M15-XSG2-01-091118	8.4	8.3	9%	7	M15-XSG2-01-091118	1809473-21	4.5		61%
Trip 8	Red	M16-XSG13-01-091118	10.4	10.2	13%	9	M16-XSG13-01-091118	1809473-22	8.7		18%
Trip 8	Red	M16-XSG24-01-091118	5.3	5.1	14%	5	M16-XSG24-01-091118	1809473-23	12.0		78%
Trip 8	Red	M16-XSG30-01-091518	4.6	4.3	15%	4	M16-XSG30-01-091518	1809475-3	3.0		43%
Trip 8	Red	M16-XSG38-01-091518	3.7	3.7	13%	3	M16-XSG38-01-091518	1809475-4	1.7		74%
Trip 8	Red	M17-XS79-01-091318	8.5	8.5	7%	8	M17-XS79-01-091318	1809473-1	6.9		21%
Trip 8	Red	M17-XSG1-01-091318	9.5	9.5	4%	9	M17-XSG1-01-091318	1809473-2	6.9		32%
Trip 8	Red	M17-XSG27-01-091318	8.5	8.8	9%	7	M17-XSG27-01-091318	1809473-3	5.2		48%
Trip 8	Red	M17-XSG36-01-091318	5.7	5.7	15%	4	M17-XSG36-01-091318	1809473-4	4.6		22%
Trip 8	Red	M17-XSG36-02-091318	6.2	6.1	8%	6	M17-XSG36-02-091318	1809473-5	4.6		29%
Trip 8	Red	M18-XSG16-01-091318	10.9	10.9	5%	10	M18-XSG16-01-091318	1809473-6	7.3		39%
Trip 8	Red	M18-XSG30-01-091318	9.4	9.6	13%	7	M18-XSG30-01-091318	1809473-7	5.9		46%
Trip 8	Red	M18-XSG32-01-091318	9.6	9.4	17%	8	M18-XSG32-01-091318	1809473-8	5.4		56%

Data Included											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M19-XSG11-01-091318	9.9	10.0	9%	8	M19-XSG11-01-091318	1809473-9	5.9		51%
Trip 8	Red	M19-XSG19-01-091318	8.4	8.1	11%	8	M19-XSG19-01-091318	1809473-10	7.5		12%
Trip 8	Red	M19-XSG25-01-091318	14.3	14.0	5%	14	M19-XSG25-01-091318	1809473-11	10.0		36%
Trip 8	Red	M19-XSG29-01-091318	10.4	10.0	12%	9	M19-XSG29-01-091318	1809473-12	4.7		75%
Trip 8	Red	M19-XSG39-01-091318	10.4	10.3	7%	9	M19-XSG39-01-091318	1809473-13	5.4		63%
Trip 8	Red	M19-XSG43-01-091318	10.2	10.2	9%	9	M19-XSG43-01-091318	1809473-14	5.3		63%
Trip 8	Red	M20-XS146-01-091718	14.2	13.1	21%	12	M20-XS146-01-091718	1809475-28	15.0		6%
Trip 8	Red	M20-XS243-01-091718	11.2	10.9	12%	10	M20-XS243-01-091718	1809475-29	11.0		2%
Trip 8	Red	M20-XS247-01-091718	7.3	7.5	12%	6	M20-XS247-01-091718	1809475-30	4.2		54%
Trip 8	Red	M20-XS267-01-091718	13.4	13.4	8%	12	M20-XS267-01-091718	1809475-31	11.0		20%
Trip 8	Red	M20-XS271-01-091718	6.0	6.2	11%	5	M20-XS271-01-091718	1809475-32	2.8		73%
Trip 8	Red	M20-XS30-01-091718	7.4	7.4	7%	7	M20-XS30-01-091718	1809475-33	5.1		37%
Trip 8	Red	M20-XS335-01-091418	7.8	7.9	6%	7	M20-XS335-01-091418	1809475-5	5.2		40%
Trip 8	Red	M20-XS422-01-091418	8.8	8.9	10%	7	M20-XS422-01-091418	1809475-6	6.0		38%
Trip 8	Red	M20-XS58-01-091718	8.8	8.1	27%	7	M20-XS58-01-091718	1809475-34	6.0		38%
Trip 8	Red	M20-XS60-01-091718	10.3	9.9	10%	10	M20-XS60-01-091718	1809475-35	7.4		32%
Trip 8	Red	M20-XSG15-01-091418	9.2	8.8	13%	8	M20-XSG15-01-091418	1809475-7	5.6		49%
Trip 8	Red	M20-XSG28-01-091418	7.3	7.5	15%	6	M20-XSG28-01-091418	1809475-8	6.8		8%
Trip 8	Red	M20-XSG7-01-091418	7.3	7.2	13%	6	M20-XSG7-01-091418	1809475-9	4.1		56%
Trip 8	Red	M21-XS1-01-091218	4.3	4.0	12%	4	M21-XS1-01-091218	1809473-24	7.0		48%
Trip 8	Red	M21-XS317-01-091218	7.4	7.4	13%	6	M21-XS317-01-091218	1809473-25	5.8		25%
Trip 8	Red	M21-XS323-01-091218	8.7	8.8	11%	8	M21-XS323-01-091218	1809473-26	7.8		11%
Trip 8	Red	M21-XS366-01-091418	7.6	7.2	13%	7	M21-XS366-01-091418	1809475-10	5.6		30%
Trip 8	Red	M21-XS366-02-091418	7.4	7.1	11%	7	M21-XS366-02-091418	1809475-11	5.4		31%
Trip 8	Red	M21-XS465-01-091218	8.9	9.0	6%	8	M21-XS465-01-091218	1809473-27	7.4		18%
Trip 8	Red	M21-XS511-01-091218	12.8	13.2	7%	11	M21-XS511-01-091218	1809473-29	11.0		15%
Trip 8	Red	M21-XS536-01-091218	9.2	9.4	6%	8	M21-XS536-01-091218	1809473-30	8.1		13%
Trip 8	Red	M21-XSG16-01-091218	6.9	6.8	19%	5	M21-XSG16-01-091218	1809473-31	7.9		14%
Trip 8	Red	M21-XSG38-01-091418	10.1	10.1	4%	10	M21-XSG38-01-091418	1809475-12	9.1		11%
Trip 8	Red	M21-XSG43-01-091418	6.5	6.6	9%	6	M21-XSG43-01-091418	1809475-13	5.1		24%
Trip 8	Red	M21-XSG7-01-091218	6.2	5.9	31%	3	M21-XSG7-01-091218	1809473-32	5.4		13%
Trip 8	Red	M22-XS112-01-091418	6.9	6.8	10%	6	M22-XS112-01-091418	1809475-14	6.0		14%
Trip 8	Red	M22-XS115-01-091418	8.9	8.8	6%	8	M22-XS115-01-091418	1809475-15	5.9		40%
Trip 8	Red	M22-XS121-01-091418	8.1	8.1	11%	7	M22-XS121-01-091418	1809475-16	5.2		44%
Trip 8	Red	M22-XS94-01-091418	6.6	6.6	10%	6	M22-XS94-01-091418	1809475-17	3.6		59%
Trip 8	Red	M23-XSG1-01-091418	10.0	10.1	14%	8	M23-XSG1-01-091418	1809475-18	6.8		38%
Trip 8	Red	M23-XSG20-01-091418	9.1	9.4	9%	8	M23-XSG20-01-091418	1809475-19	5.5		50%
Trip 8	Red	M23-XSG5-01-091418	8.5	8.4	6%	8	M23-XSG5-01-091418	1809475-20	5.6		42%
Trip 8	Red	M6-XS224-01-091118	6.0	5.5	27%	4	M6-XS224-01-091118	1809473-34	9.1		41%
Trip 8	Red	M6-XS353A-01-091618	11.1	11.0	4%	11	M6-XS353A-01-091618	1809475-36	10.0		11%
Trip 8	Red	M6-XS369-01-091618	6.8	6.8	10%	6	M6-XS369-01-091618	1809475-37	3.9		55%
Trip 8	Red	M6-XS52-01-091118	10.1	10.2	11%	9	M6-XS52-01-091118	1809473-35	5.7		56%
Trip 8	Red	M6-XSG13A-01-091618	11.1	11.3	8%	10	M6-XSG13A-01-091618	1809475-38	10.0		10%
Trip 8	Red	M6-XSG22-01-091618	9.3	9.3	10%	8	M6-XSG22-01-091618	1809475-39	6.2		40%
Trip 8	Red	M7-XSG34-01-091618	8.5	8.2	13%	7	M7-XSG34-01-091618	1809475-40	5.1		50%
Trip 8	Red	M7-XSG41-01-091618	6.4	6.3	14%	5	M7-XSG41-01-091618	1809475-41	3.2		66%
Trip 8	Red	T18-XSG7-01-091518	8.0	8.0	5%	8	T18-XSG7-01-091518	1809475-42	3.9		69%
Trip 8	Red	T19-XS9-01-091118	7.5	7.6	24%	5	T19-XS9-01-091118	1809473-36	7.3		3%
Trip 8	Red	T20-XSG3-01-091118	8.9	8.9	14%	7	T20-XSG3-01-091118	1809473-37	6.8		26%
Trip 8	Red	T21-XSG13-01-091118	12.2	12.1	10%	10	T21-XSG13-01-091118	1809473-38	8.4		37%
Trip 8	Red	T21-XSG26-01-091118	10.4	10.3	14%	9	T21-XSG26-01-091118	1809473-39	5.7		59%
Trip 8	Red	T22-XS20-01-091118	6.7	6.7	23%	5	T22-XS20-01-091118	1809473-15	5.3		23%
Trip 8	Red	T23-XSG26-01-091118	11.0	10.7	13%	10	T23-XSG26-01-091118	1809473-16	7.0		45%
Trip 8	Red	T23-XSG7-01-091118	12.9	12.7	8%	12	T23-XSG7-01-091118	1809473-17	8.7		39%
Trip 8	Red	T24-XSG2-01-091118	11.9	11.5	9%	11	T24-XSG2-01-091118	1809473-18	6.3		61%
Trip 8	Red	T26-XSG2-01-091518	5.8	6.0	18%	4	T26-XSG2-01-091518	1809475-43	5.3		9%
Trip 8	Red	T26-XSG9-01-091518	5.2	4.8	32%	4	T26-XSG9-01-091518	1809475-44	3.7		34%
Trip 9	Red	M10-XSG2-01-092818	9.3	9.7	8%	8	M10-XSG2-01-092818	1810122-1	5.8		46%
Trip 9	Blue	M10-XSG4-01-092818	11.7	11.9	11%	10	M10-XSG4-01-092818	1810122-2	7.9		39%
Trip 9	Red	M11-XS47-01-092818	7.5	7.5	6%	7	M11-XS47-01-092818	1810122-3	5.2		36%
Trip 9	Blue	M11-XSG2-01-092818	6.7	6.8	7%	6	M11-XSG2-01-092818	1810122-4	4.4		42%
Trip 9	Blue	M11-XSG25-01-092818	6.0	5.2	34%	4	M11-XSG25-01-092818	1810122-5	4.1		37%
Trip 9	Blue	M11-XSG28-01-092818	10.1	10.3	10%	9	M11-XSG28-01-092818	1810122-6	7.4		31%
Trip 9	Red	M11-XSG33-01-092818	9.0	8.9	5%	9	M11-XSG33-01-092818	1810122-7	6.6		31%
Trip 9	Red	M12-XSG26-01-092818	12.5	12.0	10%	12	M12-XSG26-01-092818	1810122-8	8.4		39%
Trip 9	Blue	M14-XSR1-01-093018	7.7	7.5	12%	7	M14-XSR1-01-093018	1810072-21	4.3		57%
Trip 9	White	M15-XSR1-01-093018	8.1	8.6	13%	7	M15-XSR1-01-093018	1810072-22	3.4		82%
Trip 9	White	M16-XSR1-01-093018	6.9	6.9	14%	6	M16-XSR1-01-093018	1810072-23	4.1		52%
Trip 9	White	M16-XSR6-01-093018	7.5	7.8	14%	5	M16-XSR6-01-093018	1810072-24	3.5		73%
Trip 9	Blue	M17-XSR1-01-093018	7.4	7.4	19%	6	M17-XSR1-01-093018	1810072-25	3.8		65%

Data Included											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	Red	M19-XSR2-01-093018	9.1	9.2	4%	8	M19-XSR2-01-093018	1810072-26	4.7		64%
Trip 9	Blue	M19-XSR2-02-093018	8.6	8.6	10%	7	M19-XSR2-02-093018	1810072-27	4.6		61%
Trip 9	Red	M1-XSG4-01-092818	7.4	7.3	14%	6	M1-XSG4-01-092818	1810072-1	4.8		43%
Trip 9	Blue	M20-XSR2-01-093018	7.8	7.7	15%	6	M20-XSR2-01-093018	1810072-28	3.6		73%
Trip 9	White	M23-XSR4-01-093018	9.4	9.6	11%	8	M23-XSR4-01-093018	1810072-29	5.1		59%
Trip 9	Red	M24-XS112-01-092518	8.5	8.4	13%	7	M24-XS112-01-092518	1810032-1	6.7		23%
Trip 9	Red	M24-XS114-01-092518	6.8	6.8	11%	6	M24-XS114-01-092518	1810032-2	5.0		31%
Trip 9	Red	M24-XSG15-01-092518	7.8	7.7	7%	7	M24-XSG15-01-092518	1810032-3	5.8		29%
Trip 9	Red	M24-XSG3-01-092518	6.6	6.6	9%	6	M24-XSG3-01-092518	1810032-4	4.6		36%
Trip 9	Red	M24-XSG32-01-092518	6.3	6.1	13%	5	M24-XSG32-01-092518	1810032-5	3.9		47%
Trip 9	Red	M24-XSR1-01-093018	6.9	6.9	13%	6	M24-XSR1-01-093018	1810072-30	6.0		13%
Trip 9	Blue	M25-XSG12-01-092818	5.8	5.4	23%	5	M25-XSG12-01-092818	1810122-10	2.8		71%
Trip 9	Blue	M25-XSG19-01-092818	7.4	7.4	14%	6	M25-XSG19-01-092818	1810122-11	5.0		38%
Trip 9	Blue	M25-XSG19-02-092818	7.6	7.2	13%	7	M25-XSG19-02-092818	1810122-12	5.0		41%
Trip 9	Blue	M25-XSG5-01-092818	4.8	5.0	14%	4	M25-XSG5-01-092818	1810122-13	2.9		50%
Trip 9	Red	M27-XS116-01-092618	6.8	7.0	9%	6	M27-XS116-01-092618	1810072-2	3.7		59%
Trip 9	Red	M27-XS149-01-092618	6.6	6.7	10%	5	M27-XS149-01-092618	1810072-3	4.0		48%
Trip 9	Red	M27-XS150-01-092618	7.7	7.7	7%	7	M27-XS150-01-092618	1810072-4	4.6		51%
Trip 9	Red	M27-XS163-01-092618	7.7	7.8	5%	7	M27-XS163-01-092618	1810072-5	5.5		34%
Trip 9	Red	M27-XSG28-01-092618	8.1	8.0	11%	7	M27-XSG28-01-092618	1810072-6	5.3		42%
Trip 9	Red	M27-XSG28-02-092618	8.5	8.4	9%	8	M27-XSG28-02-092618	1810072-7	5.3		46%
Trip 9	Red	M27-XSG48-01-092618	10.7	10.5	7%	10	M27-XSG48-01-092618	1810072-8	8.4		24%
Trip 9	Red	M27-XSG6-01-092618	5.1	5.2	12%	4	M27-XSG6-01-092618	1810072-9	3.6		35%
Trip 9	Red, Blue	M28-XS162-01-092818	14.7	13.6	43%	8	M28-XS162-01-092818	1810122-14	16.0		9%
Trip 9	White	M28-XS19-01-092918	9.1	8.6	20%	7	M28-XS19-01-092918	1810122-15	6.2		38%
Trip 9	Red	M28-XS29-01-092618	8.5	8.3	13%	7	M28-XS29-01-092618	1810032-6	7.0		19%
Trip 9	Blue	M28-XSG18-01-092918	6.9	7.0	18%	5	M28-XSG18-01-092918	1810122-16	4.8		36%
Trip 9	Red	M28-XSG49-01-092618	7.0	7.9	29%	3	M28-XSG49-01-092618	1810032-7	5.7		20%
Trip 9	Red, White	M28-XSG54-01-092918	9.2	9.2	9%	8	M28-XSG54-01-092918	1810122-17	6.7		32%
Trip 9	Red	M28-XSG7-01-092618	8.3	8.4	12%	7	M28-XSG7-01-092618	1810032-8	4.4		61%
Trip 9	White	M28-XSG76-01-092918	7.8	7.8	10%	7	M28-XSG76-01-092918	1810122-18	5.7		31%
Trip 9	Blue	M28-XSR1-01-093018	6.2	6.1	7%	6	M28-XSR1-01-093018	1810072-31	3.3		62%
Trip 9	Red	M28-XSR1-02-093018	7.5	7.6	4%	7	M28-XSR1-02-093018	1810072-32	3.3		78%
Trip 9	Red	M29-XS19-01-092518	8.9	9.0	21%	7	M29-XS19-01-092518	1810032-9	8.9		0%
Trip 9	Red	M29-XS42-01-092518	10.0	10.0	9%	9	M29-XS42-01-092518	1810032-10	7.4		30%
Trip 9	Red	M29-XS59-01-092518	7.9	8.2	12%	6	M29-XS59-01-092518	1810032-11	8.4		7%
Trip 9	Red	M29-XS64-01-092518	5.5	5.2	20%	4	M29-XS64-01-092518	1810032-12	3.0		59%
Trip 9	Red	M29-XSG1-01-092518	4.1	4.2	21%	3	M29-XSG1-01-092518	1810032-13	2.7		40%
Trip 9	Red	M29-XSG25-01-092518	5.5	5.6	10%	5	M29-XSG25-01-092518	1810032-14	3.9		34%
Trip 9	Red	M29-XSG35-01-092518	7.0	6.8	8%	6	M29-XSG35-01-092518	1810032-15	3.3		71%
Trip 9	Blue	M29-XSR4-01-093018	8.5	8.3	23%	6	M29-XSR4-01-093018	1810072-33	5.8		38%
Trip 9	Red	M29-XSR7-01-093018	7.3	7.6	12%	6	M29-XSR7-01-093018	1810072-34	7.9		8%
Trip 9	White	M2-XSR3-01-093018	4.4	4.3	6%	4	M2-XSR3-01-093018	1810072-35	2.5		55%
Trip 9	White	M30-XS144-01-092918	8.3	8.2	14%	7	M30-XS144-01-092918	1810122-19	5.6		38%
Trip 9	White	M30-XS185-01-092918	11.0	10.9	12%	9	M30-XS185-01-092918	1810122-20	8.4		27%
Trip 9	White	M30-XS62-01-092918	8.2	8.6	19%	6	M30-XS62-01-092918	1810122-21	6.5		23%
Trip 9	White	M30-XSG18-01-092918	9.6	9.4	13%	8	M30-XSG18-01-092918	1810122-22	6.6		37%
Trip 9	White	M30-XSG29-01-092918	8.6	8.7	10%	7	M30-XSG29-01-092918	1810122-23	7.3		16%
Trip 9	White	M30-XSG43-01-092918	10.1	10.1	6%	9	M30-XSG43-01-092918	1810122-24	6.6		42%
Trip 9	White	M30-XSG45-01-092918	6.9	6.9	12%	5	M30-XSG45-01-092918	1810122-25	3.8		57%
Trip 9	Red, White	M30-XSG6-01-092918	7.2	7.0	14%	6	M30-XSG6-01-092918	1810122-26	4.2		53%
Trip 9	Blue	M30-XSG61-01-092918	5.2	5.4	18%	3	M30-XSG61-01-092918	1810122-27	2.1		85%
Trip 9	White	M30-XSR5-01-093018	7.8	7.5	14%	7	M30-XSR5-01-093018	1810072-36	5.4		36%
Trip 9	Red	M31-XS1-01-092918	9.0	9.1	6%	8	M31-XS1-01-092918	1810122-28	6.7		29%
Trip 9	Blue	M31-XS39-01-092918	5.2	5.5	18%	4	M31-XS39-01-092918	1810122-29	4.3		20%
Trip 9	White	M31-XS8-01-092918	9.1	9.1	16%	8	M31-XS8-01-092918	1810122-30	6.1		40%
Trip 9	White	M31-XSG1-01-092918	8.2	7.6	21%	7	M31-XSG1-01-092918	1810122-31	3.9		71%
Trip 9	White	M31-XSG12-01-092918	9.9	9.0	34%	7	M31-XSG12-01-092918	1810122-32	6.2		46%
Trip 9	Red	M31-XSG9-01-092918	8.2	8.1	14%	7	M31-XSG9-01-092918	1810122-34	4.3		63%
Trip 9	Red	M32-XSG23-01-092918	9.7	9.7	10%	9	M32-XSG23-01-092918	1810072-10	7.6		25%
Trip 9	Red	M32-XSG26-01-092918	7.4	7.3	12%	6	M32-XSG26-01-092918	1810072-11	4.9		40%
Trip 9	Red	M32-XSG34-01-092918	9.9	10.0	5%	9	M32-XSG34-01-092918	1810072-12	7.6		27%
Trip 9	Red	M32-XSG46-01-092918	9.6	10.1	9%	8	M32-XSG46-01-092918	1810072-13	6.1		45%
Trip 9	Red	M32-XSG9-01-092918	9.4	9.2	11%	9	M32-XSG9-01-092918	1810072-14	6.3		40%
Trip 9	Red	M34-XSG15-01-092718	8.1	8.2	7%	7	M34-XSG15-01-092718	1810072-15	5.3		42%
Trip 9	Red	M35-XSG20-01-092718	8.1	8.1	9%	7	M35-XSG20-01-092718	1810072-16	6.6		21%
Trip 9	Red	M35-XSG4-01-092718	7.6	6.8	17%	7	M35-XSG4-01-092718	1810072-17	3.7		69%
Trip 9	Red	M36-XSG1-01-092718	8.8	8.9	7%	8	M36-XSG1-01-092718	1810072-18	6.1		36%
Trip 9	White	M6-XSR1-01-093018	5.8	5.9	16%	4	M6-XSR1-01-093018	1810072-37	2.5		80%
Trip 9	White	M7-XSR1-01-093018	8.7	8.5	10%	8	M7-XSR1-01-093018	1810072-38	5.3		48%

Data Included											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	White	M7-XSR1-02-093018	8.2	8.1	11%	7	M7-XSR1-02-093018	1810072-39	5.4		41%
Trip 9	Blue	M8-XSR1-01-093018	8.1	8.4	19%	5	M8-XSR1-01-093018	1810072-40	5.9		31%
Trip 9	White	T17-XSR1-01-093018	5.3	5.0	18%	4	T17-XSR1-01-093018	1810072-41	2.3		79%
Trip 9	Red	T30-XS20-01-092518	13.2	13.1	8%	11	T30-XS20-01-092518	1810032-16	9.3		34%
Trip 9	Red	T30-XS28-01-092518	11.5	11.5	6%	11	T30-XS28-01-092518	1810032-17	6.2		60%
Trip 9	Red	T30-XS8-01-092518	10.3	10.3	6%	9	T30-XS8-01-092518	1810032-18	4.5		78%
Trip 9	Red	T31-XSG7-01-092518	9.3	9.2	9%	8	T31-XSG7-01-092518	1810032-19	3.4		93%
Trip 9	Red	T31-XSG9-01-092518	10.2	10.1	5%	10	T31-XSG9-01-092518	1810032-20	5.1		67%
Trip 9	Red	T5-XSG3-01-092818	8.1	8.4	12%	7	T5-XSG3-01-092818	1810072-19	4.9		49%
Trip 9	Red	T5-XSG3-02-092818	8.1	8.1	8%	7	T5-XSG3-02-092818	1810072-20	5.0		48%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M21-XS503-01-091218	4.6	4.7	57%	0	M21-XS503-01-091218	1809473-28	7.3		45%
Trip 8	Red	M6-XS164-01-091118	3.9	4.1	62%	0	M6-XS164-01-091118	1809473-33	2.7		37%
Trip 8	Red	T24-XSG26-01-091118	3.2	3.7	51%	0	T24-XSG26-01-091118	1809473-19	4.6		35%

Removed Data - Outliers											
			XRF - Lead						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	T1-XSG5A-01-081918	54.4	6.9	231%	6	T1-XSG5A-01-081918	1808483-15	4.2		171%
Trip 9	Red	M12-XSG3-01-092818	59.8	7.7	214%	7	M12-XSG3-01-092818	1810122-9	5.2		168%
Trip 9	White	M31-XSG17-01-092918	10.6	9.5	29%	8	M31-XSG17-01-092918	1810122-33	360.0		189%

Notes:

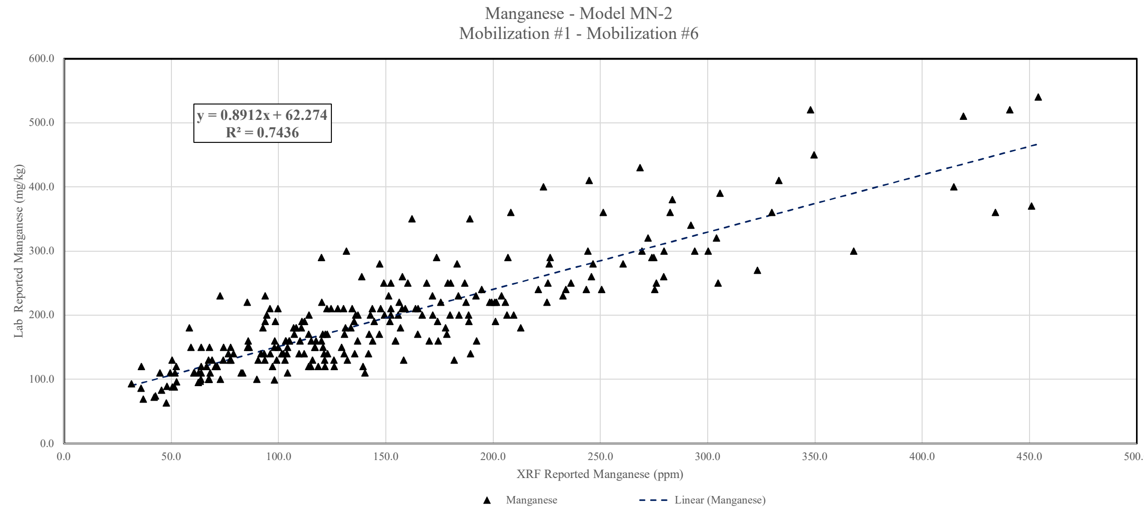
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model MN-2											
			XRF - Manganese						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	67.5	69.7	18%	49	M2-XS15-01-042418	1805041-1	100.0		39%
Trip 1	Pink	M2-XS15-02-042418	62.6	60.7	19%	51	M2-XS15-02-042418	1805041-2	110.0		55%
Trip 1	Pink	M2-XS32-01-042418	68.1	68.2	16%	54	M2-XS32-01-042418	1805041-3	110.0		47%
Trip 1	Pink	M2-XS59-01-042418	52.4	50.9	31%	29	M2-XS59-01-042418	1805041-4	96.0		59%
Trip 1	Pink	M2-XS73-01-042418	60.4	57.3	17%	51	M2-XS73-01-042418	1805041-5	110.0		58%
Trip 1	Pink	M3-XS34-01-043018	132.0	130.4	18%	109	M3-XS34-01-043018	1805042-1	130.0		2%
Trip 1	Pink	M3-XS36-01-043018	272.2	259.5	13%	235	M3-XS36-01-043018	1805042-2	320.0		16%
Trip 1	Pink	M6-XS140-01-042818	104.1	97.0	26%	76	M6-XS140-01-042818	1805041-6	150.0		36%
Trip 1	Orange	M6-XS159-01-04262018	63.8	64.4	29%	39	M6-XS159-01-04262018	1805039-1	150.0		81%
Trip 1	Pink	M6-XS251-01-04272018	189.1	188.4	10%	158	M6-XS251-01-04272018	1805039-2	350.0		60%
Trip 1	Pink	M6-XS269-01-04262018	130.1	128.9	8%	113	M6-XS269-01-04262018	1805039-3	210.0		47%
Trip 1	Pink	M6-XS269-02-04262018	144.5	142.9	9%	132	M6-XS269-02-04262018	1805039-4	190.0		27%
Trip 1	Pink	M6-XS285-01-04272018	92.7	84.7	25%	73	M6-XS285-01-04272018	1805039-5	180.0		64%
Trip 1	Pink	T10-XS1-01-042518	275.3	279.3	1%	241	T10-XS1-01-042518	1805036-1	240.0		14%
Trip 1	Pink	T10-XS20-01-042518	177.7	181.4	11%	144	T10-XS20-01-042518	1805036-2	180.0		1%
Trip 1	Pink	T10-XS33-01-042518	206.3	208.8	6%	188	T10-XS33-01-042518	1805036-3	200.0		3%
Trip 1	Pink	T10-XS56-01-042518	250.5	253.0	6%	224	T10-XS56-01-042518	1805036-4	240.0		4%
Trip 1	Pink	T10-XS78-01-042518	245.7	246.5	9%	207	T10-XS78-01-042518	1805036-5	260.0		6%
Trip 1	Pink	T11-XS1-01-042518	274.7	277.4	7%	243	T11-XS1-01-042518	1805036-6	290.0		5%
Trip 1	Pink	T11-XS20-01-042518	236.1	238.5	7%	215	T11-XS20-01-042518	1805036-7	250.0		6%
Trip 1	Pink	T11-XS60-01-042518	141.8	141.7	11%	117	T11-XS60-01-042518	1805036-8	140.0		1%
Trip 1	Pink	T17-XS1-01-04262018	41.9	41.2	32%	25	T17-XS1-01-04262018	1805039-6	72.0		53%
Trip 1	Pink	T17-XS1-02-04262018	36.8	37.2	26%	21	T17-XS1-02-04262018	1805039-7	69.0		61%
Trip 1	Pink	T17-XS143-01-04262018	178.8	172.8	13%	150	T17-XS143-01-04262018	1805039-8	250.0		33%
Trip 1	Orange	T17-XS144-01-04262018	221.0	216.3	9%	196	T17-XS144-01-04262018	1805039-9	240.0		8%
Trip 1	Pink	T17-XS194-01-04272018	135.3	137.8	26%	82	T17-XS194-01-04272018	1805039-10	140.0		3%
Trip 1	Pink	T17-XS194-02-04272018	111.8	111.2	23%	85	T17-XS194-02-04272018	1805039-11	140.0		22%
Trip 1	Pink	T17-XS20-01-04262018	157.7	155.4	15%	127	T17-XS20-01-04262018	1805039-12	260.0		49%
Trip 1	Pink	T17-XS208-01-042818	183.9	179.7	12%	163	T17-XS208-01-042818	1805041-7	200.0		8%
Trip 1	Pink	T17-XS251-01-04272018	129.2	131.5	17%	90	T17-XS251-01-04272018	1805039-13	150.0		15%
Trip 1	Pink	T17-XS257-01-04272018	201.1	202.3	12%	164	T17-XS257-01-04272018	1805039-14	190.0		6%
Trip 1	Pink	T17-XS273-01-042818	260.5	261.2	3%	251	T17-XS273-01-042818	1805041-8	280.0		7%
Trip 1	Pink	T17-XS287-01-04272018	122.7	112.1	23%	99	T17-XS287-01-04272018	1805039-15	140.0		13%
Trip 1	Pink	T17-XS304-01-042818	143.8	141.3	21%	111	T17-XS304-01-042818	1805041-9	160.0		11%
Trip 1	Pink	T17-XS317-01-04272018	122.6	124.9	10%	109	T17-XS317-01-04272018	1805039-16	170.0		32%
Trip 1	Pink	T17-XS328-01-04272018	225.1	226.7	14%	177	T17-XS328-01-04272018	1805039-17	220.0		2%
Trip 1	Pink	T17-XS369-01-043018	329.8	324.0	9%	298	T17-XS369-01-043018	1805042-4	360.0		9%
Trip 1	Pink	T17-XS377-01-042818	205.6	199.1	15%	169	T17-XS377-01-042818	1805041-10	220.0		7%
Trip 1	Pink	T17-XS393-01-043018	174.4	183.2	10%	144	T17-XS393-01-043018	1805042-5	160.0		9%
Trip 1	Pink	T17-XS417-01-04272018	273.9	266.6	9%	242	T17-XS417-01-04272018	1805039-18	290.0		6%
Trip 1	Pink	T17-XS438-01-042818	52.2	49.6	28%	35	T17-XS438-01-042818	1805041-11	120.0		79%
Trip 1	Pink	T17-XS44-01-04262018	198.2	202.9	7%	175	T17-XS44-01-04262018	1805039-19	220.0		10%
Trip 1	Pink	T17-XS442-01-04272018	171.8	174.1	13%	144	T17-XS442-01-04272018	1805039-20	200.0		15%
Trip 1	Pink	T17-XS46-01-042618	125.8	132.3	13%	103	T17-XS46-01-042618	1805041-12	120.0		5%
Trip 1	Pink	T17-XS473-01-042818	233.8	229.8	13%	198	T17-XS473-01-042818	1805041-13	240.0		3%
Trip 1	Pink	T17-XS479-01-042818	454.0	456.0	6%	417	T17-XS479-01-042818	1805041-14	540.0		17%
Trip 1	Pink	T17-XS479-02-042818	440.7	419.7	12%	401	T17-XS479-02-042818	1805041-15	520.0		17%

Trip	XRF Color	XRF ID	XRF - Manganese				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	T17-XS603-01-042818	283.4	284.3	9%	245	T17-XS603-01-042818	1805041-16	380.0		29%
Trip 1	Pink	T17-XS659-01-043018	192.2	186.4	17%	152	T17-XS659-01-043018	1805042-6	160.0		18%
Trip 1	Pink	T17-XS679-01-043018	212.8	215.3	14%	163	T17-XS679-01-043018	1805042-7	180.0		17%
Trip 1	Pink	T17-XS704-01-043018	188.7	192.3	9%	161	T17-XS704-01-043018	1805042-8	190.0		1%
Trip 1	Pink	T7-XS11-01-042418	83.2	81.2	3%	69	T7-XS11-01-042418	1805036-9	110.0		28%
Trip 1	Pink	T7-XS5-01-042418	67.4	66.1	9%	61	T7-XS5-01-042418	1805036-10	100.0		39%
Trip 1	Pink	T7-XS58-01-042418	63.4	62.7	9%	57	T7-XS58-01-042418	1805036-11	97.0		42%
Trip 1	Pink	T7-XS7-01-042418	47.9	48.7	25%	27	T7-XS7-01-042418	1805036-12	89.0		60%
Trip 1	Pink	T7-XS9-01-042418	67.2	65.5	20%	48	T7-XS9-01-042418	1805036-13	100.0		39%
Trip 1	Pink	T8-XS15-01-042418	93.5	93.7	11%	80	T8-XS15-01-042418	1805036-14	130.0		33%
Trip 1	Pink	T8-XS23-01-042418	116.9	116.5	13%	98	T8-XS23-01-042418	1805036-15	150.0		25%
Trip 1	Pink	T8-XS6-01-042418	82.4	85.8	20%	58	T8-XS6-01-042418	1805036-16	110.0		29%
Trip 1	Pink	T9-XS217-01-042518	201.5	203.0	5%	182	T9-XS217-01-042518	1805036-17	220.0		9%
Trip 1	Pink	T9-XS61-01-042518	104.0	96.9	21%	86	T9-XS61-01-042518	1805036-18	110.0		6%
Trip 1	Orange	T9-XS61-02-042518	121.6	125.9	24%	88	T9-XS61-02-042518	1805041-17	120.0		1%
Trip 1	Pink	T9-XS86-01-042518	156.7	160.3	13%	122	T9-XS86-01-042518	1805036-19	180.0		14%
Trip 1	Pink	T9-XS93-01-042518	226.1	222.5	5%	216	T9-XS93-01-042518	1805036-20	280.0		21%
Trip 2	Orange	M1-XS31-01-051218	50.3	47.7	21%	39	M1-XS31-01-051218	1805328-1	130		88%
Trip 2	Pink	M1-XS32-01-051218	36.0	33.1	49%	17	M1-XS32-01-051218	1805328-2	120		108%
Trip 2	Pink	M4-XS136-01-050918	78.9	79.7	9%	69	M4-XS136-01-050918	1805322-1	140		56%
Trip 2	Pink	M4-XS18-01-050718	63.6	66.1	18%	45	M4-XS18-01-050718	1805322-2	100		44%
Trip 2	Orange	M4-XS219-01-051018	152.2	149.9	14%	122	M4-XS219-01-051018	1805322-3	250		49%
Trip 2	Pink	M4-XS238-01-051018	121.0	121.0	13%	104	M4-XS238-01-051018	1805322-4	140		15%
Trip 2	Pink	M4-XS4-01-050718	108.0	107.4	12%	92	M4-XS4-01-050718	1805322-5	180		50%
Trip 2	Pink	M4-XS45-01-050718	76.5	74.2	19%	59	M4-XS45-01-050718	1805322-6	140		59%
Trip 2	Pink	M4-XS63-01-050718	97.9	103.3	24%	56	M4-XS63-01-050718	1805322-7	150	J	42%
Trip 2	Pink	M4-XS63-02-050718	85.3	83.1	15%	68	M4-XS63-02-050718	1805322-8	220	J	88%
Trip 2	Pink	M4-XS78-01-051018	131.1	127.4	15%	110	M4-XS78-01-051018	1805322-9	180		31%
Trip 2	Orange	M5-XS115-01-051118	93.1	86.8	24%	62	M5-XS115-01-051118	1805322-10	140		40%
Trip 2	Pink	M5-XS385-01-051118	49.4	46.3	27%	34	M5-XS385-01-051118	1805322-11	110		76%
Trip 2	Pink	M5-XS69-01-051118	149.0	150.7	12%	118	M5-XS69-01-051118	1805322-12	250		51%
Trip 2	Orange	M6-XS41-01-051118	42.5	43.2	27%	23	M6-XS41-01-051118	1805322-13	74		54%
Trip 2	Pink	M6-XS44-01-051018	98.4	98.2	32%	60	M6-XS44-01-051018	1805322-14	190		64%
Trip 2	Pink	M7-XS181-01-051018	59.1	58.5	23%	43	M7-XS181-01-051018	1805322-16	150		87%
Trip 2	Orange	M7-XS181-02-051018	67.7	67.5	12%	56	M7-XS181-02-051018	1805322-17	150		76%
Trip 2	Orange	M7-XS39-01-051018	95.9	92.6	9%	89	M7-XS39-01-051018	1805322-18	210		75%
Trip 2	Orange	M7-XS74-01-051018	131.4	133.7	11%	112	M7-XS74-01-051018	1805322-19	300		78%
Trip 2	Orange	M7-XS77-01-051018	173.6	170.5	9%	147	M7-XS77-01-051018	1805322-20	290		50%
Trip 2	Pink	M8-XS100-01-050918	121.4	117.2	20%	89	M8-XS100-01-050918	1805328-3	130		7%
Trip 2	Pink	M8-XS110-01-050918	108.1	109.0	24%	67	M8-XS110-01-050918	1805328-6	180		50%
Trip 2	Orange	M8-XS19-01-051018	199.3	185.8	17%	169	M8-XS19-01-051018	1805328-7	220		10%
Trip 2	Orange	M8-XS32-01-051018	98.0	90.9	21%	79	M8-XS32-01-051018	1805328-8	99		1%
Trip 2	Pink	M8-XS94-01-050918	103.4	98.9	20%	78	M8-XS94-01-050918	1805328-9	160		43%
Trip 2	Pink	T13-XS12-01-050818	419.1	421.5	5%	391	T13-XS12-01-050818	1805322-21	510		20%
Trip 2	Pink	T13-XS24-01-050818	125.7	129.1	16%	95	T13-XS24-01-050818	1805322-22	130		3%
Trip 2	Pink	T14-XS12-01-050818	292.1	287.8	6%	273	T14-XS12-01-050818	1805322-23	340		15%
Trip 2	Pink	T14-XS27-01-050818	187.3	186.3	10%	169	T14-XS27-01-050818	1805322-24	220		16%
Trip 2	Pink	T15-XS2-01-050818	146.9	141.4	9%	136	T15-XS2-01-050818	1805322-25	170		15%
Trip 2	Pink	T15-XS45-01-050818	115.1	119.7	14%	90	T15-XS45-01-050818	1805322-26	160		33%
Trip 2	Pink	T17-XS122-01-050718	102.8	104.3	14%	81	T17-XS122-01-050718	1805322-27	130		23%
Trip 2	Pink	T17-XS176-01-050718	114.0	119.5	15%	88	T17-XS176-01-050718	1805322-28	120		5%
Trip 2	Pink	T17-XS178-01-050718	164.8	168.4	10%	142	T17-XS178-01-050718	1805322-29	170		3%
Trip 2	Pink	T17-XS619-01-050718	194.6	197.2	5%	179	T17-XS619-01-050718	1805322-30	240		21%
Trip 2	Pink	T17-XS619-02-050718	183.7	183.6	14%	153	T17-XS619-02-050718	1805322-31	230		22%
Trip 2	Pink	T17-XS645-01-050718	174.0	165.5	20%	137	T17-XS645-01-050718	1805322-32	190		9%
Trip 2	Pink	T17-XS669-01-050718	136.7	133.4	20%	107	T17-XS669-01-050718	1805322-33	160		16%
Trip 2	Pink	T1-XS104-01-051318	115.0	114.9	8%	105	T1-XS104-01-051318	1805328-10	120		4%
Trip 2	Pink	T1-XS20-01-051318	147.5	153.5	12%	117	T1-XS20-01-051318	1805328-11	210		35%
Trip 2	Pink	T1-XS54-01-051318	136.8	140.4	11%	117	T1-XS54-01-051318	1805328-12	200		38%
Trip 2	Pink	T1-XS54-02-051318	135.8	138.6	10%	117	T1-XS54-02-051318	1805328-13	200		38%
Trip 2	Pink	T1-XS69-01-051318	347.8	323.4	19%	310	T1-XS69-01-051318	1805328-14	520		40%
Trip 2	Orange	T3-XS10-01-051218	99.1	97.9	8%	90	T3-XS10-01-051218	1805328-15	130		27%
Trip 2	Orange	T3-XS5-01-051218	97.0	98.1	7%	88	T3-XS5-01-051218	1805328-16	120		21%
Trip 2	Pink	T4-XS23-01-051218	63.8	63.7	15%	50	T4-XS23-01-051218	1805328-17	120		61%
Trip 2	Orange	T4-XS32-01-051218	63.9	60.5	25%	40	T4-XS32-01-051218	1805328-18	110		53%
Trip 2	Pink	T4-XS43-01-051218	66.3	64.1	19%	55	T4-XS43-01-051218	1805328-19	120		58%
Trip 2	Pink	T5-XS18-01-051418	31.3	32.9	24%	22	T5-XS18-01-051418	1805328-20	93		99%
Trip 2	Pink	T6-XS2-01-051218	62.5	64.6	17%	43	T6-XS2-01-051218	1805328-21	95		41%
Trip 2	Orange	T6-XS25-01-051218	72.8	74.0	11%	57	T6-XS25-01-051218	1805328-22	100		32%
Trip 3	Pink	M14-XS36-01-052418	77.6	78.1	10%	65	M14-XS36-01-052418	1805632-1	150		64%
Trip 3	Pink	M14-XS40-01-052418	85.7	81.1	21%	66	M14-XS40-01-052418	1805632-2	160		61%
Trip 3	Pink	M14-XS64-01-052418	127.5	120.1	12%	113	M14-XS64-01-052418	1805632-3	210		49%

Trip	XRF Color	XRF ID	XRF - Manganese				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 3	Pink	M14-XS67-01-052418	68.9	71.1	17%	49	M14-XS67-01-052418	1805632-4	130		61%
Trip 3	Pink	M15-XS3-01-052118	155.6	143.8	15%	137	M15-XS3-01-052118	1805589-2	200		25%
Trip 3	Pink	M15-XS22-01-052118	98.1	94.4	12%	87	M15-XS22-01-052118	1805589-1	160		48%
Trip 3	Pink	M15-XS46-01-052118	133.6	133.1	10%	113	M15-XS46-01-052118	1805589-3	180		30%
Trip 3	Pink	M15-XS46-02-052118	114.0	111.6	17%	89	M15-XS46-02-052118	1805589-4	170		39%
Trip 3	Pink	M15-XS82-01-052118	244.6	241.0	11%	203	M15-XS82-01-052118	1805589-6	410		51%
Trip 3	Pink	M15-XS93-01-052118	147.0	151.9	9%	125	M15-XS93-01-052118	1805589-7	280		62%
Trip 3	Pink	M16-XS4-01-052118	156.1	160.4	12%	123	M16-XS4-01-052118	1805589-12	220		34%
Trip 3	Pink	M16-XS30-01-052118	111.9	108.1	22%	87	M16-XS30-01-052118	1805589-10	190		52%
Trip 3	Pink	M16-XS31-01-052118	93.7	95.8	12%	80	M16-XS31-01-052118	1805589-11	190		68%
Trip 3	Pink	M16-XS128-01-052118	157.5	162.6	13%	130	M16-XS128-01-052118	1805589-8	210		29%
Trip 3	Pink	M16-XS154-01-052618	142.1	138.5	20%	106	M16-XS154-01-052618	1806235-2	170		18%
Trip 3	Pink	M16-XS177-01-052618	96.1	97.4	14%	78	M16-XS177-01-052618	1806235-3	140		37%
Trip 3	Pink	M16-XS191-01-052618	104.8	108.0	20%	74	M16-XS191-01-052618	1806235-4	160		42%
Trip 3	Pink	M16-XS191-02-052618	120.7	119.0	11%	101	M16-XS191-02-052618	1806235-5	150		22%
Trip 3	Pink	M17-XS55-01-052618	71.3	68.3	20%	54	M17-XS55-01-052618	1806235-6	120		51%
Trip 3	Pink	M17-XS83-01-052618	60.8	56.2	27%	47	M17-XS83-01-052618	1806235-7	110		58%
Trip 3	Pink	M17-XS83-02-052618	60.5	60.2	12%	52	M17-XS83-02-052618	1806235-8	110		58%
Trip 3	Pink	M18-XS155-01-052518	51.2	50.6	21%	35	M18-XS155-01-052518	1805632-5	88		53%
Trip 3	Pink	M18-XS161-01-052518	109.4	104.8	17%	92	M18-XS161-01-052518	1805632-6	140		24%
Trip 3	Pink	M19-XS22-02-052318	99.7	93.1	34%	64	M19-XS22-02-052318	1805632-8	150		40%
Trip 3	Pink	M19-XS22-01-052318	86.2	89.3	27%	57	M19-XS22-01-052318	1805632-7	150		54%
Trip 3	Pink	M19-XS43-01-052318	225.5	211.2	25%	152	M19-XS43-01-052318	1805632-9	250		10%
Trip 3	Pink	T21-XS55-02-052118	232.4	231.3	10%	198	T21-XS55-02-052118	1805589-16	230		1%
Trip 3	Pink	T22-XS64-01-052218	179.8	180.3	9%	155	T22-XS64-01-052218	1805632-11	200		11%
Trip 3	Pink	T23-XS23-01-052118	300.1	300.7	9%	261	T23-XS23-01-052118	1805589-19	300		0%
Trip 3	Pink	T23-XS40-01-052118	200.6	204.7	11%	172	T23-XS40-01-052118	1805589-20	220		9%
Trip 3	Pink	T24-XS48-01-052418	163.7	148.7	29%	135	T24-XS48-01-052418	1805632-12	210		25%
Trip 4	Pink	M13-XS72-01-060618	333.1	329.8	10%	297	M13-XS72-01-060618	1806235-1	410		21%
Trip 4	Pink	M20-XS5-01-060518	279.5	286.0	11%	230	M20-XS5-01-060518	1806235-20	300		7%
Trip 4	Pink	M20-XS11-01-060618	110.0	113.5	18%	83	M20-XS11-01-060618	1806235-9	160		37%
Trip 4	Pink	M20-XS18-01-060618	105.0	107.2	11%	87	M20-XS18-01-060618	1806235-12	160		41%
Trip 4	Pink	M20-XS86-01-060618	94.5	92.1	16%	79	M20-XS86-01-060618	1806235-21	200		72%
Trip 4	Pink	M20-XS130-01-060418	434.0	442.9	15%	332	M20-XS130-01-060418	1806235-10	360		19%
Trip 4	Pink	M20-XS166-01-060518	186.6	185.6	12%	162	M20-XS166-01-060518	1806235-11	250		29%
Trip 4	Pink	M20-XS185-01-060418	140.2	132.5	18%	121	M20-XS185-01-060418	1806235-13	110		24%
Trip 4	Pink	M20-XS231-01-060418	181.8	172.6	39%	104	M20-XS231-01-060418	1806235-14	130		33%
Trip 4	Pink	M20-XS278-01-060418	323.0	325.2	15%	243	M20-XS278-01-060418	1806235-15	270		18%
Trip 4	Pink	M20-XS306-01-060518	226.5	228.8	10%	193	M20-XS306-01-060518	1806235-16	290		25%
Trip 4	Pink	M20-XS312-01-060518	116.7	113.0	11%	104	M20-XS312-01-060518	1806235-17	150		25%
Trip 4	Pink	M20-XS365-01-060618	67.2	60.0	27%	52	M20-XS365-01-060618	1806235-18	130		64%
Trip 4	Pink	M20-XS365-02-060618	51.5	57.2	30%	28	M20-XS365-02-060618	1806235-19	110		72%
Trip 4	Pink	M21-XS14-01-060818	115.6	119.6	16%	89	M21-XS14-01-060818	1806234-3	130		12%
Trip 4	Pink	M21-XS27-01-060818	134.2	132.3	27%	80	M21-XS27-01-060818	1806234-7	210		44%
Trip 4	Pink	M21-XS27-02-060818	142.7	141.2	21%	99	M21-XS27-02-060818	1806234-8	200		33%
Trip 4	Pink	M21-XS40-01-060818	282.4	281.7	10%	249	M21-XS40-01-060818	1806234-15	360		24%
Trip 4	Pink	M21-XS46-01-060818	164.9	164.3	11%	140	M21-XS46-01-060818	1806234-18	210		24%
Trip 4	Pink	M21-XS122-01-060818	305.6	299.2	8%	286	M21-XS122-01-060818	1806234-1	390		24%
Trip 4	Pink	M21-XS126-01-060818	349.5	353.3	6%	316	M21-XS126-01-060818	1806234-2	450		25%
Trip 4	Pink	M21-XS175-01-060818	293.9	289.7	7%	271	M21-XS175-01-060818	1806234-4	300		2%
Trip 4	Pink	M21-XS225-01-060518	251.3	256.5	11%	210	M21-XS225-01-060518	1806235-22	360		36%
Trip 4	Pink	M21-XS259-01-060918	77.3	74.4	22%	61	M21-XS259-01-060918	1806234-5	130		51%
Trip 4	Pink	M21-XS260-01-060918	152.3	153.7	9%	128	M21-XS260-01-060918	1806234-6	200		27%
Trip 4	Pink	M21-XS282-01-060918	70.4	68.7	11%	62	M21-XS282-01-060918	1806234-9	120		52%
Trip 4	Pink	M21-XS290-01-060918	206.8	209.8	11%	165	M21-XS290-01-060918	1806234-10	290		33%
Trip 4	Pink	M21-XS292-01-060518	168.9	158.5	16%	147	M21-XS292-01-060518	1806235-23	250		39%
Trip 4	Pink	M21-XS302-02-060918	119.9	92.3	63%	68	M21-XS302-02-060918	1806234-12	160		29%
Trip 4	Pink	M21-XS302-01-060918	85.4	86.3	14%	69	M21-XS302-01-060918	1806234-11	150		55%
Trip 4	Pink	M21-XS334-01-060918	246.5	249.8	10%	210	M21-XS334-01-060918	1806234-13	280		13%
Trip 4	Pink	M21-XS377-01-060918	118.4	91.0	80%	60	M21-XS377-01-060918	1806234-14	120		1%
Trip 4	Pink	M21-XS419-01-060818	191.9	189.3	7%	179	M21-XS419-01-060818	1806234-17	230		18%
Trip 4	Pink	M21-XS477-01-060818	166.9	169.6	13%	127	M21-XS477-01-060818	1806234-19	200		18%
Trip 4	Pink	M21-XS541-01-060818	152.3	150.2	8%	137	M21-XS541-01-060818	1806234-20	210		32%
Trip 4	Pink	M21-XS596-01-060518	106.9	107.1	11%	89	M21-XS596-01-060518	1806235-24	180		51%
Trip 4	Pink	M21-XS615-01-060518	122.5	125.9	14%	99	M21-XS615-01-060518	1806235-25	210		53%
Trip 4	Pink	M21-XS619-01-060618	223.4	217.8	22%	174	M21-XS619-01-060618	1806235-26	400		57%
Trip 4	Pink	M22-XS14-01-060418	414.7	449.8	16%	322	M22-XS14-01-060418	1806235-27	400		4%
Trip 4	Pink	M22-XS30-01-060418	90.4	85.8	16%	75	M22-XS30-01-060418	1806235-28	130		36%
Trip 4	Pink	M22-XS40-01-060518	243.4	237.8	17%	192	M22-XS40-01-060518	1806235-29	240		1%
Trip 4	Pink	M22-XS60-01-060418	154.3	139.3	30%	109	M22-XS60-01-060418	1806235-30	160		4%
Trip 4	Pink	M22-XS87-01-060418	203.9	208.0	10%	171	M22-XS87-01-060418	1806235-31	230		12%
Trip 4	Pink	M23-XS20-01-061018	368.0	341.1	18%	312	M23-XS20-01-061018	1806233-3	300		20%

Trip	XRF Color	XRF ID	XRF - Manganese: Average Ex Situ XRF (ppm)	XRF - Manganese: Median Ex Situ XRF (ppm)	XRF - Manganese: Relative Standard Deviation	XRF - Manganese: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M23-XS48-01-061018	170.2	174.0	11%	143	M23-XS48-01-061018	1806233-4	160		6%
Trip 4	Pink	M23-XS54-01-061118	74.2	59.0	51%	45	M23-XS54-01-061118	1806312-1	130		55%
Trip 4	Pink	M23-XS64-01-061018	89.8	82.8	15%	79	M23-XS64-01-061018	1806233-5	100		11%
Trip 4	Pink	M23-XS70-01-061018	304.7	323.6	12%	253	M23-XS70-01-061018	1806233-6	250		20%
Trip 4	Pink	M23-XS79-01-061018	178.4	176.1	15%	141	M23-XS79-01-061018	1806233-7	170		5%
Trip 4	Pink	M23-XS102-01-061018	268.4	276.9	12%	228	M23-XS102-01-061018	1806233-1	430		46%
Trip 4	Pink	M23-XS123-01-061018	154.5	153.3	12%	132	M23-XS123-01-061018	1806233-2	160		4%
Trip 4	Pink	M24-XS100-01-061118	269.2	266.1	16%	204	M24-XS100-01-061118	1806312-3	300		11%
Trip 4	Pink	M24-XS128-01-061118	183.0	185.1	13%	157	M24-XS128-01-061118	1806312-4	280		42%
Trip 4	Pink	T18-XS14-01-061118	149.2	152.5	14%	114	T18-XS14-01-061118	1806312-5	200		29%
Trip 4	Pink	T18-XS27-01-061118	44.6	46.5	13%	36	T18-XS27-01-061118	1806312-6	110		85%
Trip 4	Pink	T25-XS2-01-060618	279.3	269.1	17%	226	T25-XS2-01-060618	1806235-32	260		7%
Trip 4	Pink	T26-XS1-01-061018	189.3	152.3	38%	130	T26-XS1-01-061018	1806233-8	140		30%
Trip 4	Pink	T26-XS8-01-061018	139.3	144.5	21%	103	T26-XS8-01-061018	1806233-9	120		15%
Trip 4	Pink	T27-XS6-01-061018	275.9	285.0	22%	192	T27-XS6-01-061018	1806233-11	250		10%
Trip 4	Pink	T27-XS19-01-061018	158.1	156.0	18%	130	T27-XS19-01-061018	1806233-10	130		20%
Trip 5	Pink	M26-XS13-01-061818	45.4	42.6	13%	40	M26-XS13-01-061818	1806558-1	83		59%
Trip 5	Pink	M26-XS25-01-061818	102.1	93.0	26%	76	M26-XS25-01-061818	1806558-2	140		31%
Trip 5	Pink	M27-XS21-01-061918	138.7	132.7	21%	110	M27-XS21-01-061918	1806558-10	260		61%
Trip 5	Pink	M27-XS29-01-061818	135.1	133.0	16%	109	M27-XS29-01-061818	1806558-14	190		34%
Trip 5	Pink	M27-XS38-01-061918	72.7	72.0	17%	55	M27-XS38-01-061918	1806558-15	230		104%
Trip 5	Pink	M27-XS108-01-061918	124.4	119.0	15%	103	M27-XS108-01-061918	1806558-3	210		51%
Trip 5	Pink	M27-XS109-01-061918	143.5	148.4	14%	118	M27-XS109-01-061918	1806558-4	210		38%
Trip 5	Pink	M27-XS123-01-061818	58.4	45.1	55%	39	M27-XS123-01-061818	1806558-5	180		102%
Trip 5	Pink	M27-XS188-01-061918	180.2	178.7	10%	159	M27-XS188-01-061918	1806558-6	250		32%
Trip 5	Pink	M27-XS197-01-061918	151.1	149.5	9%	135	M27-XS197-01-061918	1806558-7	230		41%
Trip 5	Pink	M27-XS210-02-061818	110.5	109.7	9%	99	M27-XS210-02-061818	1806558-9	180		48%
Trip 5	Pink	M27-XS210-01-061818	110.8	105.5	13%	101	M27-XS210-01-061818	1806558-8	190		53%
Trip 5	Pink	M27-XS239-01-061818	77.7	66.5	45%	50	M27-XS239-01-061818	1806558-11	130		50%
Trip 5	Pink	M27-XS275-01-061918	114.0	113.6	9%	102	M27-XS275-01-061918	1806558-12	200		55%
Trip 5	Pink	M27-XS283-01-061818	93.6	90.3	19%	70	M27-XS283-01-061818	1806558-13	230		84%
Trip 5	Pink	M28-XS8-01-062018	99.6	97.4	9%	92	M28-XS8-01-062018	1806558-21	210	J	71%
Trip 5	Pink	M28-XS43-01-062018	35.8	34.2	45%	19	M28-XS43-01-062018	1806558-20	86		82%
Trip 5	Pink	M28-XS105-01-062018	120.0	122.2	12%	102	M28-XS105-01-062018	1806558-16	220		59%
Trip 5	Pink	M28-XS148-01-062018	91.6	90.0	13%	80	M28-XS148-01-062018	1806558-17	140		42%
Trip 5	Pink	M28-XS155-01-062018	74.3	76.4	20%	50	M28-XS155-01-062018	1806558-18	150		67%
Trip 5	Pink	M28-XS170-01-062018	304.1	307.1	16%	246	M28-XS170-01-062018	1806558-19	320		5%
Trip 5	Pink	M30-XS138-01-062218	208.1	204.6	13%	177	M30-XS138-01-062218	1806693-1	360		53%
Trip 5	Pink	M30-XS222-01-062218	160.2	156.9	20%	122	M30-XS222-01-062218	1806693-2	250		44%
Trip 5	Pink	T32-XS5-01-062018	103.7	104.3	12%	89	T32-XS5-01-062018	1806558-22	140		30%
Trip 6	Orange	M10-XS10A-01-071118	159.0	164.2	11%	136	M10-XS10A-01-071118	1807369-1	210.0		28%
Trip 6	Orange	M10-XS31-01-071118	209.4	206.2	12%	178	M10-XS31-01-071118	1807369-2	200.0		5%
Trip 6	Orange	M10-XS31-02-071118	188.5	183.3	11%	167	M10-XS31-02-071118	1807369-3	200.0		6%
Trip 6	Orange	M11-XS11-01-071118	151.8	148.9	15%	128	M11-XS11-01-071118	1807369-4	190.0		22%
Trip 6	Red	M11-XS7-01-071118	130.4	117.8	34%	98	M11-XS7-01-071118	1807369-5	140.0		7%
Trip 6	Red	M12-XS27-01-071518	47.6	41.8	40%	32	M12-XS27-01-071518	1807369-6	63.0		28%
Trip 6	Orange	M24-XS115-01-071418	450.9	389.2	36%	292	M24-XS115-01-071418	1807369-7	370.0		20%
Trip 6	Red	M25-XS16-01-071718	121.7	108.8	28%	90	M25-XS16-01-071718	1807452-1	170.0		33%
Trip 6	Red	M25-XS23-01-071718	162.1	145.4	27%	135	M25-XS23-01-071718	1807452-2	350.0		73%
Trip 6	Red	M25-XS47-01-071718	103.1	102.6	20%	78	M25-XS47-01-071718	1807452-3	160.0		43%
Trip 6	Red	M25-XS88-01-071718	117.3	115.0	11%	106	M25-XS88-01-071718	1807452-4	160.0		31%
Trip 6	Orange	M30-XS127-01-071618	50.4	47.4	18%	41	M30-XS127-01-071618	1807369-9	88.0		54%
Trip 6	Orange	M30-XS170-01-071618	120.4	118.6	13%	101	M30-XS170-01-071618	1807369-10	170.0		34%
Trip 6	Red	M30-XS95-01-071618	119.8	119.6	25%	81	M30-XS95-01-071618	1807369-11	290.0		83%
Trip 6	Red	M31-XS9-01-071018	107.2	100.6	17%	91	M31-XS9-01-071018	1807369-12	170.0		45%
Trip 6	Orange	M32-XS58-01-071018	130.7	130.9	17%	105	M32-XS58-01-071018	1807369-13	170.0		26%
Trip 6	Red	M32-XS89-01-071018	171.5	178.1	14%	125	M32-XS89-01-071018	1807369-14	230.0		29%
Trip 6	Orange	M33-XS85-01-071218	175.4	173.2	10%	158	M33-XS85-01-071218	1807369-16	220.0		23%
Trip 6	Red	M33-XS93-01-071218	101.4	101.7	14%	85	M33-XS93-01-071218	1807369-17	140.0		32%
Trip 6	Red	T33-XS43-01-071718	244.0	248.5	9%	202	T33-XS43-01-071718	1807452-5	300.0		21%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
Trip	XRF Color	XRF ID	XRF - Manganese				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 2	Pink	M6-XS81-01-051018	25.4	19.5	120%	0	M6-XS81-01-051018	1805322-15	64		86%
Trip 3	Blue	M15-XS73-01-052118	0.0	0.0	0%	0	M15-XS73-01-052118	1805589-5	190		200%
Trip 3	Blue	M16-XS45-01-052118	0.0	0.0	0%	0	M16-XS45-01-052118	1805589-13	220		200%
Trip 3	Blue	M16-XS166-01-052118	0.0	0.0	0%	0	M16-XS166-01-052118	1805589-9	220		200%
Trip 3	Blue	T20-XS14-01-052218	0.0	0.0	0%	0	T20-XS14-01-052218	1805632-10	210		200%
Trip 3	Blue	T21-XS6-01-052118	0.0	0.0	0%	0	T21-XS6-01-052118	1805589-17	180		200%
Trip 3	Blue	T21-XS35-01-052118	0.0	0.0	0%	0	T21-XS35-01-052118	1805589-14	250		200%
Trip 3	Blue	T21-XS55-01-052118	0.0	0.0	0%	0	T21-XS55-01-052118	1805589-15	230		200%
Trip 3	Blue	T22-XS17-01-052118	0.0	0.0	0%	0	T22-XS17-01-052118	1805589-18	250		200%
Trip 4	Pink	M21-XS403-01-060818	26.9	31.2	50%	0	M21-XS403-01-060818	1806234-16	71		90%

Removed Data - Above 500 ppm											
Trip	XRF Color	XRF ID	XRF - Manganese				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 2	Pink	M8-XS102-01-050918	630.0	602.0	12%	558	M8-XS102-01-050918	1805328-4	350		57%
Trip 2	Pink	M8-XS102-02-050918	584.1	593.4	6%	524	M8-XS102-02-050918	1805328-5	340		53%
Trip 6	Orange	M33-XS22-01-071218	545.1	532.8	11%	468	M33-XS22-01-071218	1807369-15	1,300		82%

Notes:

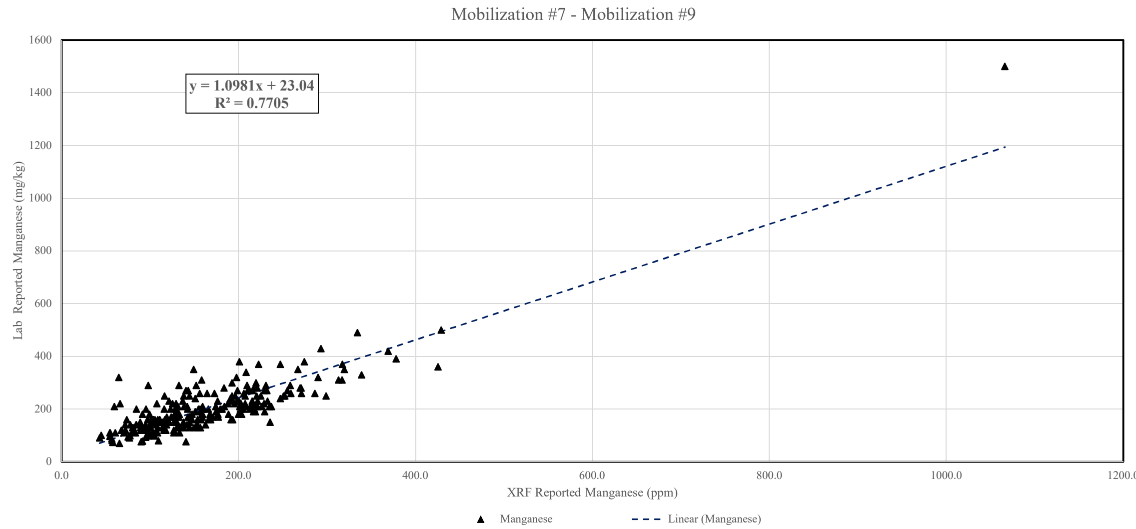
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included											
			XRF - Manganese						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M10-XS22-01-082118	77.9	76.9	18%	61	M10-XS22-01-082118	1808494-1	140	J	57%
Trip 7	Red	M10-XS39-01-082118	99.0	96.7	15%	78	M10-XS39-01-082118	1808494-2	100		1%
Trip 7	Red	M10-XS43-01-082118	99.7	91.8	23%	77	M10-XS43-01-082118	1808494-3	180		57%
Trip 7	Red	M1-XSG2-01-081918	197.8	200.8	7%	173	M1-XSG2-01-081918	1808483-1	320		47%
Trip 7	Pink	M34-XS110-01-081218	94.2	99.5	15%	70	M34-XS110-01-081218	1808303-1	120		24%
Trip 7	Pink	M34-XS22-01-081218	132.9	135.3	7%	122	M34-XS22-01-081218	1808303-2	290		74%
Trip 7	Pink	M34-XS43-01-081218	147.5	140.7	13%	131	M34-XS43-01-081218	1808303-3	160		8%
Trip 7	Pink	M34-XS50-01-081218	188.2	190.5	8%	163	M34-XS50-01-081218	1808303-4	220		16%
Trip 7	Pink	M34-XS68-01-081218	369.1	374.8	9%	328	M34-XS68-01-081218	1808303-5	420		13%
Trip 7	Pink	M35-XS11-01-081218	425.7	328.9	43%	287	M35-XS11-01-081218	1808303-6	360		17%
Trip 7	Pink	M35-XS20-01-081318	140.8	133.9	17%	119	M35-XS20-01-081318	1808303-7	76		60%
Trip 7	Pink	M35-XS31-01-081218	177.3	181.8	13%	147	M35-XS31-01-081218	1808303-8	170		4%
Trip 7	Pink	M35-XS63-01-081218	61.0	56.7	22%	47	M35-XS63-01-081218	1808303-9	110		57%
Trip 7	Pink	M35-XS74-01-081318	99.3	92.9	25%	75	M35-XS74-01-081318	1808303-10	110		10%
Trip 7	Pink	M35-XS74-02-081318	106.3	105.2	23%	81	M35-XS74-02-081318	1808303-11	110		3%
Trip 7	Pink	M36-XS20-01-081218	108.7	103.7	24%	78	M36-XS20-01-081218	1808303-12	150		32%
Trip 7	Pink	M36-XS2-01-081218	146.3	132.4	25%	112	M36-XS2-01-081218	1808303-13	170	J	15%
Trip 7	Pink	M36-XS31-01-081218	157.6	149.8	19%	129	M36-XS31-01-081218	1808303-15	160		2%
Trip 7	Pink	M37-XS124A-01-081318	217.7	218.0	9%	194	M37-XS124A-01-081318	1808303-16	280		25%
Trip 7	Pink	M37-XS144-01-081318	258.7	265.5	10%	215	M37-XS144-01-081318	1808303-17	290		11%
Trip 7	Pink	M37-XS2-01-081318	317.0	310.9	17%	264	M37-XS2-01-081318	1808303-18	310		2%
Trip 7	Pink	M37-XS23-01-081318	95.3	83.5	40%	68	M37-XS23-01-081318	1808303-19	93		2%
Trip 7	Pink	M37-XS38-01-081318	92.1	93.1	26%	64	M37-XS38-01-081318	1808356-1	120		26%
Trip 7	Pink	M37-XS44-01-081318	208.7	210.8	15%	173	M37-XS44-01-081318	1808356-2	340		48%
Trip 7	Pink	M37-XS50-01-081318	221.3	223.7	11%	182	M37-XS50-01-081318	1808356-3	280		23%
Trip 7	Pink	M37-XS7-01-081318	247.6	253.4	14%	193	M37-XS7-01-081318	1808356-4	370		40%
Trip 7	Red	M38-XS20-01-081818	124.2	120.8	19%	96	M38-XS20-01-081818	1808483-2	170		31%
Trip 7	Red	M3-XS19-01-081718	111.2	116.2	16%	86	M3-XS19-01-081718	1808476-1	160		36%
Trip 7	Red	M3-XS41-01-081718	152.5	150.1	17%	122	M3-XS41-01-081718	1808476-2	290		62%
Trip 7	Red	M4-XS210-01-081818	57.0	53.0	49%	27	M4-XS210-01-081818	1808483-3	87		42%
Trip 7	Red	M4-XSG11-01-081818	80.5	74.4	18%	70	M4-XSG11-01-081818	1808483-4	130		47%
Trip 7	Red	M4-XSG2-01-081818	105.4	104.1	14%	87	M4-XSG2-01-081818	1808483-5	98		7%
Trip 7	Red	M5-XS131-01-082018	100.9	94.9	18%	80	M5-XS131-01-082018	1808487-1	130		25%
Trip 7	Red	M5-XS15-01-081818	67.7	57.5	50%	40	M5-XS15-01-081818	1808483-6	120		56%
Trip 7	Red	M5-XS192-01-081818	144.8	144.2	18%	107	M5-XS192-01-081818	1808483-7	250		53%
Trip 7	Red	M5-XS199-01-082018	89.9	77.5	42%	60	M5-XS199-01-082018	1808487-2	120		29%
Trip 7	Red	M5-XS207A-01-082018	72.4	58.5	52%	50	M5-XS207A-01-082018	1808487-3	120		50%
Trip 7	Red	M5-XS261-01-082018	95.3	94.4	10%	85	M5-XS261-01-082018	1808487-4	140		38%
Trip 7	Red	M5-XS263-01-082018	74.0	63.3	40%	47	M5-XS263-01-082018	1808487-5	160		74%
Trip 7	Red	M5-XS305-01-082018	138.7	136.9	15%	118	M5-XS305-01-082018	1808487-6	210		41%
Trip 7	Red	M5-XS476-01-082018	115.4	117.8	8%	103	M5-XS476-01-082018	1808487-7	150		26%
Trip 7	Red	M5-XS488-01-082018	114.2	117.4	8%	102	M5-XS488-01-082018	1808487-8	150		27%

Data Included												
			XRF - Manganese						ALS Results			
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M6-XS108-01-081618	174.9	168.7	20%	143	M6-XS108-01-081618	1808476-3	190		8%
Trip 7	Red	M6-XS108-02-081618	133.2	134.8	3%	125	M6-XS108-02-081618	1808476-4	180		30%
Trip 7	Red	M6-XS198-01-081618	151.1	148.8	11%	129	M6-XS198-01-081618	1808476-5	240		45%
Trip 7	Red	M6-XS249-01-081618	117.9	108.2	30%	79	M6-XS249-01-081618	1808476-6	160		30%
Trip 7	Red	M6-XS289-01-081618	103.5	112.5	24%	63	M6-XS289-01-081618	1808476-7	150		37%
Trip 7	Red	M6-XS324-01-081618	231.0	237.5	15%	173	M6-XS324-01-081618	1808476-8	290		23%
Trip 7	Red	M6-XS60-01-081618	84.2	85.6	14%	66	M6-XS60-01-081618	1808476-9	140		50%
Trip 7	Red	M6-XS72-01-081618	84.8	79.8	18%	69	M6-XS72-01-081618	1808476-10	200		81%
Trip 7	Pink	M7-XS162A-01-081518	130.0	124.4	21%	96	M7-XS162A-01-081518	1808356-5	210		47%
Trip 7	Pink	M7-XS203-01-081418	155.0	167.3	16%	116	M7-XS203-01-081418	1808356-6	200		25%
Trip 7	Pink	M7-XS213-01-081518	95.4	96.2	15%	72	M7-XS213-01-081518	1808356-7	200		71%
Trip 7	Pink	M7-XS214-01-081518	142.5	137.2	16%	115	M7-XS214-01-081518	1808356-8	200		34%
Trip 7	Pink	M7-XS235A-01-081418	196.3	195.6	3%	190	M7-XS235A-01-081418	1808356-9	250		24%
Trip 7	Pink	M7-XS244-01-081518	143.0	139.5	22%	108	M7-XS244-01-081518	1808356-10	170		17%
Trip 7	Pink	M8-XS55-01-081418	153.0	150.8	17%	113	M8-XS55-01-081418	1808356-20	140		9%
Trip 7	Pink	M8-XSG16-01-081518	156.6	157.3	16%	119	M8-XSG16-01-081518	1808356-11	200		24%
Trip 7	Pink	M8-XSG28-01-081418	212.3	201.1	10%	197	M8-XSG28-01-081418	1808356-12	270		24%
Trip 7	Pink	M8-XSG31-01-081518	214.0	193.8	21%	174	M8-XSG31-01-081518	1808356-13	210		2%
Trip 7	Pink	M8-XSG37-01-081418	183.9	179.9	8%	163	M8-XSG37-01-081418	1808356-14	210		13%
Trip 7	Pink	M8-XSG40-01-081418	192.9	193.4	5%	181	M8-XSG40-01-081418	1808356-15	250		26%
Trip 7	Pink	M8-XSG4-01-081518	210.7	215.8	13%	172	M8-XSG4-01-081518	1808356-16	270		25%
Trip 7	Pink	M8-XSG44-01-081418	219.3	212.6	29%	147	M8-XSG44-01-081418	1808356-17	190		14%
Trip 7	Pink	M8-XSG44-02-081418	205.8	218.6	16%	161	M8-XSG44-02-081418	1808356-18	200		3%
Trip 7	Pink	M8-XSG47-01-081418	215.0	218.4	10%	176	M8-XSG47-01-081418	1808356-19	220		2%
Trip 7	Red	M8-XSG6-01-081518	159.5	158.6	22%	111	M8-XSG6-01-081518	1808476-11	180		12%
Trip 7	Red	T10-XSG1-01-081818	201.3	212.0	11%	162	T10-XSG1-01-081818	1808483-10	210		4%
Trip 7	Red	T13-XSG16-01-081618	142.1	134.5	27%	102	T13-XSG16-01-081618	1808476-13	210		39%
Trip 7	Red	T13-XSG26-01-081618	378.2	366.2	10%	342	T13-XSG26-01-081618	1808476-14	390		3%
Trip 7	Red	T13-XSG7-01-081618	339.2	336.0	8%	310	T13-XSG7-01-081618	1808476-15	330		3%
Trip 7	Red	T15-XS20-01-081718	97.9	95.1	20%	75	T15-XS20-01-081718	1808483-11	99		1%
Trip 7	Red	T15-XSG5-01-081718	193.6	198.8	13%	158	T15-XSG5-01-081718	1808483-12	160		19%
Trip 7	Red	T17-XSG17-01-081618	66.3	51.1	59%	39	T17-XSG17-01-081618	1808476-16	220		107%
Trip 7	Red	T17-XSG27-01-081618	116.3	99.6	35%	83	T17-XSG27-01-081618	1808476-17	200		53%
Trip 7	Red	T17-XSG31-01-081518	107.9	99.8	32%	76	T17-XSG31-01-081518	1808476-18	220		68%
Trip 7	Red	T17-XSG7-02-081618	156.8	140.7	23%	133	T17-XSG7-02-081618	1808476-20	130		19%
Trip 7	Red	T1-XSG38-01-081918	159.0	159.9	12%	134	T1-XSG38-01-081918	1808483-13	170		7%
Trip 7	Red	T1-XSG49A-01-081918	153.6	133.3	30%	125	T1-XSG49A-01-081918	1808483-14	160		4%
Trip 7	Red	T4-XS15A-01-081918	181.6	179.0	16%	138	T4-XS15A-01-081918	1808487-9	200		10%
Trip 7	Red	T4-XSG10-01-081918	89.3	89.8	12%	72	T4-XSG10-01-081918	1808483-16	130		37%
Trip 7	Red	T4-XSG39-01-081918	81.0	78.9	19%	65	T4-XSG39-01-081918	1808483-17	130		46%
Trip 7	Red	T4-XSG50A-01-081918	193.3	197.1	8%	170	T4-XSG50A-01-081918	1808483-18	230		17%
Trip 7	Red	T5-XSG10-01-081918	220.0	220.2	2%	214	T5-XSG10-01-081918	1808483-19	300		31%
Trip 7	Red	T6-XSG6-01-081918	75.4	67.4	33%	57	T6-XSG6-01-081918	1808487-10	94		22%
Trip 7	Red	T6-XSG6-02-081918	76.8	75.2	16%	64	T6-XSG6-02-081918	1808487-11	91		17%
Trip 7	Red	T9-XSG12-01-081818	233.1	226.6	14%	200	T9-XSG12-01-081818	1808483-20	230		1%
Trip 8	Red	M13-XS112-01-091518	105.8	102.9	17%	88	M13-XS112-01-091518	1809475-1	160		41%
Trip 8	Red	M13-XS258-01-091518	91.5	69.6	58%	50	M13-XS258-01-091518	1809475-2	180		65%
Trip 8	Red	M14-XS62-01-091818	91.7	90.8	20%	72	M14-XS62-01-091818	1809475-21	130		35%
Trip 8	Red	M14-XSG14A-01-091818	118.6	113.2	27%	77	M14-XSG14A-01-091818	1809475-22	140		17%
Trip 8	Red	M14-XSG27A-01-091818	229.1	221.9	12%	209	M14-XSG27A-01-091818	1809475-23	270		16%
Trip 8	Red	M14-XSG41-01-091818	255.3	252.4	10%	223	M14-XSG41-01-091818	1809475-24	270		6%
Trip 8	Red	M14-XSG49-01-091818	250.9	249.3	8%	226	M14-XSG49-01-091818	1809475-25	250		0%
Trip 8	Red	M14-XSG58-01-091818	215.8	201.2	20%	176	M14-XSG58-01-091818	1809475-26	270		22%
Trip 8	Red	M14-XSG6-01-091818	317.5	327.6	15%	255	M14-XSG6-01-091818	1809475-27	370		15%
Trip 8	Red	M15-XSG20-01-091118	121.5	117.3	22%	89	M15-XSG20-01-091118	1809473-20	230		62%
Trip 8	Red	M15-XSG2-01-091118	151.1	154.2	11%	129	M15-XSG2-01-091118	1809473-21	190		23%
Trip 8	Red	M16-XSG13-01-091118	215.6	214.1	9%	192	M16-XSG13-01-091118	1809473-22	230		6%
Trip 8	Red	M16-XSG30-01-091518	81.8	80.0	19%	59	M16-XSG30-01-091518	1809475-3	110		29%
Trip 8	Red	M16-XSG38-01-091518	58.0	59.7	10%	46	M16-XSG38-01-091518	1809475-4	74		24%
Trip 8	Red	M17-XS79-01-091318	109.1	109.2	16%	88	M17-XS79-01-091318	1809473-1	130		18%
Trip 8	Red	M17-XSG1-01-091318	234.9	236.2	15%	193	M17-XSG1-01-091318	1809473-2	210		11%
Trip 8	Red	M17-XSG27-01-091318	112.6	109.6	21%	87	M17-XSG27-01-091318	1809473-3	150		28%
Trip 8	Red	M17-XSG36-01-091318	108.5	110.7	14%	89	M17-XSG36-01-091318	1809473-4	110		1%
Trip 8	Red	M17-XSG36-02-091318	103.3	103.3	16%	80	M17-XSG36-02-091318	1809473-5	110		6%
Trip 8	Red	M18-XSG16-01-091318	237.1	241.4	20%	177	M18-XSG16-01-091318	1809473-6	210		12%
Trip 8	Red	M18-XSG30-01-091318	128.6	129.6	14%	102	M18-XSG30-01-091318	1809473-7	180		33%

Data Included											
			XRF - Manganese						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M18-XSG32-01-091318	167.7	166.7	16%	131	M18-XSG32-01-091318	1809473-8	180		7%
Trip 8	Red	M19-XSG11-01-091318	299.2	268.2	29%	256	M19-XSG11-01-091318	1809473-9	250		18%
Trip 8	Red	M19-XSG19-01-091318	109.4	110.8	33%	64	M19-XSG19-01-091318	1809473-10	150		31%
Trip 8	Red	M19-XSG25-01-091318	229.6	224.4	15%	192	M19-XSG25-01-091318	1809473-11	190		19%
Trip 8	Red	M19-XSG29-01-091318	217.2	215.0	28%	146	M19-XSG29-01-091318	1809473-12	190		13%
Trip 8	Red	M19-XSG39-01-091318	153.8	155.2	11%	132	M19-XSG39-01-091318	1809473-13	140		9%
Trip 8	Red	M19-XSG43-01-091318	235.8	225.4	27%	178	M19-XSG43-01-091318	1809473-14	150		44%
Trip 8	Red	M20-XS146-01-091718	72.1	68.9	28%	50	M20-XS146-01-091718	1809475-28	140		64%
Trip 8	Red	M20-XS243-01-091718	43.0	44.7	29%	20	M20-XS243-01-091718	1809475-29	91		72%
Trip 8	Red	M20-XS247-01-091718	147.5	150.6	7%	129	M20-XS247-01-091718	1809475-30	180		20%
Trip 8	Red	M20-XS267-01-091718	84.7	83.5	14%	71	M20-XS267-01-091718	1809475-31	140		49%
Trip 8	Red	M20-XS271-01-091718	274.7	287.6	19%	190	M20-XS271-01-091718	1809475-32	380		32%
Trip 8	Red	M20-XS30-01-091718	117.8	115.6	16%	94	M20-XS30-01-091718	1809475-33	150		24%
Trip 8	Red	M20-XS335-01-091418	129.4	127.2	6%	122	M20-XS335-01-091418	1809475-5	190		38%
Trip 8	Red	M20-XS422-01-091418	159.7	157.4	8%	141	M20-XS422-01-091418	1809475-6	210		27%
Trip 8	Red	M20-XS58-01-091718	104.0	105.9	11%	84	M20-XS58-01-091718	1809475-34	160		42%
Trip 8	Red	M20-XS60-01-091718	177.0	179.0	8%	158	M20-XS60-01-091718	1809475-35	180		2%
Trip 8	Red	M20-XSG15-01-091418	247.3	242.9	6%	233	M20-XSG15-01-091418	1809475-7	240		3%
Trip 8	Red	M20-XSG28-01-091418	125.4	118.9	23%	91	M20-XSG28-01-091418	1809475-8	220		55%
Trip 8	Red	M20-XSG7-01-091418	65.6	63.1	42%	37	M20-XSG7-01-091418	1809475-9	70		6%
Trip 8	Red	M21-XS1-01-091218	98.0	91.7	50%	48	M21-XS1-01-091218	1809473-24	290		99%
Trip 8	Red	M21-XS317-01-091218	119.0	122.4	18%	88	M21-XS317-01-091218	1809473-25	170		35%
Trip 8	Red	M21-XS323-01-091218	128.3	126.9	11%	113	M21-XS323-01-091218	1809473-26	160		22%
Trip 8	Red	M21-XS366-01-091418	55.0	55.7	29%	29	M21-XS366-01-091418	1809475-10	110		67%
Trip 8	Red	M21-XS366-02-091418	45.1	47.6	24%	27	M21-XS366-02-091418	1809475-11	100		76%
Trip 8	Red	M21-XS465-01-091218	222.7	228.1	16%	179	M21-XS465-01-091218	1809473-27	370		50%
Trip 8	Red	M21-XS511-01-091218	209.9	202.2	12%	181	M21-XS511-01-091218	1809473-29	290		32%
Trip 8	Red	M21-XS536-01-091218	334.5	333.6	5%	317	M21-XS536-01-091218	1809473-30	490		38%
Trip 8	Red	M21-XSG16-01-091218	59.9	64.6	28%	38	M21-XSG16-01-091218	1809473-31	210		111%
Trip 8	Red	M21-XSG38-01-091418	293.2	285.7	15%	247	M21-XSG38-01-091418	1809475-12	430		38%
Trip 8	Red	M21-XSG43-01-091418	131.3	124.2	14%	110	M21-XSG43-01-091418	1809475-13	170		26%
Trip 8	Red	M22-XS112-01-091418	130.4	125.8	9%	120	M22-XS112-01-091418	1809475-14	190		37%
Trip 8	Red	M22-XS115-01-091418	200.6	186.4	17%	166	M22-XS115-01-091418	1809475-15	230		14%
Trip 8	Red	M22-XS121-01-091418	290.2	289.6	9%	255	M22-XS121-01-091418	1809475-16	320		10%
Trip 8	Red	M22-XS94-01-091418	138.4	134.4	30%	93	M22-XS94-01-091418	1809475-17	130		6%
Trip 8	Red	M23-XSG1-01-091418	192.7	194.3	8%	171	M23-XSG1-01-091418	1809475-18	300		44%
Trip 8	Red	M23-XSG20-01-091418	188.8	175.2	19%	145	M23-XSG20-01-091418	1809475-19	180		5%
Trip 8	Red	M23-XSG5-01-091418	207.8	214.0	22%	154	M23-XSG5-01-091418	1809475-20	220		6%
Trip 8	Red	M6-XS353A-01-091618	183.6	183.9	11%	158	M6-XS353A-01-091618	1809475-36	280		42%
Trip 8	Red	M6-XS369-01-091618	206.3	215.4	19%	161	M6-XS369-01-091618	1809475-37	260		23%
Trip 8	Red	M6-XS52-01-091118	126.8	130.1	15%	102	M6-XS52-01-091118	1809473-35	110		14%
Trip 8	Red	M6-XSG13A-01-091618	207.5	208.1	11%	171	M6-XSG13A-01-091618	1809475-38	250		19%
Trip 8	Red	M6-XSG22-01-091618	319.8	331.4	18%	242	M6-XSG22-01-091618	1809475-39	350		9%
Trip 8	Red	M7-XSG34-01-091618	174.2	164.5	15%	141	M7-XSG34-01-091618	1809475-40	210		19%
Trip 8	Red	M7-XSG41-01-091618	132.0	138.7	14%	105	M7-XSG41-01-091618	1809475-41	140		6%
Trip 8	Red	T18-XSG7-01-091518	121.5	120.4	5%	116	T18-XSG7-01-091518	1809475-42	150		21%
Trip 8	Red	T19-XS9-01-091118	143.2	140.1	16%	117	T19-XS9-01-091118	1809473-36	270		61%
Trip 8	Red	T20-XSG3-01-091118	132.9	126.3	37%	78	T20-XSG3-01-091118	1809473-37	170		24%
Trip 8	Red	T21-XSG13-01-091118	313.1	314.5	11%	268	T21-XSG13-01-091118	1809473-38	310		1%
Trip 8	Red	T21-XSG26-01-091118	252.5	237.9	12%	229	T21-XSG26-01-091118	1809473-39	250		1%
Trip 8	Red	T22-XS20-01-091118	137.2	126.3	15%	120	T22-XS20-01-091118	1809473-15	230		51%
Trip 8	Red	T23-XSG26-01-091118	271.2	270.3	19%	213	T23-XSG26-01-091118	1809473-16	260		4%
Trip 8	Red	T23-XSG7-01-091118	218.1	217.0	10%	188	T23-XSG7-01-091118	1809473-17	200		9%
Trip 8	Red	T24-XSG2-01-091118	226.5	234.7	12%	183	T24-XSG2-01-091118	1809473-18	210		8%
Trip 8	Red	T26-XSG2-01-091518	154.5	158.6	8%	136	T26-XSG2-01-091518	1809475-43	130		17%
Trip 8	Red	T26-XSG9-01-091518	94.5	88.1	22%	74	T26-XSG9-01-091518	1809475-44	130		32%
Trip 9	Red	M10-XSG2-01-092818	159.1	157.1	8%	147	M10-XSG2-01-092818	1810122-1	200		23%
Trip 9	Blue	M10-XSG4-01-092818	219.4	212.8	14%	188	M10-XSG4-01-092818	1810122-2	210		4%
Trip 9	Red	M11-XS47-01-092818	131.7	134.0	14%	103	M11-XS47-01-092818	1810122-3	210		46%
Trip 9	Blue	M11-XSG2-01-092818	115.7	122.4	13%	92	M11-XSG2-01-092818	1810122-4	130		12%
Trip 9	Blue	M11-XSG25-01-092818	103.5	107.0	29%	65	M11-XSG25-01-092818	1810122-5	160		43%
Trip 9	Blue	M11-XSG28-01-092818	232.1	218.7	21%	187	M11-XSG28-01-092818	1810122-6	270		15%
Trip 9	Red	M11-XSG33-01-092818	166.2	167.1	13%	130	M11-XSG33-01-092818	1810122-7	200		18%
Trip 9	Red	M12-XSG26-01-092818	220.5	215.5	10%	202	M12-XSG26-01-092818	1810122-8	250		13%
Trip 9	Blue	M14-XSR1-01-093018	126.8	130.0	11%	105	M14-XSR1-01-093018	1810072-21	120		6%
Trip 9	White	M15-XSR1-01-093018	203.5	192.0	23%	159	M15-XSR1-01-093018	1810072-22	180		12%

Data Included											
			XRF - Manganese						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	White	M16-XSR1-01-093018	259.5	251.1	20%	204	M16-XSR1-01-093018	1810072-23	260		0%
Trip 9	White	M16-XSR6-01-093018	158.7	161.4	11%	130	M16-XSR6-01-093018	1810072-24	180		13%
Trip 9	Blue	M17-XSR1-01-093018	221.7	225.9	19%	166	M17-XSR1-01-093018	1810072-25	230		4%
Trip 9	Red	M19-XSR2-01-093018	168.6	171.6	8%	144	M19-XSR2-01-093018	1810072-26	170		1%
Trip 9	Blue	M19-XSR2-02-093018	171.2	168.5	10%	151	M19-XSR2-02-093018	1810072-27	170		1%
Trip 9	Red	M1-XSG4-01-092818	156.3	159.3	9%	133	M1-XSG4-01-092818	1810072-1	260		50%
Trip 9	Blue	M20-XSR2-01-093018	133.5	126.6	34%	89	M20-XSR2-01-093018	1810072-28	110		19%
Trip 9	White	M23-XSR4-01-093018	145.2	146.9	10%	124	M23-XSR4-01-093018	1810072-29	130		11%
Trip 9	Red	M24-XS112-01-092518	173.1	172.6	11%	152	M24-XS112-01-092518	1810032-1	260		40%
Trip 9	Red	M24-XS114-01-092518	116.5	113.0	12%	104	M24-XS114-01-092518	1810032-2	250		73%
Trip 9	Red	M24-XSG15-01-092518	138.2	129.2	16%	119	M24-XSG15-01-092518	1810032-3	250		58%
Trip 9	Red	M24-XSG3-01-092518	114.1	103.3	22%	92	M24-XSG3-01-092518	1810032-4	130		13%
Trip 9	Red	M24-XSG32-01-092518	116.8	119.3	20%	86	M24-XSG32-01-092518	1810032-5	160		31%
Trip 9	Red	M24-XSR1-01-093018	97.3	100.4	11%	84	M24-XSR1-01-093018	1810072-30	160		49%
Trip 9	Blue	M25-XSG12-01-092818	54.7	55.7	12%	45	M25-XSG12-01-092818	1810122-10	110		67%
Trip 9	Blue	M25-XSG19-01-092818	102.6	104.7	12%	81	M25-XSG19-01-092818	1810122-11	150		38%
Trip 9	Blue	M25-XSG19-02-092818	111.0	106.5	24%	79	M25-XSG19-02-092818	1810122-12	160		36%
Trip 9	Red	M27-XS116-01-092618	109.0	108.3	7%	101	M27-XS116-01-092618	1810072-2	160		38%
Trip 9	Red	M27-XS149-01-092618	54.5	51.7	19%	44	M27-XS149-01-092618	1810072-3	97		56%
Trip 9	Red	M27-XS150-01-092618	64.7	58.3	50%	38	M27-XS150-01-092618	1810072-4	320		133%
Trip 9	Red	M27-XS163-01-092618	149.4	151.6	11%	125	M27-XS163-01-092618	1810072-5	350		80%
Trip 9	Red	M27-XSG28-01-092618	77.5	80.1	22%	56	M27-XSG28-01-092618	1810072-6	99		24%
Trip 9	Red	M27-XSG28-02-092618	98.3	78.4	63%	53	M27-XSG28-02-092618	1810072-7	98		0%
Trip 9	Red	M27-XSG48-01-092618	116.6	114.3	8%	107	M27-XSG48-01-092618	1810072-8	140		18%
Trip 9	Red	M27-XSG6-01-092618	96.5	87.6	18%	84	M27-XSG6-01-092618	1810072-9	120		22%
Trip 9	Red, Blue	M28-XS162-01-092818	429.1	437.5	21%	300	M28-XS162-01-092818	1810122-14	500		15%
Trip 9	White	M28-XS19-01-092918	213.1	207.8	21%	172	M28-XS19-01-092918	1810122-15	200		6%
Trip 9	Red	M28-XS29-01-092618	70.6	69.2	8%	63	M28-XS29-01-092618	1810032-6	110		44%
Trip 9	Blue	M28-XSG18-01-092918	115.8	117.6	19%	76	M28-XSG18-01-092918	1810122-16	120		4%
Trip 9	Red	M28-XSG49-01-092618	129.5	132.3	21%	83	M28-XSG49-01-092618	1810032-7	220		52%
Trip 9	Red, White	M28-XSG54-01-092918	195.7	187.8	15%	162	M28-XSG54-01-092918	1810122-17	220		12%
Trip 9	Red	M28-XSG7-01-092618	57.1	61.3	23%	36	M28-XSG7-01-092618	1810032-8	81		35%
Trip 9	White	M28-XSG76-01-092918	165.9	155.8	35%	113	M28-XSG76-01-092918	1810122-18	160		4%
Trip 9	Blue	M28-XSR1-01-093018	137.8	127.2	17%	119	M28-XSR1-01-093018	1810072-31	150		8%
Trip 9	Red	M28-XSR1-02-093018	128.3	134.2	15%	100	M28-XSR1-02-093018	1810072-32	150		16%
Trip 9	Red	M29-XS19-01-092518	191.1	197.3	8%	165	M29-XS19-01-092518	1810032-9	240		23%
Trip 9	Red	M29-XS42-01-092518	179.3	170.1	18%	144	M29-XS42-01-092518	1810032-10	200		11%
Trip 9	Red	M29-XS59-01-092518	130.1	125.2	11%	113	M29-XS59-01-092518	1810032-11	200		42%
Trip 9	Red	M29-XS64-01-092518	89.1	91.5	13%	68	M29-XS64-01-092518	1810032-12	150		51%
Trip 9	Red	M29-XSG1-01-092518	90.1	44.8	128%	31	M29-XSG1-01-092518	1810032-13	76		17%
Trip 9	Red	M29-XSG25-01-092518	99.7	98.5	26%	57	M29-XSG25-01-092518	1810032-14	140		34%
Trip 9	Red	M29-XSG35-01-092518	91.4	89.4	11%	80	M29-XSG35-01-092518	1810032-15	79		15%
Trip 9	Blue	M29-XSR4-01-093018	225.2	197.9	39%	137	M29-XSR4-01-093018	1810072-33	250		10%
Trip 9	Red	M29-XSR7-01-093018	1066.1	1054.0	6%	980	M29-XSR7-01-093018	1810072-34	1500		34%
Trip 9	White	M2-XSR3-01-093018	83.5	74.1	29%	55	M2-XSR3-01-093018	1810072-35	110		27%
Trip 9	White	M30-XS144-01-092918	144.5	137.6	14%	126	M30-XS144-01-092918	1810122-19	170		16%
Trip 9	White	M30-XS185-01-092918	203.8	206.7	9%	179	M30-XS185-01-092918	1810122-20	200		2%
Trip 9	White	M30-XS62-01-092918	202.4	184.5	25%	145	M30-XS62-01-092918	1810122-21	200		1%
Trip 9	White	M30-XSG18-01-092918	168.4	161.6	24%	112	M30-XSG18-01-092918	1810122-22	160		5%
Trip 9	White	M30-XSG29-01-092918	228.8	225.7	25%	170	M30-XSG29-01-092918	1810122-23	220		4%
Trip 9	White	M30-XSG43-01-092918	221.8	218.3	8%	203	M30-XSG43-01-092918	1810122-24	210		5%
Trip 9	White	M30-XSG45-01-092918	105.3	110.2	11%	86	M30-XSG45-01-092918	1810122-25	140		28%
Trip 9	Red, White	M30-XSG6-01-092918	158.6	156.6	21%	119	M30-XSG6-01-092918	1810122-26	310		65%
Trip 9	Blue	M30-XSG61-01-092918	81.1	77.3	14%	69	M30-XSG61-01-092918	1810122-27	120		39%
Trip 9	White	M30-XSR5-01-093018	270.8	276.8	9%	241	M30-XSR5-01-093018	1810072-36	280		3%
Trip 9	Red	M31-XS1-01-092918	198.6	198.8	27%	122	M31-XS1-01-092918	1810122-28	230		15%
Trip 9	Blue	M31-XS39-01-092918	101.3	100.0	19%	79	M31-XS39-01-092918	1810122-29	160		45%
Trip 9	White	M31-XS8-01-092918	209.2	208.8	15%	161	M31-XS8-01-092918	1810122-30	210		0%
Trip 9	White	M31-XSG1-01-092918	130.6	130.6	12%	109	M31-XSG1-01-092918	1810122-31	130		0%
Trip 9	White	M31-XSG12-01-092918	286.6	281.4	19%	205	M31-XSG12-01-092918	1810122-32	260		10%
Trip 9	White	M31-XSG17-01-092918	162.9	163.8	10%	134	M31-XSG17-01-092918	1810122-33	140		15%
Trip 9	Red	M31-XSG9-01-092918	134.6	126.0	15%	114	M31-XSG9-01-092918	1810122-34	130		3%
Trip 9	Red	M32-XSG23-01-092918	176.4	182.3	10%	150	M32-XSG23-01-092918	1810072-10	230		26%
Trip 9	Red	M32-XSG26-01-092918	157.2	153.9	13%	134	M32-XSG26-01-092918	1810072-11	190		19%
Trip 9	Red	M32-XSG34-01-092918	267.4	255.4	19%	227	M32-XSG34-01-092918	1810072-12	350		27%
Trip 9	Red	M32-XSG46-01-092918	191.5	155.7	47%	151	M32-XSG46-01-092918	1810072-13	160		18%

Data Included											
			XRF - Manganese						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	Red	M32-XSG9-01-092918	210.7	205.7	13%	175	M32-XSG9-01-092918	1810072-14	270		25%
Trip 9	Red	M34-XSG15-01-092718	123.4	113.3	39%	82	M34-XSG15-01-092718	1810072-15	200		47%
Trip 9	Red	M35-XSG20-01-092718	198.9	199.9	21%	153	M35-XSG20-01-092718	1810072-16	270		30%
Trip 9	Red	M35-XSG4-01-092718	164.5	158.3	25%	108	M35-XSG4-01-092718	1810072-17	260		45%
Trip 9	Red	M36-XSG1-01-092718	140.8	136.2	15%	116	M36-XSG1-01-092718	1810072-18	270		63%
Trip 9	White	M6-XSR1-01-093018	118.0	123.1	26%	59	M6-XSR1-01-093018	1810072-37	120		2%
Trip 9	White	M7-XSR1-01-093018	201.2	197.1	7%	189	M7-XSR1-01-093018	1810072-38	380		62%
Trip 9	White	M7-XSR1-02-093018	160.1	162.2	12%	130	M7-XSR1-02-093018	1810072-39	200		22%
Trip 9	Blue	M8-XSR1-01-093018	141.7	137.9	30%	76	M8-XSR1-01-093018	1810072-40	140		1%
Trip 9	White	T17-XSR1-01-093018	269.6	270.6	14%	223	T17-XSR1-01-093018	1810072-41	280		4%
Trip 9	Red	T30-XS20-01-092518	202.8	202.6	4%	188	T30-XS20-01-092518	1810032-16	220		8%
Trip 9	Red	T30-XS28-01-092518	200.1	201.8	9%	170	T30-XS28-01-092518	1810032-17	180		11%
Trip 9	Red	T30-XS8-01-092518	149.9	147.9	20%	110	T30-XS8-01-092518	1810032-18	130		14%
Trip 9	Red	T31-XSG7-01-092518	109.5	111.0	12%	90	T31-XSG7-01-092518	1810032-19	80		31%
Trip 9	Red	T31-XSG9-01-092518	144.7	142.5	13%	124	T31-XSG9-01-092518	1810032-20	150		4%
Trip 9	Red	T5-XSG3-01-092818	124.2	118.6	14%	106	T5-XSG3-01-092818	1810072-19	170		31%
Trip 9	Red	T5-XSG3-02-092818	120.2	122.8	11%	101	T5-XSG3-02-092818	1810072-20	160		28%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Manganese: Average Ex Situ XRF (ppm)	XRF - Manganese: Median Ex Situ XRF (ppm)	XRF - Manganese: Relative Standard Deviation	XRF - Manganese: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 7	Pink	M36-XS3-01-081218	20.6	11.4	143%	0	M36-XS3-01-081218	1808303-14	49		82%
Trip 7	Pink	M37-XS31-01-081318	20.2	20.2	62%	0	M37-XS31-01-081318	1808303-20	71		111%
Trip 7	Red	M9-XS19A-01-081718	0.0	0.0	0%	0	M9-XS19A-01-081718	1808483-8	80		200%
Trip 7	Red	M9-XS28A-01-081718	55.2	57.9	93%	0	M9-XS28A-01-081718	1808483-9	250		128%
Trip 7	Red	T17-XSG7-01-081618	59.4	67.9	55%	0	T17-XSG7-01-081618	1808476-19	130		74%
Trip 8	Red	M16-XSG24-01-091118	27.9	37.9	99%	0	M16-XSG24-01-091118	1809473-23	230		157%
Trip 8	Red	M21-XS503-01-091218	0.0	0.0	0%	0	M21-XS503-01-091218	1809473-28	110		200%
Trip 8	Red	M21-XSG7-01-091218	62.6	52.1	68%	0	M21-XSG7-01-091218	1809473-32	190		101%
Trip 8	Red	M6-XS164-01-091118	0.0	0.0	0%	0	M6-XS164-01-091118	1809473-33	87		200%
Trip 8	Red	M6-XS224-01-091118	30.5	19.7	121%	0	M6-XS224-01-091118	1809473-34	210		149%
Trip 8	Red	T24-XSG26-01-091118	0.0	0.0	0%	0	T24-XSG26-01-091118	1809473-19	100		200%
Trip 9	Blue	M25-XSG5-01-092818	12.8	10.6	113%	0	M25-XSG5-01-092818	1810122-13	51		120%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Manganese: Average Ex Situ XRF (ppm)	XRF - Manganese: Median Ex Situ XRF (ppm)	XRF - Manganese: Relative Standard Deviation	XRF - Manganese: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 7	Red	M8-XS83-01-081418	119.6	119.7	9%	108	M8-XS83-01-081418	1808476-12	490		122%
Trip 7	Red	T1-XSG5A-01-081918	3157.9	113.8	255%	98	T1-XSG5A-01-081918	1808483-15	120		185%
Trip 9	Red	M12-XSG3-01-092818	3999.5	272.5	228%	223	M12-XSG3-01-092818	1810122-9	330		170%

Notes:

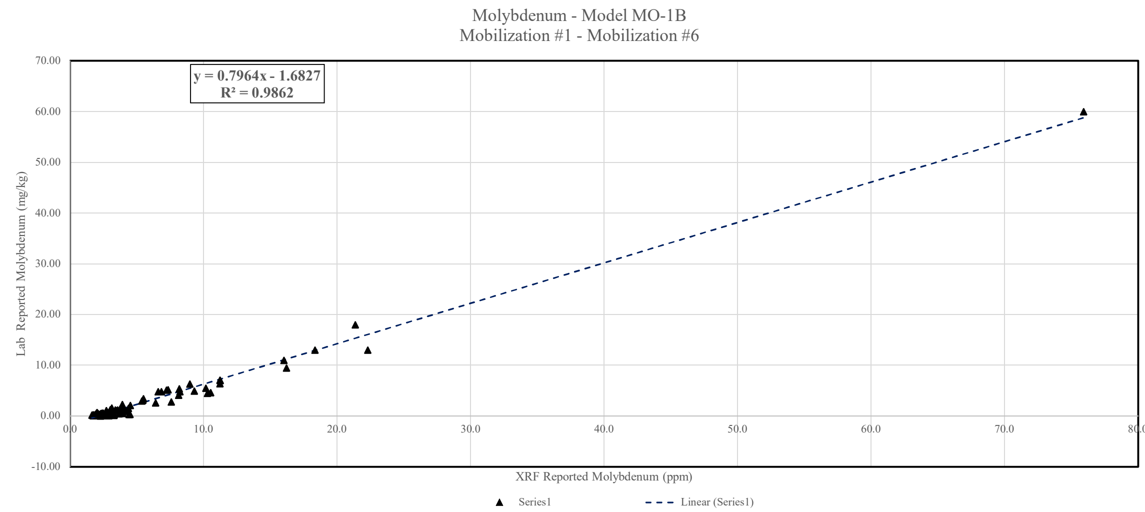
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model MO-1B											
			XRF - Molybdenum						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	2.7	2.5	16%	2	M2-XS15-01-042418	1805041-1	0.17		176%
Trip 1	Pink	M2-XS15-02-042418	2.8	2.8	14%	2	M2-XS15-02-042418	1805041-2	0.15		179%
Trip 1	Pink	M2-XS32-01-042418	2.8	2.4	32%	2	M2-XS32-01-042418	1805041-3	0.56		134%
Trip 1	Pink	M2-XS59-01-042418	2.1	2.2	30%	1	M2-XS59-01-042418	1805041-4	0.14		175%
Trip 1	Pink	M3-XS34-01-043018	2.2	2.0	21%	2	M3-XS34-01-043018	1805042-1	0.10		183%
Trip 1	Pink	M3-XS36-01-043018	2.3	2.6	32%	1	M3-XS36-01-043018	1805042-2	0.54		124%
Trip 1	Pink	M6-XS140-01-042818	2.4	2.4	36%	1	M6-XS140-01-042818	1805041-6	0.25		162%
Trip 1	Orange	M6-XS159-01-04262018	2.9	3.1	30%	1	M6-XS159-01-04262018	1805039-1	0.43		148%
Trip 1	Pink	M6-XS269-02-04262018	3.6	3.5	43%	2	M6-XS269-02-04262018	1805039-4	0.43		158%
Trip 1	Pink	T10-XS20-01-042518	1.8	1.9	23%	1	T10-XS20-01-042518	1805036-2	0.12		175%
Trip 1	Pink	T10-XS33-01-042518	2.2	2.2	16%	2	T10-XS33-01-042518	1805036-3	0.14		176%
Trip 1	Pink	T10-XS78-01-042518	1.8	1.6	31%	1	T10-XS78-01-042518	1805036-5	0.18		164%
Trip 1	Pink	T11-XS20-01-042518	1.6	1.6	21%	1	T11-XS20-01-042518	1805036-7	0.21		154%
Trip 1	Pink	T11-XS60-01-042518	2.3	2.4	31%	1	T11-XS60-01-042518	1805036-8	0.09		185%
Trip 1	Pink	T17-XS1-02-04262018	2.4	2.6	43%	1	T17-XS1-02-04262018	1805039-7	0.07		189%
Trip 1	Pink	T17-XS143-01-04262018	2.0	2.1	36%	1	T17-XS143-01-04262018	1805039-8	0.73		93%
Trip 1	Orange	T17-XS144-01-04262018	1.9	1.9	32%	1	T17-XS144-01-04262018	1805039-9	0.32		142%
Trip 1	Pink	T17-XS194-01-04272018	2.4	2.4	10%	2	T17-XS194-01-04272018	1805039-10	0.11		183%
Trip 1	Pink	T17-XS194-02-04272018	1.8	1.8	25%	1	T17-XS194-02-04272018	1805039-11	0.11		177%
Trip 1	Pink	T17-XS20-01-04262018	2.2	2.0	29%	2	T17-XS20-01-04262018	1805039-12	0.21		165%
Trip 1	Pink	T17-XS208-01-042818	2.4	2.7	30%	1	T17-XS208-01-042818	1805041-7	0.13		180%
Trip 1	Pink	T17-XS251-01-04272018	2.7	2.7	18%	2	T17-XS251-01-04272018	1805039-13	0.28		162%
Trip 1	Pink	T17-XS257-01-04272018	2.4	2.4	12%	2	T17-XS257-01-04272018	1805039-14	0.14		178%
Trip 1	Pink	T17-XS273-01-042818	2.6	2.6	14%	2	T17-XS273-01-042818	1805041-8	0.18		174%
Trip 1	Pink	T17-XS287-01-04272018	2.3	2.4	20%	2	T17-XS287-01-04272018	1805039-15	0.43		136%
Trip 1	Pink	T17-XS317-01-04272018	2.7	2.3	48%	1	T17-XS317-01-04272018	1805039-16	0.19		173%
Trip 1	Pink	T17-XS328-01-04272018	2.0	2.1	16%	2	T17-XS328-01-04272018	1805039-17	0.19		166%
Trip 1	Pink	T17-XS369-01-043018	2.0	2.0	22%	1	T17-XS369-01-043018	1805042-4	0.18		167%
Trip 1	Pink	T17-XS377-01-042818	2.1	2.1	35%	1	T17-XS377-01-042818	1805041-10	0.24		160%
Trip 1	Pink	T17-XS417-01-04272018	2.3	2.5	21%	2	T17-XS417-01-04272018	1805039-18	0.12		180%
Trip 1	Pink	T17-XS438-01-042818	2.3	2.3	8%	2	T17-XS438-01-042818	1805041-11	0.04		193%
Trip 1	Pink	T17-XS44-01-04262018	2.3	2.1	43%	1	T17-XS44-01-04262018	1805039-19	0.15		175%
Trip 1	Pink	T17-XS442-01-04272018	1.8	1.5	34%	1	T17-XS442-01-04272018	1805039-20	0.16		167%
Trip 1	Pink	T17-XS473-01-042818	2.2	2.2	15%	2	T17-XS473-01-042818	1805041-13	0.17		172%
Trip 1	Pink	T17-XS479-01-042818	1.8	1.9	22%	1	T17-XS479-01-042818	1805041-14	0.25		152%
Trip 1	Pink	T17-XS479-02-042818	2.0	2.1	16%	2	T17-XS479-02-042818	1805041-15	0.25		155%
Trip 1	Pink	T7-XS11-01-042418	2.0	2.0	1%	1	T7-XS11-01-042418	1805036-9	0.10		181%
Trip 1	Pink	T7-XS5-01-042418	2.5	2.4	21%	2	T7-XS5-01-042418	1805036-10	0.13		180%
Trip 1	Pink	T7-XS58-01-042418	1.8	1.8	24%	1	T7-XS58-01-042418	1805036-11	0.11		178%
Trip 1	Pink	T7-XS7-01-042418	2.4	2.6	32%	1	T7-XS7-01-042418	1805036-12	0.10		184%
Trip 1	Pink	T7-XS9-01-042418	2.5	2.4	20%	2	T7-XS9-01-042418	1805036-13	0.11		183%
Trip 1	Pink	T8-XS15-01-042418	2.3	2.3	12%	2	T8-XS15-01-042418	1805036-14	0.18		171%
Trip 1	Pink	T8-XS23-01-042418	2.3	2.1	36%	1	T8-XS23-01-042418	1805036-15	0.19		169%
Trip 1	Pink	T8-XS6-01-042418	2.7	2.6	27%	2	T8-XS6-01-042418	1805036-16	0.10		186%
Trip 1	Pink	T9-XS217-01-042518	2.2	2.3	24%	1	T9-XS217-01-042518	1805036-17	0.16		173%
Trip 1	Pink	T9-XS93-01-042518	2.1	2.0	23%	2	T9-XS93-01-042518	1805036-20	0.27		155%

Data Included in Model MO-1B											
			XRF - Molybdenum						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 2	Orange	M1-XS31-01-051218	1.8	1.7	22%	1	M5-XS69-01-051118	1805322-12	0.09	J	181%
Trip 2	Pink	M1-XS32-01-051218	1.7	1.5	24%	1	M6-XS41-01-051118	1805322-13	0.07	J	184%
Trip 2	Pink	M4-XS136-01-050918	2.6	2.4	20%	2	M1-XS31-01-051218	1805328-1	0.09	J	186%
Trip 2	Pink	M4-XS45-01-050718	2.4	2.3	25%	1	M8-XS110-01-050918	1805328-6	0.07		189%
Trip 2	Pink	M4-XS63-01-050718	3.3	3.1	20%	2	M8-XS19-01-051018	1805328-7	0.31		166%
Trip 2	Pink	M4-XS63-02-050718	2.5	2.4	21%	2	M8-XS32-01-051018	1805328-8	0.51		132%
Trip 2	Pink	M4-XS78-01-051018	3.1	3.1	29%	2	M8-XS94-01-050918	1805328-9	0.20	J	175%
Trip 2	Pink	M6-XS44-01-051018	2.0	2.0	13%	2	T1-XS69-01-051318	1805328-14	0.14	J	174%
Trip 2	Pink	M6-XS81-01-051018	1.8	1.7	22%	1	T3-XS10-01-051218	1805328-15	0.16	J	167%
Trip 2	Orange	M7-XS181-02-051018	2.3	2.3	38%	1	T4-XS23-01-051218	1805328-17	0.10	J	183%
Trip 2	Orange	M7-XS39-01-051018	1.8	1.7	16%	2	T4-XS32-01-051218	1805328-18	0.08	J	183%
Trip 2	Orange	M8-XS19-01-051018	2.9	3.2	24%	1	M7-XS39-01-051018	1805322-18	0.20	J	175%
Trip 2	Pink	M8-XS94-01-050918	2.4	2.0	44%	1	M7-XS77-01-051018	1805322-20	0.19	J	171%
Trip 2	Pink	T13-XS24-01-050818	2.7	2.7	11%	2	T6-XS25-01-051218	1805328-22	0.11	J	185%
Trip 2	Pink	T15-XS45-01-050818	2.2	2.2	30%	1	M4-XS238-01-051018	1805322-4	0.34		147%
Trip 2	Pink	T17-XS122-01-050718	2.1	1.9	29%	1	M4-XS4-01-050718	1805322-5	0.08	J	184%
Trip 2	Pink	T17-XS178-01-050718	1.9	2.0	10%	2	M4-XS63-01-050718	1805322-7	0.61		105%
Trip 2	Pink	T17-XS645-01-050718	2.2	2.1	17%	2	M5-XS115-01-051118	1805322-10	0.15	J	174%
Trip 2	Pink	T17-XS669-01-050718	2.0	2.0	39%	1	M5-XS385-01-051118	1805322-11	0.07	J	187%
Trip 2	Pink	T1-XS54-01-051318	1.7	1.4	31%	1	T14-XS12-01-050818	1805322-23	0.21		157%
Trip 2	Pink	T1-XS69-01-051318	3.2	2.8	48%	2	T15-XS2-01-050818	1805322-25	0.20	J	176%
Trip 2	Orange	T3-XS10-01-051218	1.7	1.7	19%	1	T15-XS45-01-050818	1805322-26	0.24		151%
Trip 2	Pink	T4-XS23-01-051218	2.0	1.8	32%	1	T17-XS176-01-050718	1805322-28	0.12	J	177%
Trip 2	Orange	T4-XS32-01-051218	2.4	2.4	20%	2	T17-XS178-01-050718	1805322-29	0.14	J	178%
Trip 2	Pink	T5-XS18-01-051418	3.3	3.2	14%	3	T17-XS619-02-050718	1805322-31	0.15	J	183%
Trip 2	Pink	T6-XS2-01-051218	2.2	2.3	24%	1	T17-XS645-01-050718	1805322-32	0.15	J	174%
Trip 2	Orange	T6-XS25-01-051218	1.8	2.0	22%	1	T17-XS669-01-050718	1805322-33	0.13	J	174%
Trip 3	Pink	M14-XS36-01-052418	3.5	3.1	30%	2	M14-XS36-01-052418	1805632-1	1.20		98%
Trip 3	Pink	M14-XS40-01-052418	3.7	3.8	29%	3	M14-XS40-01-052418	1805632-2	0.82		128%
Trip 3	Pink	M14-XS64-01-052418	6.8	6.6	13%	6	M14-XS64-01-052418	1805632-3	4.80		35%
Trip 3	Pink	M14-XS67-01-052418	3.9	3.6	51%	2	M14-XS67-01-052418	1805632-4	0.53		153%
Trip 3	Pink	M15-XS22-01-052118	3.0	3.1	26%	2	M15-XS22-01-052118	1805589-1	1.30		79%
Trip 3	Pink	M15-XS3-01-052118	2.5	2.5	18%	2	M15-XS3-01-052118	1805589-2	0.60		121%
Trip 3	Pink	M15-XS46-01-052118	4.4	4.6	11%	4	M15-XS46-01-052118	1805589-3	1.50		98%
Trip 3	Pink	M15-XS46-02-052118	3.7	3.7	10%	3	M15-XS46-02-052118	1805589-4	1.40		91%
Trip 3	Pink	M15-XS82-01-052118	18.3	17.8	8%	17	M15-XS82-01-052118	1805589-6	13.00		34%
Trip 3	Pink	M15-XS93-01-052118	6.4	6.7	16%	5	M15-XS93-01-052118	1805589-7	2.60		84%
Trip 3	Pink	M16-XS128-01-052118	4.5	4.7	28%	3	M16-XS128-01-052118	1805589-8	2.10		73%
Trip 3	Pink	M16-XS154-01-052618	4.1	4.0	10%	4	M16-XS154-01-052618	1806235-2	0.96		123%
Trip 3	Pink	M16-XS177-01-052618	5.5	5.4	6%	5	M16-XS177-01-052618	1806235-3	3.40		47%
Trip 3	Pink	M16-XS191-01-052618	8.2	8.5	11%	7	M16-XS191-01-052618	1806235-4	4.80		52%
Trip 3	Pink	M16-XS191-02-052618	9.3	8.2	35%	7	M16-XS191-02-052618	1806235-5	4.90		62%
Trip 3	Pink	M16-XS30-01-052118	4.1	3.8	19%	3	M16-XS30-01-052118	1805589-10	1.20		109%
Trip 3	Pink	M16-XS31-01-052118	3.5	3.9	31%	2	M16-XS31-01-052118	1805589-11	1.10		103%
Trip 3	Pink	M16-XS4-01-052118	3.8	3.8	15%	3	M16-XS4-01-052118	1805589-12	1.50		86%
Trip 3	Pink	M17-XS55-01-052618	10.3	9.1	39%	7	M17-XS55-01-052618	1806235-6	4.50		78%
Trip 3	Pink	M17-XS83-02-052618	10.5	10.2	20%	8	M17-XS83-02-052618	1806235-8	4.60	J	78%
Trip 3	Pink	M18-XS155-01-052518	2.4	2.4	28%	2	M18-XS155-01-052518	1805632-5	0.12	J	181%
Trip 3	Pink	M19-XS22-01-052318	16.0	15.1	16%	14	M19-XS22-01-052318	1805632-7	11.00		37%
Trip 3	Pink	M19-XS22-02-052318	16.2	15.5	24%	12	M19-XS22-02-052318	1805632-8	9.50		52%
Trip 3	Pink	M19-XS43-01-052318	2.9	2.7	22%	2	M19-XS43-01-052318	1805632-9	0.48		143%
Trip 3	Pink	T21-XS55-02-052118	4.5	4.6	22%	3	T21-XS55-02-052118	1805589-16	0.32		173%
Trip 3	Pink	T22-XS64-01-052218	2.8	2.6	37%	2	T22-XS64-01-052218	1805632-11	0.21		172%
Trip 3	Pink	T23-XS23-01-052118	2.4	2.3	24%	2	T23-XS23-01-052118	1805589-19	0.48		133%
Trip 3	Pink	T23-XS40-01-052118	2.8	3.1	34%	1	T23-XS40-01-052118	1805589-20	0.64		126%
Trip 3	Pink	T24-XS48-01-052418	3.1	3.2	26%	2	T24-XS48-01-052418	1805632-12	1.60		64%
Trip 4	Pink	M20-XS130-01-060418	4.4	4.6	21%	3	M20-XS130-01-060418	1806235-10	0.33		172%
Trip 4	Pink	M20-XS166-01-060518	11.2	11.2	4%	11	M20-XS166-01-060518	1806235-11	7.10		45%
Trip 4	Pink	M20-XS185-01-060418	2.4	2.5	15%	2	M20-XS185-01-060418	1806235-13	0.29		157%
Trip 4	Pink	M20-XS231-01-060418	2.1	2.0	13%	2	M20-XS231-01-060418	1806235-14	0.35		143%
Trip 4	Pink	M20-XS306-01-060518	2.2	2.2	25%	2	M20-XS306-01-060518	1806235-16	0.09	J	184%
Trip 4	Pink	M20-XS312-01-060518	2.8	3.1	22%	2	M20-XS312-01-060518	1806235-17	0.58		132%
Trip 4	Pink	M20-XS365-01-060618	3.4	3.4	18%	3	M20-XS365-01-060618	1806235-18	1.20		95%
Trip 4	Pink	M20-XS365-02-060618	3.0	3.3	30%	1	M20-XS365-02-060618	1806235-19	1.20		85%
Trip 4	Pink	M20-XS5-01-060518	2.4	2.5	34%	1	M20-XS5-01-060518	1806235-20	0.35		148%
Trip 4	Pink	M21-XS122-01-060818	1.8	1.8	16%	2	M21-XS122-01-060818	1806234-1	0.09	J	181%
Trip 4	Pink	M21-XS126-01-060818	8.1	8.0	15%	6	M21-XS126-01-060818	1806234-2	4.10		66%
Trip 4	Pink	M21-XS14-01-060818	2.1	2.2	26%	1	M21-XS14-01-060818	1806234-3	0.53		118%
Trip 4	Pink	M21-XS175-01-060818	2.4	2.2	21%	2	M21-XS175-01-060818	1806234-4	0.51		129%
Trip 4	Pink	M21-XS225-01-060518	11.2	11.4	4%	11	M21-XS225-01-060518	1806235-22	6.40		55%
Trip 4	Pink	M21-XS259-01-060918	6.6	6.2	25%	5	M21-XS259-01-060918	1806234-5	4.80		31%

Data Included in Model MO-1B											
			XRF - Molybdenum						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M21-XS260-01-060918	3.9	3.9	20%	3	M21-XS260-01-060918	1806234-6	1.50		89%
Trip 4	Pink	M21-XS27-01-060818	5.3	5.4	9%	5	M21-XS27-01-060818	1806234-7	3.00		56%
Trip 4	Pink	M21-XS27-02-060818	5.4	5.5	10%	5	M21-XS27-02-060818	1806234-8	3.10		55%
Trip 4	Pink	M21-XS282-01-060918	2.7	2.7	25%	2	M21-XS282-01-060918	1806234-9	0.22		169%
Trip 4	Pink	M21-XS290-01-060918	2.7	2.6	25%	2	M21-XS290-01-060918	1806234-10	0.86		105%
Trip 4	Pink	M21-XS292-01-060518	10.2	10.1	12%	9	M21-XS292-01-060518	1806235-23	5.50		59%
Trip 4	Pink	M21-XS302-01-060918	7.2	7.2	8%	6	M21-XS302-01-060918	1806234-11	5.10		34%
Trip 4	Pink	M21-XS302-02-060918	7.3	7.1	12%	6	M21-XS302-02-060918	1806234-12	5.20		34%
Trip 4	Pink	M21-XS334-01-060918	2.7	2.7	15%	2	M21-XS334-01-060918	1806234-13	0.78		111%
Trip 4	Pink	M21-XS377-01-060918	2.9	3.0	20%	2	M21-XS377-01-060918	1806234-14	0.10	J	187%
Trip 4	Pink	M21-XS40-01-060818	22.3	22.1	3%	21	M21-XS40-01-060818	1806234-15	13.00		53%
Trip 4	Pink	M21-XS403-01-060818	3.2	2.9	35%	2	M21-XS403-01-060818	1806234-16	0.55		142%
Trip 4	Pink	M21-XS419-01-060818	2.7	2.9	31%	1	M21-XS419-01-060818	1806234-17	1.10		84%
Trip 4	Pink	M21-XS477-01-060818	3.0	2.9	27%	2	M21-XS477-01-060818	1806234-19	0.46		146%
Trip 4	Pink	M21-XS541-01-060818	2.8	2.7	26%	2	M21-XS541-01-060818	1806234-20	0.22		170%
Trip 4	Pink	M21-XS596-01-060518	2.6	2.6	16%	2	M21-XS596-01-060518	1806235-24	0.23		167%
Trip 4	Pink	M21-XS615-01-060518	1.9	1.5	54%	1	M21-XS615-01-060518	1806235-25	0.12	J	176%
Trip 4	Pink	M21-XS619-01-060618	9.0	9.0	27%	5	M21-XS619-01-060618	1806235-26	6.30		35%
Trip 4	Pink	M22-XS14-01-060418	4.0	4.0	13%	3	M22-XS14-01-060418	1806235-27	1.10		115%
Trip 4	Pink	M22-XS30-01-060418	2.5	2.5	9%	2	M22-XS30-01-060418	1806235-28	0.19	J	172%
Trip 4	Pink	M22-XS60-01-060418	4.1	4.2	17%	3	M22-XS60-01-060418	1806235-30	1.00		121%
Trip 4	Pink	M22-XS87-01-060418	2.2	2.3	24%	1	M22-XS87-01-060418	1806235-31	0.34		146%
Trip 5	Pink	M27-XS38-01-061918	3.9	3.8	42%	2	M27-XS38-01-061918	1806558-15	2.30		51%
Trip 5	Pink	M30-XS138-01-062218	21.3	20.5	8%	20	M30-XS138-01-062218	1806693-1	18.00		17%
Trip 5	Pink	M30-XS222-01-062218	2.4	2.3	13%	2	M30-XS222-01-062218	1806693-2	0.60		120%
Trip 6	Orange	M24-XS115-01-071418	11.2	10.9	6%	11	M24-XS115-01-071418	1807369-7	7.00		46%
Trip 6	Orange	M30-XS127-01-071618	7.6	7.5	14%	6	M30-XS127-01-071618	1807369-9	2.80		92%
Trip 6	Red	M32-XS89-01-071018	8.2	8.5	21%	5	M32-XS89-01-071018	1807369-14	5.40		41%
Trip 5	Pink	M28-XS148-01-062018	75.9	75.5	13%	65	M28-XS148-01-062018	1806558-17	60.00		23%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Molybdenum Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS73-01-042418	1.9	2.1	53%	0	M2-XS73-01-042418	1805041-5	0.16		170%
Trip 1	Pink	M6-XS251-01-04272018	1.3	1.5	53%	0	M6-XS251-01-04272018	1805039-2	0.21		146%
Trip 1	Pink	M6-XS269-01-04262018	2.5	3.2	81%	0	M6-XS269-01-04262018	1805039-3	0.61		121%
Trip 1	Pink	M6-XS285-01-04272018	3.7	3.7	61%	0	M6-XS285-01-04272018	1805039-5	1.80		68%
Trip 1	Pink	T10-XS1-01-042518	0.9	0.6	41%	0	T10-XS1-01-042518	1805036-1	0.20		129%
Trip 1	Pink	T10-XS56-01-042518	1.6	1.7	56%	0	T10-XS56-01-042518	1805036-4	0.18		159%
Trip 1	Pink	T11-XS1-01-042518	1.1	1.5	82%	0	T11-XS1-01-042518	1805036-6	0.21		137%
Trip 1	Pink	T17-XS1-01-04262018	1.4	1.6	87%	0	T17-XS1-01-04262018	1805039-6	0.07		181%
Trip 1	Pink	T17-XS304-01-042818	0.5	0.0	155%	0	T17-XS304-01-042818	1805041-9	0.15		106%
Trip 1	Pink	T17-XS393-01-043018	1.9	2.1	52%	0	T17-XS393-01-043018	1805042-5	0.15		171%
Trip 1	Pink	T17-XS46-01-042618	1.0	1.2	84%	0	T17-XS46-01-042618	1805041-12	0.14		149%
Trip 1	Pink	T17-XS603-01-042818	1.0	0.8	115%	0	T17-XS603-01-042818	1805041-16	0.07		176%
Trip 1	Pink	T17-XS659-01-043018	2.0	2.0	62%	0	T17-XS659-01-043018	1805042-6	0.10		181%
Trip 1	Pink	T17-XS679-01-043018	2.0	2.4	53%	0	T17-XS679-01-043018	1805042-7	0.17		169%
Trip 1	Pink	T17-XS704-01-043018	1.8	2.0	57%	0	T17-XS704-01-043018	1805042-8	0.10		179%
Trip 1	Pink	T9-XS61-01-042518	1.9	2.4	60%	0	T9-XS61-01-042518	1805036-18	0.40		132%
Trip 1	Orange	T9-XS61-02-042518	1.7	1.9	59%	0	T9-XS61-02-042518	1805041-17	0.45		117%
Trip 1	Pink	T9-XS86-01-042518	0.8	0.7	114%	0	T9-XS86-01-042518	1805036-19	0.18		129%
Trip 2	Pink	M4-XS18-01-050718	1.9	2.2	55%	0	M1-XS32-01-051218	1805328-2	0.08	J	185%
Trip 2	Orange	M4-XS219-01-051018	1.4	1.5	69%	0	M8-XS100-01-050918	1805328-3	0.04	J	188%
Trip 2	Pink	M4-XS238-01-051018	2.3	2.3	71%	0	M8-XS102-01-050918	1805328-4	0.03	U	194%
Trip 2	Orange	M5-XS115-01-051118	1.5	1.7	87%	0	T1-XS104-01-051318	1805328-10	0.15	J	163%
Trip 2	Pink	M5-XS385-01-051118	1.1	1.3	85%	0	T1-XS20-01-051318	1805328-11	0.19	J	142%
Trip 2	Pink	M5-XS69-01-051118	1.7	1.9	54%	0	T1-XS54-01-051318	1805328-12	0.14	J	169%
Trip 2	Orange	M6-XS41-01-051118	1.2	1.4	88%	0	T1-XS54-02-051318	1805328-13	0.14	J	158%
Trip 2	Pink	M7-XS181-01-051018	1.3	1.5	67%	0	T3-XS5-01-051218	1805328-16	0.13	J	163%
Trip 2	Orange	M7-XS77-01-051018	1.3	1.6	66%	0	T5-XS18-01-051418	1805328-20	0.31		122%
Trip 2	Pink	M8-XS100-01-050918	1.2	1.6	79%	0	M6-XS44-01-051018	1805322-14	0.08	J	175%
Trip 2	Pink	M8-XS102-01-050918	0.0	0.0	0%	0	M6-XS81-01-051018	1805322-15	0.05	J	200%
Trip 2	Pink	M8-XS102-02-050918	0.0	0.0	0%	0	M7-XS181-01-051018	1805322-16	0.12	J	200%
Trip 2	Pink	M8-XS110-01-050918	1.5	1.9	84%	0	M7-XS181-02-051018	1805322-17	0.12	J	170%
Trip 2	Orange	M8-XS32-01-051018	1.9	2.2	58%	0	M7-XS74-01-051018	1805322-19	0.20		162%
Trip 2	Pink	T13-XS12-01-050818	1.7	2.0	60%	0	T6-XS2-01-051218	1805328-21	0.13	J	172%
Trip 2	Pink	T14-XS12-01-050818	1.5	1.6	54%	0	M4-XS136-01-050918	1805322-1	0.24		143%
Trip 2	Pink	T14-XS27-01-050818	1.5	1.9	83%	0	M4-XS18-01-050718	1805322-2	0.14	J	166%
Trip 2	Pink	T15-XS2-01-050818	2.1	2.3	53%	0	M4-XS219-01-051018	1805322-3	0.15	J	173%
Trip 2	Pink	T17-XS176-01-050718	2.2	2.2	56%	0	M4-XS45-01-050718	1805322-6	0.10	J	182%
Trip 2	Pink	T17-XS619-01-050718	1.7	1.8	53%	0	M4-XS63-02-050718	1805322-8	0.63		90%
Trip 2	Pink	T17-XS619-02-050718	1.6	1.6	67%	0	M4-XS78-01-051018	1805322-9	0.34		131%
Trip 2	Pink	T1-XS104-01-051318	1.5	1.1	124%	0	T13-XS12-01-050818	1805322-21	0.28		138%
Trip 2	Pink	T1-XS20-01-051318	1.4	1.4	57%	0	T13-XS24-01-050818	1805322-22	0.14	J	163%
Trip 2	Pink	T1-XS54-02-051318	0.8	0.6	126%	0	T14-XS27-01-050818	1805322-24	0.16	J	136%
Trip 2	Orange	T3-XS5-01-051218	1.5	1.4	64%	0	T17-XS122-01-050718	1805322-27	0.16	J	160%
Trip 3	Pink	M18-XS161-01-052518	9.4	8.5	83%	0	M18-XS161-01-052518	1805632-6	0.50		180%
Trip 4	Pink	M13-XS72-01-060618	0.2	0.0	245%	0	M13-XS72-01-060618	1806235-1	0.13	J	59%
Trip 4	Pink	M20-XS11-01-060618	0.5	0.0	159%	0	M20-XS11-01-060618	1806235-9	0.10	J	135%
Trip 4	Pink	M20-XS18-01-060618	0.8	0.6	113%	0	M20-XS18-01-060618	1806235-12	0.17	J	130%
Trip 4	Pink	M20-XS86-01-060618	1.7	2.0	55%	0	M20-XS86-01-060618	1806235-21	0.09	J	179%
Trip 4	Pink	M20-XS278-01-060418	0.2	0.0	245%	0	M20-XS278-01-060418	1806235-15	0.18	J	26%
Trip 4	Pink	M22-XS40-01-060518	1.3	0.8	117%	0	M22-XS40-01-060518	1806235-29	0.27	J	129%
Trip 4	Pink	M23-XS20-01-061018	0.8	0.7	112%	0	M23-XS20-01-061018	1806233-3	0.31		91%
Trip 4	Pink	M23-XS48-01-061018	0.0	0.0	0%	0	M23-XS48-01-061018	1806233-4	0.13	J	200%
Trip 4	Pink	M23-XS54-01-061118	0.8	0.7	110%	0	M23-XS54-01-061118	1806312-1	0.59		31%
Trip 4	Pink	M23-XS64-01-061018	0.0	0.0	0%	0	M23-XS64-01-061018	1806233-5	0.23		200%
Trip 4	Pink	M23-XS70-01-061018	0.2	0.0	245%	0	M23-XS70-01-061018	1806233-6	0.17	J	33%
Trip 4	Pink	M23-XS79-01-061018	0.0	0.0	0%	0	M23-XS79-01-061018	1806233-7	0.15	J	200%
Trip 4	Pink	M23-XS102-01-061018	0.0	0.0	0%	0	M23-XS102-01-061018	1806233-1	0.27		200%
Trip 4	Pink	M23-XS123-01-061018	0.0	0.0	0%	0	M23-XS123-01-061018	1806233-2	0.20		200%
Trip 4	Pink	M24-XS100-01-061118	0.4	0.0	155%	0	M24-XS100-01-061118	1806312-3	0.17	J	78%
Trip 4	Pink	M24-XS128-01-061118	0.0	0.0	0%	0	M24-XS128-01-061118	1806312-4	3.00		200%
Trip 4	Pink	T18-XS14-01-061118	0.0	0.0	0%	0	T18-XS14-01-061118	1806312-5	0.13	J	200%
Trip 4	Pink	T18-XS27-01-061118	0.0	0.0	0%	0	T18-XS27-01-061118	1806312-6	0.05	J	200%
Trip 4	Pink	T25-XS2-01-060618	1.8	2.0	55%	0	T25-XS2-01-060618	1806235-32	0.23		154%
Trip 4	Pink	T26-XS1-01-061018	0.9	0.8	112%	0	T26-XS1-01-061018	1806233-8	2.10		83%
Trip 4	Pink	T27-XS6-01-061018	0.0	0.0	0%	0	T27-XS6-01-061018	1806233-11	0.16	J	200%
Trip 4	Pink	T27-XS19-01-061018	0.5	0.0	155%	0	T27-XS19-01-061018	1806233-10	0.12	J	126%
Trip 5	Pink	M26-XS13-01-061818	0.2	0.0	245%	0	M26-XS13-01-061818	1806558-1	0.68		107%
Trip 5	Pink	M26-XS25-01-061818	0.2	0.0	245%	0	M26-XS25-01-061818	1806558-2	0.58		101%
Trip 5	Pink	M27-XS21-01-061918	1.5	0.0	175%	0	M27-XS21-01-061918	1806558-10	1.30		13%
Trip 5	Pink	M27-XS29-01-061818	0.0	0.0	0%	0	M27-XS29-01-061818	1806558-14	0.41		200%
Trip 5	Pink	M27-XS108-01-061918	0.0	0.0	0%	0	M27-XS108-01-061918	1806558-3	0.61		200%

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Molybdenum Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 5	Pink	M27-XS109-01-061918	0.0	0.0	0%	0	M27-XS109-01-061918	1806558-4	0.35		200%
Trip 5	Pink	M27-XS123-01-061818	0.0	0.0	0%	0	M27-XS123-01-061818	1806558-5	0.18	J	200%
Trip 5	Pink	M27-XS188-01-061918	0.0	0.0	0%	0	M27-XS188-01-061918	1806558-6	0.73		200%
Trip 5	Pink	M27-XS197-01-061918	0.0	0.0	0%	0	M27-XS197-01-061918	1806558-7	0.30		200%
Trip 5	Pink	M27-XS210-02-061818	0.0	0.0	0%	0	M27-XS210-02-061818	1806558-9	0.36		200%
Trip 5	Pink	M27-XS210-01-061818	0.0	0.0	0%	0	M27-XS210-01-061818	1806558-8	0.33		200%
Trip 5	Pink	M27-XS239-01-061818	0.0	0.0	0%	0	M27-XS239-01-061818	1806558-11	0.25		200%
Trip 5	Pink	M27-XS275-01-061918	0.3	0.0	245%	0	M27-XS275-01-061918	1806558-12	0.62		80%
Trip 5	Pink	M27-XS283-01-061818	0.9	0.0	156%	0	M27-XS283-01-061818	1806558-13	0.89		0%
Trip 5	Pink	M28-XS8-01-062018	0.0	0.0	0%	0	M28-XS8-01-062018	1806558-21	0.06	J	200%
Trip 5	Pink	M28-XS105-01-062018	0.0	0.0	0%	0	M28-XS105-01-062018	1806558-16	0.14	J	200%
Trip 5	Pink	M28-XS155-01-062018	0.2	0.0	245%	0	M28-XS155-01-062018	1806558-18	0.87		127%
Trip 5	Pink	M28-XS170-01-062018	0.0	0.0	0%	0	M28-XS170-01-062018	1806558-19	0.70		200%
Trip 5	Pink	T32-XS5-01-062018	0.0	0.0	0%	0	T32-XS5-01-062018	1806558-22	0.19	J	200%
Trip 6	Orange	M10-XS10A-01-071118	0.0	0.0	0%	0	M10-XS10A-01-071118	1807369-1	0.28		200%
Trip 6	Orange	M10-XS31-01-071118	0.0	0.0	0%	0	M10-XS31-01-071118	1807369-2	0.20	U	200%
Trip 6	Orange	M10-XS31-02-071118	0.0	0.0	0%	0	M10-XS31-02-071118	1807369-3	0.19	U	200%
Trip 6	Orange	M11-XS11-01-071118	3.9	3.6	68%	0	M11-XS11-01-071118	1807369-4	1.50		88%
Trip 6	Red	M11-XS7-01-071118	0.8	0.7	113%	0	M11-XS7-01-071118	1807369-5	1.80		75%
Trip 6	Red	M12-XS27-01-071518	0.0	0.0	0%	0	M12-XS27-01-071518	1807369-6	0.21	U	200%
Trip 6	Red	M25-XS16-01-071718	0.0	0.0	0%	0	M25-XS16-01-071718	1807452-1	3.50	J	200%
Trip 6	Red	M25-XS23-01-071718	0.0	0.0	0%	0	M25-XS23-01-071718	1807452-2	0.23		200%
Trip 6	Red	M25-XS88-01-071718	0.0	0.0	0%	0	M25-XS88-01-071718	1807452-4	0.26		200%
Trip 6	Orange	M30-XS170-01-071618	0.8	0.0	156%	0	M30-XS170-01-071618	1807369-10	2.00		85%
Trip 6	Red	M30-XS95-01-071618	0.5	0.0	157%	0	M30-XS95-01-071618	1807369-11	1.30		92%
Trip 6	Red	M31-XS9-01-071018	0.0	0.0	0%	0	M31-XS9-01-071018	1807369-12	0.19	U	200%
Trip 6	Orange	M32-XS58-01-071018	0.0	0.0	0%	0	M32-XS58-01-071018	1807369-13	0.47		200%
Trip 6	Orange	M33-XS22-01-071218	1.1	1.5	79%	0	M33-XS22-01-071218	1807369-15	1.50		30%
Trip 6	Orange	M33-XS85-01-071218	0.0	0.0	0%	0	M33-XS85-01-071218	1807369-16	0.27		200%
Trip 6	Red	M33-XS93-01-071218	0.0	0.0	0%	0	M33-XS93-01-071218	1807369-17	0.78		200%
Trip 6	Red	T33-XS43-01-071718	0.0	0.0	0%	0	T33-XS43-01-071718	1807452-5	0.20	U	200%
Trip 2	Pink	M4-XS4-01-050718	2.3	2.5	28%	1	M8-XS102-02-050918	1805328-5	0.03	U	194%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Molybdenum Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M21-XS46-01-060818	19.3	5.3	177%	2	M21-XS46-01-060818	1806234-18	1.30		175%

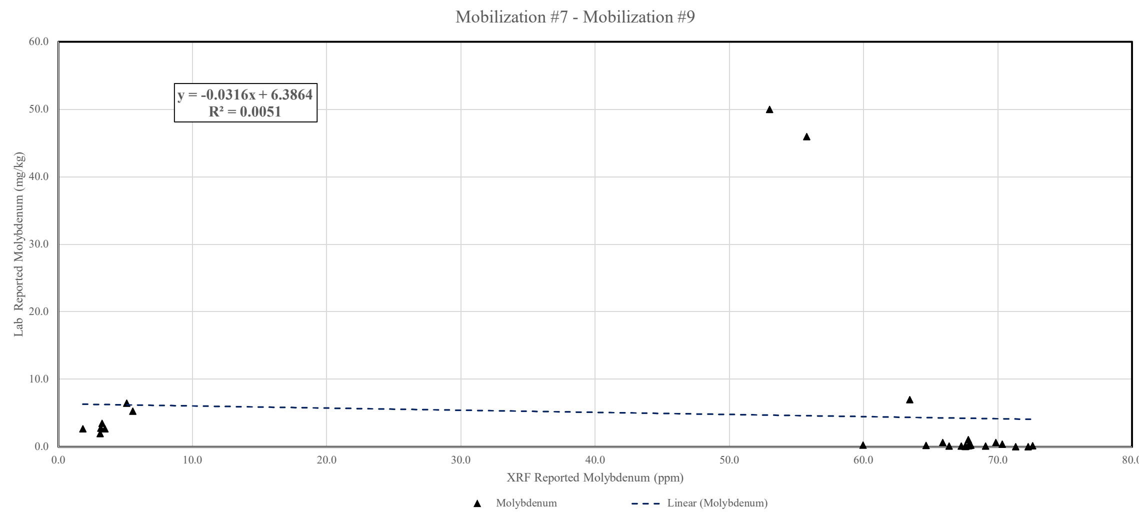
Removed Data - Instrument Setting

Trip	XRF Color	XRF ID	XRF - Molybdenum Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Blue	M15-XS73-01-052118	13.7	13.6	5%	13	M15-XS73-01-052118	1805589-5	2.2		145%
Trip 3	Blue	M16-XS45-01-052118	14.9	13.9	16%	13	M16-XS45-01-052118	1805589-13	3.7		120%
Trip 3	Blue	M16-XS166-01-052118	16.1	16.1	4%	15	M16-XS166-01-052118	1805589-9	8.5		62%
Trip 3	Blue	T20-XS14-01-052218	12.6	12.5	5%	12	T20-XS14-01-052218	1805632-10	0.2	J	195%
Trip 3	Blue	T21-XS6-01-052118	13.6	12.4	24%	12	T21-XS6-01-052118	1805589-17	0.2		193%
Trip 3	Blue	T21-XS35-01-052118	12.5	12.4	5%	12	T21-XS35-01-052118	1805589-14	0.4		186%
Trip 3	Blue	T21-XS55-01-052118	12.5	12.4	1%	12	T21-XS55-01-052118	1805589-15	0.3		190%
Trip 3	Blue	T22-XS17-01-052118	12.1	12.3	3%	11	T22-XS17-01-052118	1805589-18	0.3		191%

Removed Data - Unusually Large Residual

Trip	XRF Color	XRF ID	XRF - Molybdenum Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 2	Orange	M7-XS74-01-051018	2.1	2.3	31%	1	T4-XS43-01-051218	1805328-19	3.3		43%
Trip 2	Pink	T4-XS43-01-051218	6.3	6.2	16%	5	T17-XS619-01-050718	1805322-30	0.2	J	190%
Trip 3	Pink	M17-XS83-01-052618	17.1	15.9	52%	7	M17-XS83-01-052618	1806235-7	7.5	J	78%
Trip 4	Pink	T26-XS8-01-061018	5.9	6.0	7%	5	T26-XS8-01-061018	1806233-9	6.0		2%
Trip 5	Pink	M28-XS43-01-062018	7.4	7.2	8%	7	M28-XS43-01-062018	1806558-20	7.9		7%
Trip 6	Red	M25-XS47-01-071718	3.4	2.5	68%	1	M25-XS47-01-071718	1807452-3	3.0		14%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
U = Not detected
XRF = X-ray fluorescence



Data Included											
Trip	XRF Color	XRF ID	XRF - Molybdenum				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 7	Red	M6-XS72-01-081618	66.4	66.3	2%	65	M6-XS72-01-081618	1808476-10	0.2	J	199%
Trip 7	Red	M9-XS19A-01-081718	72.2	72.0	1%	71	M9-XS19A-01-081718	1808483-8	0.1	J	200%
Trip 7	Red	M9-XS28A-01-081718	64.6	64.8	2%	63	M9-XS28A-01-081718	1808483-9	0.3		198%
Trip 7	Red	T13-XSG16-01-081618	72.6	71.9	3%	70	T13-XSG16-01-081618	1808476-13	0.2	J	199%
Trip 7	Red	T17-XSG17-01-081618	68.0	67.5	4%	66	T17-XSG17-01-081618	1808476-16	0.3		198%
Trip 7	Red	T17-XSG27-01-081618	67.3	67.2	2%	66	T17-XSG27-01-081618	1808476-17	0.1	J	199%
Trip 7	Red	T17-XSG31-01-081518	69.1	68.7	2%	67	T17-XSG31-01-081518	1808476-18	0.2	J	199%
Trip 7	Red	T17-XSG7-01-081618	67.5	67.4	5%	62	T17-XSG7-01-081618	1808476-19	0.1	J	199%
Trip 7	Red	T1-XSG49A-01-081918	3.2	3.2	43%	2	T1-XSG49A-01-081918	1808483-14	3.5		8%
Trip 7	Red	T5-XSG10-01-081918	3.1	3.2	22%	2	T5-XSG10-01-081918	1808483-19	2.0		43%
Trip 8	Red	M14-XSG14A-01-091818	1.8	1.7	30%	1	M14-XSG14A-01-091818	1809475-22	2.7		39%
Trip 8	Red	M15-XSG20-01-091118	67.8	67.6	3%	65	M15-XSG20-01-091118	1809473-20	0.3		198%
Trip 8	Red	M16-XSG24-01-091118	63.4	63.7	4%	60	M16-XSG24-01-091118	1809473-23	7.0		160%
Trip 8	Red	M21-XS1-01-091218	59.9	59.3	4%	57	M21-XS1-01-091218	1809473-24	0.3		198%
Trip 8	Red	M21-XS366-01-091418	5.5	5.2	19%	4	M21-XS366-01-091418	1809475-10	5.3		4%
Trip 8	Red	M21-XS366-02-091418	5.1	4.9	28%	3	M21-XS366-02-091418	1809475-11	6.5		25%
Trip 8	Red	M21-XS465-01-091218	3.1	2.8	26%	2	M21-XS465-01-091218	1809473-27	2.8		11%
Trip 8	Red	M21-XS503-01-091218	67.6	67.4	3%	66	M21-XS503-01-091218	1809473-28	0.1	J	199%
Trip 8	Red	M21-XS536-01-091218	3.4	2.8	43%	2	M21-XS536-01-091218	1809473-30	2.7		24%
Trip 8	Red	M21-XSG16-01-091218	67.8	68.5	3%	64	M21-XSG16-01-091218	1809473-31	1.1		194%
Trip 8	Red	M21-XSG7-01-091218	67.8	68.1	4%	64	M21-XSG7-01-091218	1809473-32	0.2	J	199%
Trip 8	Red	M6-XS164-01-091118	71.3	71.2	2%	70	M6-XS164-01-091118	1809473-33	0.1	J	200%
Trip 8	Red	M6-XS224-01-091118	65.9	65.9	1%	65	M6-XS224-01-091118	1809473-34	0.7		196%
Trip 8	Red	T19-XS9-01-091118	69.8	69.3	2%	68	T19-XS9-01-091118	1809473-36	0.7		196%
Trip 8	Red	T22-XS20-01-091118	67.9	67.6	2%	67	T22-XS20-01-091118	1809473-15	0.2		199%
Trip 8	Red	T24-XSG26-01-091118	70.3	69.9	2%	69	T24-XSG26-01-091118	1809473-19	0.4		198%
Trip 9	Red	M27-XSG28-01-092618	53.0	52.6	14%	43	M27-XSG28-01-092618	1810072-6	50.0		6%
Trip 9	Red	M27-XSG28-02-092618	55.7	52.4	21%	45	M27-XSG28-02-092618	1810072-7	46.0		19%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Molybdenum				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 7	Red	M10-XS22-01-082118	0.0	0.0	0%	0	M10-XS22-01-082118	1808494-1	0.32	J	200%
Trip 7	Red	M10-XS39-01-082118	0.0	0.0	0%	0	M10-XS39-01-082118	1808494-2	0.10	J	200%
Trip 7	Red	M10-XS43-01-082118	0.0	0.0	0%	0	M10-XS43-01-082118	1808494-3	0.14	J	200%
Trip 7	Red	M1-XSG2-01-081918	0.0	0.0	0%	0	M1-XSG2-01-081918	1808483-1	0.14	J	200%
Trip 7	Pink	M34-XS110-01-081218	2.3	2.0	78%	0	M34-XS110-01-081218	1808303-1	0.58		120%
Trip 7	Pink	M34-XS22-01-081218	0.0	0.0	0%	0	M34-XS22-01-081218	1808303-2	0.50		200%
Trip 7	Pink	M34-XS43-01-081218	0.2	0.0	245%	0	M34-XS43-01-081218	1808303-3	0.49		83%
Trip 7	Pink	M34-XS50-01-081218	0.0	0.0	0%	0	M34-XS50-01-081218	1808303-4	0.81		200%
Trip 7	Pink	M34-XS68-01-081218	0.0	0.0	0%	0	M34-XS68-01-081218	1808303-5	1.20		200%
Trip 7	Pink	M35-XS11-01-081218	0.2	0.0	245%	0	M35-XS11-01-081218	1808303-6	0.58		90%
Trip 7	Pink	M35-XS20-01-081318	0.0	0.0	0%	0	M35-XS20-01-081318	1808303-7	2.60		200%
Trip 7	Pink	M35-XS31-01-081218	0.0	0.0	0%	0	M35-XS31-01-081218	1808303-8	0.27		200%
Trip 7	Pink	M35-XS63-01-081218	0.0	0.0	0%	0	M35-XS63-01-081218	1808303-9	0.20		200%
Trip 7	Pink	M35-XS74-01-081318	0.2	0.0	245%	0	M35-XS74-01-081318	1808303-10	0.51	J	69%
Trip 7	Pink	M35-XS74-02-081318	0.5	0.0	156%	0	M35-XS74-02-081318	1808303-11	0.26	J	61%
Trip 7	Pink	M36-XS20-01-081218	0.0	0.0	0%	0	M36-XS20-01-081218	1808303-12	0.09	J	200%
Trip 7	Pink	M36-XS2-01-081218	0.0	0.0	0%	0	M36-XS2-01-081218	1808303-13	0.24		200%
Trip 7	Pink	M36-XS3-01-081218	0.0	0.0	0%	0	M36-XS3-01-081218	1808303-14	0.05	J	200%
Trip 7	Pink	M36-XS31-01-081218	2.1	2.3	64%	0	M36-XS31-01-081218	1808303-15	0.70		101%
Trip 7	Pink	M37-XS124A-01-081318	3.9	4.0	57%	0	M37-XS124A-01-081318	1808303-16	2.50		44%
Trip 7	Pink	M37-XS144-01-081318	0.0	0.0	0%	0	M37-XS144-01-081318	1808303-17	1.60		200%
Trip 7	Pink	M37-XS2-01-081318	0.0	0.0	0%	0	M37-XS2-01-081318	1808303-18	0.15	J	200%
Trip 7	Pink	M37-XS23-01-081318	0.0	0.0	0%	0	M37-XS23-01-081318	1808303-19	0.13	J	200%
Trip 7	Pink	M37-XS31-01-081318	1.4	1.3	115%	0	M37-XS31-01-081318	1808303-20	0.23		144%
Trip 7	Pink	M37-XS38-01-081318	0.0	0.0	0%	0	M37-XS38-01-081318	1808356-1	0.12	J	200%
Trip 7	Pink	M37-XS44-01-081318	0.8	0.8	110%	0	M37-XS44-01-081318	1808356-2	2.10		91%
Trip 7	Pink	M37-XS50-01-081318	0.0	0.0	0%	0	M37-XS50-01-081318	1808356-3	0.57		200%
Trip 7	Pink	M37-XS7-01-081318	0.0	0.0	0%	0	M37-XS7-01-081318	1808356-4	0.25		200%
Trip 7	Red	M38-XS20-01-081818	0.0	0.0	0%	0	M38-XS20-01-081818	1808483-2	0.40		200%
Trip 7	Red	M3-XS19-01-081718	0.0	0.0	0%	0	M3-XS19-01-081718	1808476-1	0.13	J	200%
Trip 7	Red	M3-XS41-01-081718	0.0	0.0	0%	0	M3-XS41-01-081718	1808476-2	0.14	J	200%
Trip 7	Red	M4-XS210-01-081818	0.0	0.0	0%	0	M4-XS210-01-081818	1808483-3	0.04	J	200%
Trip 7	Red	M4-XSG11-01-081818	0.0	0.0	0%	0	M4-XSG11-01-081818	1808483-4	0.09	J	200%
Trip 7	Red	M4-XSG2-01-081818	0.0	0.0	0%	0	M4-XSG2-01-081818	1808483-5	0.08	J	200%
Trip 7	Red	M5-XS131-01-082018	0.0	0.0	0%	0	M5-XS131-01-082018	1808487-1	0.25		200%
Trip 7	Red	M5-XS15-01-081818	0.0	0.0	0%	0	M5-XS15-01-081818	1808483-6	0.06	J	200%
Trip 7	Red	M5-XS192-01-081818	0.0	0.0	0%	0	M5-XS192-01-081818	1808483-7	0.15	J	200%
Trip 7	Red	M5-XS199-01-082018	0.0	0.0	0%	0	M5-XS199-01-082018	1808487-2	0.17	J	200%
Trip 7	Red	M5-XS207A-01-082018	0.0	0.0	0%	0	M5-XS207A-01-082018	1808487-3	0.30		200%
Trip 7	Red	M5-XS261-01-082018	0.0	0.0	0%	0	M5-XS261-01-082018	1808487-4	0.30		200%
Trip 7	Red	M5-XS263-01-082018	1.5	0.0	265%	0	M5-XS263-01-082018	1808487-5	0.43		112%
Trip 7	Red	M5-XS305-01-082018	0.0	0.0	0%	0	M5-XS305-01-082018	1808487-6	0.26		200%
Trip 7	Red	M5-XS476-01-082018	0.0	0.0	0%	0	M5-XS476-01-082018	1808487-7	0.12	J	200%
Trip 7	Red	M5-XS488-01-082018	0.0	0.0	0%	0	M5-XS488-01-082018	1808487-8	0.11	J	200%
Trip 7	Red	M6-XS108-01-081618	0.0	0.0	0%	0	M6-XS108-01-081618	1808476-3	0.14	J	200%
Trip 7	Red	M6-XS108-02-081618	0.0	0.0	0%	0	M6-XS108-02-081618	1808476-4	0.17	J	200%
Trip 7	Red	M6-XS198-01-081618	0.0	0.0	0%	0	M6-XS198-01-081618	1808476-5	0.18	J	200%
Trip 7	Red	M6-XS249-01-081618	0.0	0.0	0%	0	M6-XS249-01-081618	1808476-6	0.11	J	200%
Trip 7	Red	M6-XS289-01-081618	0.0	0.0	0%	0	M6-XS289-01-081618	1808476-7	0.19	J	200%
Trip 7	Red	M6-XS324-01-081618	0.0	0.0	0%	0	M6-XS324-01-081618	1808476-8	0.25		200%
Trip 7	Red	M6-XS60-01-081618	0.0	0.0	0%	0	M6-XS60-01-081618	1808476-9	0.10	J	200%
Trip 7	Pink	M7-XS162A-01-081518	3.3	3.2	78%	0	M7-XS162A-01-081518	1808356-5	0.20		177%
Trip 7	Pink	M7-XS203-01-081418	0.0	0.0	0%	0	M7-XS203-01-081418	1808356-6	0.15	J	200%
Trip 7	Pink	M7-XS213-01-081518	0.0	0.0	0%	0	M7-XS213-01-081518	1808356-7	0.22		200%
Trip 7	Pink	M7-XS214-01-081518	0.0	0.0	0%	0	M7-XS214-01-081518	1808356-8	0.15	J	200%
Trip 7	Pink	M7-XS235A-01-081418	0.0	0.0	0%	0	M7-XS235A-01-081418	1808356-9	0.19	J	200%
Trip 7	Pink	M7-XS244-01-081518	0.0	0.0	0%	0	M7-XS244-01-081518	1808356-10	0.13	J	200%
Trip 7	Pink	M8-XS55-01-081418	0.7	0.0	245%	0	M8-XS55-01-081418	1808356-20	0.07	J	165%
Trip 7	Red	M8-XS83-01-081418	3.1	2.6	84%	0	M8-XS83-01-081418	1808476-12	0.12	J	185%
Trip 7	Pink	M8-XSG16-01-081518	0.0	0.0	0%	0	M8-XSG16-01-081518	1808356-11	0.11	J	200%
Trip 7	Pink	M8-XSG28-01-081418	0.0	0.0	0%	0	M8-XSG28-01-081418	1808356-12	0.14	J	200%
Trip 7	Pink	M8-XSG31-01-081518	0.0	0.0	0%	0	M8-XSG31-01-081518	1808356-13	0.21		200%
Trip 7	Pink	M8-XSG37-01-081418	0.0	0.0	0%	0	M8-XSG37-01-081418	1808356-14	0.17	J	200%
Trip 7	Pink	M8-XSG40-01-081418	0.0	0.0	0%	0	M8-XSG40-01-081418	1808356-15	0.15	J	200%
Trip 7	Pink	M8-XSG4-01-081518	0.0	0.0	0%	0	M8-XSG4-01-081518	1808356-16	0.12	J	200%
Trip 7	Pink	M8-XSG44-01-081418	0.0	0.0	0%	0	M8-XSG44-01-081418	1808356-17	0.14	J	200%
Trip 7	Pink	M8-XSG44-02-081418	0.0	0.0	0%	0	M8-XSG44-02-081418	1808356-18	0.17	J	200%
Trip 7	Pink	M8-XSG47-01-081418	0.0	0.0	0%	0	M8-XSG47-01-081418	1808356-19	0.14	J	200%
Trip 7	Red	M8-XSG6-01-081518	0.0	0.0	0%	0	M8-XSG6-01-081518	1808476-11	0.06	J	200%
Trip 7	Red	T10-XSG1-01-081818	0.0	0.0	0%	0	T10-XSG1-01-081818	1808483-10	0.17	J	200%
Trip 7	Red	T13-XSG26-01-081618	0.0	0.0	0%	0	T13-XSG26-01-081618	1808476-14	0.21		200%

Removed Data - Below Limit of Detection											
			XRF - Molybdenum						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	T13-XSG7-01-081618	0.0	0.0	0%	0	T13-XSG7-01-081618	1808476-15	0.21	J	200%
Trip 7	Red	T15-XS20-01-081718	0.0	0.0	0%	0	T15-XS20-01-081718	1808483-11	0.32		200%
Trip 7	Red	T15-XSG5-01-081718	0.0	0.0	0%	0	T15-XSG5-01-081718	1808483-12	0.16	J	200%
Trip 7	Red	T17-XSG7-02-081618	0.0	0.0	0%	0	T17-XSG7-02-081618	1808476-20	0.10	J	200%
Trip 7	Red	T1-XSG38-01-081918	0.0	0.0	0%	0	T1-XSG38-01-081918	1808483-13	0.25		200%
Trip 7	Red	T1-XSG5A-01-081918	876.4	0.0	265%	0	T1-XSG5A-01-081918	1808483-15	0.21		200%
Trip 7	Red	T4-XS15A-01-081918	2.9	3.1	58%	0	T4-XS15A-01-081918	1808487-9	2.20		28%
Trip 7	Red	T4-XSG10-01-081918	0.0	0.0	0%	0	T4-XSG10-01-081918	1808483-16	0.14	J	200%
Trip 7	Red	T4-XSG39-01-081918	0.0	0.0	0%	0	T4-XSG39-01-081918	1808483-17	0.08	J	200%
Trip 7	Red	T4-XSG50A-01-081918	0.0	0.0	0%	0	T4-XSG50A-01-081918	1808483-18	0.10	J	200%
Trip 7	Red	T6-XSG6-01-081918	0.0	0.0	0%	0	T6-XSG6-01-081918	1808487-10	0.16	J	200%
Trip 7	Red	T6-XSG6-02-081918	0.0	0.0	0%	0	T6-XSG6-02-081918	1808487-11	0.12	J	200%
Trip 7	Red	T9-XSG12-01-081818	0.0	0.0	0%	0	T9-XSG12-01-081818	1808483-20	0.17	J	200%
Trip 8	Red	M13-XS112-01-091518	0.0	0.0	0%	0	M13-XS112-01-091518	1809475-1	0.39		200%
Trip 8	Red	M13-XS258-01-091518	0.0	0.0	0%	0	M13-XS258-01-091518	1809475-2	0.16	J	200%
Trip 8	Red	M14-XS62-01-091818	0.0	0.0	0%	0	M14-XS62-01-091818	1809475-21	0.61		200%
Trip 8	Red	M14-XSG27A-01-091818	0.0	0.0	0%	0	M14-XSG27A-01-091818	1809475-23	0.91		200%
Trip 8	Red	M14-XSG41-01-091818	0.0	0.0	0%	0	M14-XSG41-01-091818	1809475-24	0.63		200%
Trip 8	Red	M14-XSG49-01-091818	0.0	0.0	0%	0	M14-XSG49-01-091818	1809475-25	0.27		200%
Trip 8	Red	M14-XSG58-01-091818	0.0	0.0	0%	0	M14-XSG58-01-091818	1809475-26	0.34		200%
Trip 8	Red	M14-XSG6-01-091818	0.2	0.0	245%	0	M14-XSG6-01-091818	1809475-27	0.45		66%
Trip 8	Red	M15-XSG2-01-091118	0.0	0.0	0%	0	M15-XSG2-01-091118	1809473-21	0.21		200%
Trip 8	Red	M16-XSG13-01-091118	0.2	0.0	245%	0	M16-XSG13-01-091118	1809473-22	1.00		131%
Trip 8	Red	M16-XSG30-01-091518	0.0	0.0	0%	0	M16-XSG30-01-091518	1809475-3	0.21		200%
Trip 8	Red	M16-XSG38-01-091518	0.0	0.0	0%	0	M16-XSG38-01-091518	1809475-4	0.09	J	200%
Trip 8	Red	M17-XS79-01-091318	1.4	1.5	59%	0	M17-XS79-01-091318	1809473-1	1.70		18%
Trip 8	Red	M17-XSG1-01-091318	0.0	0.0	0%	0	M17-XSG1-01-091318	1809473-2	0.32		200%
Trip 8	Red	M17-XSG27-01-091318	0.0	0.0	0%	0	M17-XSG27-01-091318	1809473-3	0.14	J	200%
Trip 8	Red	M17-XSG36-01-091318	0.0	0.0	0%	0	M17-XSG36-01-091318	1809473-4	0.20		200%
Trip 8	Red	M17-XSG36-02-091318	0.0	0.0	0%	0	M17-XSG36-02-091318	1809473-5	0.25		200%
Trip 8	Red	M18-XSG16-01-091318	0.0	0.0	0%	0	M18-XSG16-01-091318	1809473-6	0.16	J	200%
Trip 8	Red	M18-XSG30-01-091318	0.0	0.0	0%	0	M18-XSG30-01-091318	1809473-7	0.36		200%
Trip 8	Red	M18-XSG32-01-091318	0.0	0.0	0%	0	M18-XSG32-01-091318	1809473-8	0.18	J	200%
Trip 8	Red	M19-XSG11-01-091318	0.0	0.0	0%	0	M19-XSG11-01-091318	1809473-9	0.20		200%
Trip 8	Red	M19-XSG19-01-091318	0.2	0.0	245%	0	M19-XSG19-01-091318	1809473-10	0.68		112%
Trip 8	Red	M19-XSG25-01-091318	0.0	0.0	0%	0	M19-XSG25-01-091318	1809473-11	0.28		200%
Trip 8	Red	M19-XSG29-01-091318	0.0	0.0	0%	0	M19-XSG29-01-091318	1809473-12	0.16	J	200%
Trip 8	Red	M19-XSG39-01-091318	0.0	0.0	0%	0	M19-XSG39-01-091318	1809473-13	0.25		200%
Trip 8	Red	M19-XSG43-01-091318	0.0	0.0	0%	0	M19-XSG43-01-091318	1809473-14	0.16	J	200%
Trip 8	Red	M20-XS146-01-091718	0.7	0.0	158%	0	M20-XS146-01-091718	1809475-28	0.22		105%
Trip 8	Red	M20-XS243-01-091718	0.9	0.0	175%	0	M20-XS243-01-091718	1809475-29	1.10		25%
Trip 8	Red	M20-XS247-01-091718	0.0	0.0	0%	0	M20-XS247-01-091718	1809475-30	0.10	J	200%
Trip 8	Red	M20-XS267-01-091718	3.9	2.3	135%	0	M20-XS267-01-091718	1809475-31	0.38		164%
Trip 8	Red	M20-XS271-01-091718	0.0	0.0	0%	0	M20-XS271-01-091718	1809475-32	0.07	J	200%
Trip 8	Red	M20-XS30-01-091718	0.0	0.0	0%	0	M20-XS30-01-091718	1809475-33	0.15	J	200%
Trip 8	Red	M20-XS335-01-091418	0.0	0.0	0%	0	M20-XS335-01-091418	1809475-5	0.32		200%
Trip 8	Red	M20-XS422-01-091418	0.0	0.0	0%	0	M20-XS422-01-091418	1809475-6	0.15	J	200%
Trip 8	Red	M20-XS58-01-091718	0.0	0.0	0%	0	M20-XS58-01-091718	1809475-34	0.16	J	200%
Trip 8	Red	M20-XS60-01-091718	0.0	0.0	0%	0	M20-XS60-01-091718	1809475-35	0.15	J	200%
Trip 8	Red	M20-XSG15-01-091418	0.0	0.0	0%	0	M20-XSG15-01-091418	1809475-7	0.25		200%
Trip 8	Red	M20-XSG28-01-091418	1.4	0.7	124%	0	M20-XSG28-01-091418	1809475-8	1.50		10%
Trip 8	Red	M20-XSG7-01-091418	0.0	0.0	0%	0	M20-XSG7-01-091418	1809475-9	0.17	J	200%
Trip 8	Red	M21-XS317-01-091218	0.2	0.0	245%	0	M21-XS317-01-091218	1809473-25	0.47		79%
Trip 8	Red	M21-XS323-01-091218	1.4	1.5	56%	0	M21-XS323-01-091218	1809473-26	1.90		28%
Trip 8	Red	M21-XS511-01-091218	0.0	0.0	0%	0	M21-XS511-01-091218	1809473-29	0.34		200%
Trip 8	Red	M21-XSG38-01-091418	2.0	2.2	66%	0	M21-XSG38-01-091418	1809475-12	2.30	J	14%
Trip 8	Red	M21-XSG43-01-091418	0.0	0.0	0%	0	M21-XSG43-01-091418	1809475-13	0.13	J	200%
Trip 8	Red	M22-XS112-01-091418	0.0	0.0	0%	0	M22-XS112-01-091418	1809475-14	0.47		200%
Trip 8	Red	M22-XS115-01-091418	0.0	0.0	0%	0	M22-XS115-01-091418	1809475-15	0.42		200%
Trip 8	Red	M22-XS121-01-091418	0.0	0.0	0%	0	M22-XS121-01-091418	1809475-16	0.23		200%
Trip 8	Red	M22-XS94-01-091418	0.0	0.0	0%	0	M22-XS94-01-091418	1809475-17	0.11	J	200%
Trip 8	Red	M23-XSG1-01-091418	0.0	0.0	0%	0	M23-XSG1-01-091418	1809475-18	0.06	J	200%
Trip 8	Red	M23-XSG20-01-091418	0.0	0.0	0%	0	M23-XSG20-01-091418	1809475-19	0.13	J	200%
Trip 8	Red	M23-XSG5-01-091418	0.0	0.0	0%	0	M23-XSG5-01-091418	1809475-20	0.13	J	200%
Trip 8	Red	M6-XS353A-01-091618	0.2	0.0	245%	0	M6-XS353A-01-091618	1809475-36	2.10		167%
Trip 8	Red	M6-XS369-01-091618	0.0	0.0	0%	0	M6-XS369-01-091618	1809475-37	0.08	J	200%
Trip 8	Red	M6-XS52-01-091118	0.0	0.0	0%	0	M6-XS52-01-091118	1809473-35	0.10	J	200%
Trip 8	Red	M6-XSG13A-01-091618	1.3	0.0	245%	0	M6-XSG13A-01-091618	1809475-38	0.34		115%
Trip 8	Red	M6-XSG22-01-091618	0.0	0.0	0%	0	M6-XSG22-01-091618	1809475-39	0.12	J	200%
Trip 8	Red	M7-XSG34-01-091618	0.0	0.0	0%	0	M7-XSG34-01-091618	1809475-40	0.10	J	200%
Trip 8	Red	M7-XSG41-01-091618	0.0	0.0	0%	0	M7-XSG41-01-091618	1809475-41	0.07	J	200%

Removed Data - Below Limit of Detection											
			XRF - Molybdenum						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	T18-XSG7-01-091518	0.0	0.0	0%	0	T18-XSG7-01-091518	1809475-42	0.08	J	200%
Trip 8	Red	T20-XSG3-01-091118	56.4	67.5	49%	0	T20-XSG3-01-091118	1809473-37	0.15	J	199%
Trip 8	Red	T21-XSG13-01-091118	0.0	0.0	0%	0	T21-XSG13-01-091118	1809473-38	0.34		200%
Trip 8	Red	T21-XSG26-01-091118	0.0	0.0	0%	0	T21-XSG26-01-091118	1809473-39	0.21		200%
Trip 8	Red	T23-XSG26-01-091118	0.0	0.0	0%	0	T23-XSG26-01-091118	1809473-16	0.33		200%
Trip 8	Red	T23-XSG7-01-091118	0.0	0.0	0%	0	T23-XSG7-01-091118	1809473-17	0.42		200%
Trip 8	Red	T24-XSG2-01-091118	0.0	0.0	0%	0	T24-XSG2-01-091118	1809473-18	0.20		200%
Trip 8	Red	T26-XSG2-01-091518	0.0	0.0	0%	0	T26-XSG2-01-091518	1809475-43	1.90		200%
Trip 8	Red	T26-XSG9-01-091518	0.0	0.0	0%	0	T26-XSG9-01-091518	1809475-44	0.81		200%
Trip 9	Red	M10-XSG2-01-092818	0.0	0.0	0%	0	M10-XSG2-01-092818	1810122-1	0.13	J	200%
Trip 9	Blue	M10-XSG4-01-092818	0.0	0.0	0%	0	M10-XSG4-01-092818	1810122-2	0.15	J	200%
Trip 9	Red	M11-XS47-01-092818	0.0	0.0	0%	0	M11-XS47-01-092818	1810122-3	0.12	J	200%
Trip 9	Blue	M11-XSG2-01-092818	0.0	0.0	0%	0	M11-XSG2-01-092818	1810122-4	0.17	J	200%
Trip 9	Blue	M11-XSG25-01-092818	0.9	0.0	245%	0	M11-XSG25-01-092818	1810122-5	0.11	J	156%
Trip 9	Blue	M11-XSG28-01-092818	0.2	0.0	245%	0	M11-XSG28-01-092818	1810122-6	0.14	J	56%
Trip 9	Red	M11-XSG33-01-092818	0.0	0.0	0%	0	M11-XSG33-01-092818	1810122-7	0.13	J	200%
Trip 9	Red	M12-XSG26-01-092818	0.0	0.0	0%	0	M12-XSG26-01-092818	1810122-8	0.15	J	200%
Trip 9	Blue	M14-XSR1-01-093018	0.0	0.0	0%	0	M14-XSR1-01-093018	1810072-21	0.27		200%
Trip 9	White	M15-XSR1-01-093018	0.0	0.0	0%	0	M15-XSR1-01-093018	1810072-22	0.16	J	200%
Trip 9	White	M16-XSR1-01-093018	0.0	0.0	0%	0	M16-XSR1-01-093018	1810072-23	0.17	J	200%
Trip 9	White	M16-XSR6-01-093018	0.0	0.0	0%	0	M16-XSR6-01-093018	1810072-24	0.11	J	200%
Trip 9	Blue	M17-XSR1-01-093018	0.0	0.0	0%	0	M17-XSR1-01-093018	1810072-25	0.09	J	200%
Trip 9	Red	M19-XSR2-01-093018	0.0	0.0	0%	0	M19-XSR2-01-093018	1810072-26	0.11	J	200%
Trip 9	Blue	M19-XSR2-02-093018	0.0	0.0	0%	0	M19-XSR2-02-093018	1810072-27	0.11	J	200%
Trip 9	Red	M1-XSG4-01-092818	0.0	0.0	0%	0	M1-XSG4-01-092818	1810072-1	0.13	J	200%
Trip 9	Blue	M20-XSR2-01-093018	0.7	0.0	155%	0	M20-XSR2-01-093018	1810072-28	0.14	J	137%
Trip 9	White	M23-XSR4-01-093018	0.0	0.0	0%	0	M23-XSR4-01-093018	1810072-29	0.33		200%
Trip 9	Red	M24-XS112-01-092518	0.0	0.0	0%	0	M24-XS112-01-092518	1810032-1	0.18	J	200%
Trip 9	Red	M24-XS114-01-092518	0.0	0.0	0%	0	M24-XS114-01-092518	1810032-2	0.32		200%
Trip 9	Red	M24-XSG15-01-092518	0.0	0.0	0%	0	M24-XSG15-01-092518	1810032-3	1.30		200%
Trip 9	Red	M24-XSG3-01-092518	0.0	0.0	0%	0	M24-XSG3-01-092518	1810032-4	0.25		200%
Trip 9	Red	M24-XSG32-01-092518	0.0	0.0	0%	0	M24-XSG32-01-092518	1810032-5	0.17	J	200%
Trip 9	Red	M24-XSR1-01-093018	0.0	0.0	0%	0	M24-XSR1-01-093018	1810072-30	0.16	J	200%
Trip 9	Blue	M25-XSG12-01-092818	0.0	0.0	0%	0	M25-XSG12-01-092818	1810122-10	0.18	J	200%
Trip 9	Blue	M25-XSG19-01-092818	0.0	0.0	0%	0	M25-XSG19-01-092818	1810122-11	0.09	J	200%
Trip 9	Blue	M25-XSG19-02-092818	0.0	0.0	0%	0	M25-XSG19-02-092818	1810122-12	0.11	J	200%
Trip 9	Blue	M25-XSG5-01-092818	0.0	0.0	0%	0	M25-XSG5-01-092818	1810122-13	0.17	U	200%
Trip 9	Red	M27-XS116-01-092618	0.0	0.0	0%	0	M27-XS116-01-092618	1810072-2	0.25		200%
Trip 9	Red	M27-XS149-01-092618	0.0	0.0	0%	0	M27-XS149-01-092618	1810072-3	0.10	J	200%
Trip 9	Red	M27-XS150-01-092618	0.0	0.0	0%	0	M27-XS150-01-092618	1810072-4	0.09	J	200%
Trip 9	Red	M27-XS163-01-092618	0.0	0.0	0%	0	M27-XS163-01-092618	1810072-5	0.56		200%
Trip 9	Red	M27-XSG48-01-092618	0.0	0.0	0%	0	M27-XSG48-01-092618	1810072-8	0.25		200%
Trip 9	Red	M27-XSG6-01-092618	0.0	0.0	0%	0	M27-XSG6-01-092618	1810072-9	0.29		200%
Trip 9	Red, Blue	M28-XS162-01-092818	0.9	0.0	169%	0	M28-XS162-01-092818	1810122-14	1.90		76%
Trip 9	White	M28-XS19-01-092918	0.0	0.0	0%	0	M28-XS19-01-092918	1810122-15	0.08	J	200%
Trip 9	Red	M28-XS29-01-092618	6.7	1.7	205%	0	M28-XS29-01-092618	1810032-6	1.00		148%
Trip 9	Blue	M28-XSG18-01-092918	0.0	0.0	0%	0	M28-XSG18-01-092918	1810122-16	0.09	J	200%
Trip 9	Red	M28-XSG49-01-092618	0.0	0.0	0%	0	M28-XSG49-01-092618	1810032-7	0.15	J	200%
Trip 9	Red, White	M28-XSG54-01-092918	0.0	0.0	0%	0	M28-XSG54-01-092918	1810122-17	0.33		200%
Trip 9	Red	M28-XSG7-01-092618	5.4	4.8	76%	0	M28-XSG7-01-092618	1810032-8	0.09	J	193%
Trip 9	White	M28-XSG76-01-092918	0.0	0.0	0%	0	M28-XSG76-01-092918	1810122-18	0.29		200%
Trip 9	Blue	M28-XSR1-01-093018	0.0	0.0	0%	0	M28-XSR1-01-093018	1810072-31	0.06	J	200%
Trip 9	Red	M28-XSR1-02-093018	0.0	0.0	0%	0	M28-XSR1-02-093018	1810072-32	0.08	J	200%
Trip 9	Red	M29-XS19-01-092518	0.0	0.0	0%	0	M29-XS19-01-092518	1810032-9	0.26		200%
Trip 9	Red	M29-XS42-01-092518	0.0	0.0	0%	0	M29-XS42-01-092518	1810032-10	0.17	J	200%
Trip 9	Red	M29-XS59-01-092518	0.0	0.0	0%	0	M29-XS59-01-092518	1810032-11	0.80		200%
Trip 9	Red	M29-XS64-01-092518	0.0	0.0	0%	0	M29-XS64-01-092518	1810032-12	0.13	J	200%
Trip 9	Red	M29-XSG1-01-092518	0.0	0.0	0%	0	M29-XSG1-01-092518	1810032-13	0.07	J	200%
Trip 9	Red	M29-XSG25-01-092518	0.0	0.0	0%	0	M29-XSG25-01-092518	1810032-14	0.10	J	200%
Trip 9	Red	M29-XSG35-01-092518	0.0	0.0	0%	0	M29-XSG35-01-092518	1810032-15	0.07	J	200%
Trip 9	Blue	M29-XSR4-01-093018	0.0	0.0	0%	0	M29-XSR4-01-093018	1810072-33	0.11	J	200%
Trip 9	Red	M29-XSR7-01-093018	0.0	0.0	0%	0	M29-XSR7-01-093018	1810072-34	0.06	J	200%
Trip 9	White	M2-XSR3-01-093018	0.0	0.0	0%	0	M2-XSR3-01-093018	1810072-35	0.12	J	200%
Trip 9	White	M30-XS144-01-092918	0.0	0.0	0%	0	M30-XS144-01-092918	1810122-19	0.34		200%
Trip 9	White	M30-XS185-01-092918	0.0	0.0	0%	0	M30-XS185-01-092918	1810122-20	0.39		200%
Trip 9	White	M30-XS62-01-092918	0.2	0.0	245%	0	M30-XS62-01-092918	1810122-21	0.49		83%
Trip 9	White	M30-XSG18-01-092918	0.0	0.0	0%	0	M30-XSG18-01-092918	1810122-22	0.18	J	200%
Trip 9	White	M30-XSG29-01-092918	0.0	0.0	0%	0	M30-XSG29-01-092918	1810122-23	0.30		200%
Trip 9	White	M30-XSG43-01-092918	0.0	0.0	0%	0	M30-XSG43-01-092918	1810122-24	0.17	J	200%
Trip 9	White	M30-XSG45-01-092918	0.0	0.0	0%	0	M30-XSG45-01-092918	1810122-25	0.07	J	200%
Trip 9	Red, White	M30-XSG6-01-092918	0.1	0.0	346%	0	M30-XSG6-01-092918	1810122-26	1.10		167%

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Molybdenum				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 9	Blue	M30-XSG61-01-092918	0.0	0.0	0%	0	M30-XSG61-01-092918	1810122-27	0.05	J	200%
Trip 9	White	M30-XSR5-01-093018	0.0	0.0	0%	0	M30-XSR5-01-093018	1810072-36	0.17	J	200%
Trip 9	Red	M31-XS1-01-092918	0.0	0.0	0%	0	M31-XS1-01-092918	1810122-28	0.40		200%
Trip 9	Blue	M31-XS39-01-092918	1.2	1.5	81%	0	M31-XS39-01-092918	1810122-29	3.20		90%
Trip 9	White	M31-XS8-01-092918	0.0	0.0	0%	0	M31-XS8-01-092918	1810122-30	0.27		200%
Trip 9	White	M31-XSG1-01-092918	0.0	0.0	0%	0	M31-XSG1-01-092918	1810122-31	0.09	J	200%
Trip 9	White	M31-XSG12-01-092918	0.0	0.0	0%	0	M31-XSG12-01-092918	1810122-32	0.12	J	200%
Trip 9	White	M31-XSG17-01-092918	0.0	0.0	0%	0	M31-XSG17-01-092918	1810122-33	0.12	J	200%
Trip 9	Red	M31-XSG9-01-092918	0.0	0.0	0%	0	M31-XSG9-01-092918	1810122-34	0.09	J	200%
Trip 9	Red	M32-XSG23-01-092918	0.0	0.0	0%	0	M32-XSG23-01-092918	1810072-10	0.26		200%
Trip 9	Red	M32-XSG26-01-092918	0.0	0.0	0%	0	M32-XSG26-01-092918	1810072-11	0.21		200%
Trip 9	Red	M32-XSG34-01-092918	0.0	0.0	0%	0	M32-XSG34-01-092918	1810072-12	0.14	J	200%
Trip 9	Red	M32-XSG46-01-092918	0.0	0.0	0%	0	M32-XSG46-01-092918	1810072-13	0.17	J	200%
Trip 9	Red	M32-XSG9-01-092918	0.0	0.0	0%	0	M32-XSG9-01-092918	1810072-14	0.20	J	200%
Trip 9	Red	M34-XSG15-01-092718	0.0	0.0	0%	0	M34-XSG15-01-092718	1810072-15	0.35		200%
Trip 9	Red	M35-XSG20-01-092718	0.0	0.0	0%	0	M35-XSG20-01-092718	1810072-16	0.11	J	200%
Trip 9	Red	M35-XSG4-01-092718	0.0	0.0	0%	0	M35-XSG4-01-092718	1810072-17	0.09	J	200%
Trip 9	Red	M36-XSG1-01-092718	0.0	0.0	0%	0	M36-XSG1-01-092718	1810072-18	0.67		200%
Trip 9	White	M6-XSR1-01-093018	0.0	0.0	0%	0	M6-XSR1-01-093018	1810072-37	0.06	J	200%
Trip 9	White	M7-XSR1-01-093018	0.0	0.0	0%	0	M7-XSR1-01-093018	1810072-38	0.48		200%
Trip 9	White	M7-XSR1-02-093018	0.0	0.0	0%	0	M7-XSR1-02-093018	1810072-39	0.36		200%
Trip 9	Blue	M8-XSR1-01-093018	0.2	0.0	245%	0	M8-XSR1-01-093018	1810072-40	0.19		14%
Trip 9	White	T17-XSR1-01-093018	0.0	0.0	0%	0	T17-XSR1-01-093018	1810072-41	0.14	J	200%
Trip 9	Red	T30-XS20-01-092518	0.0	0.0	0%	0	T30-XS20-01-092518	1810032-16	0.17	J	200%
Trip 9	Red	T30-XS28-01-092518	0.0	0.0	0%	0	T30-XS28-01-092518	1810032-17	0.14	J	200%
Trip 9	Red	T30-XS8-01-092518	0.0	0.0	0%	0	T30-XS8-01-092518	1810032-18	0.10	J	200%
Trip 9	Red	T31-XSG7-01-092518	0.0	0.0	0%	0	T31-XSG7-01-092518	1810032-19	0.09	J	200%
Trip 9	Red	T31-XSG9-01-092518	0.0	0.0	0%	0	T31-XSG9-01-092518	1810032-20	0.09	J	200%
Trip 9	Red	T5-XSG3-01-092818	0.0	0.0	0%	0	T5-XSG3-01-092818	1810072-19	0.24		200%
Trip 9	Red	T5-XSG3-02-092818	0.0	0.0	0%	0	T5-XSG3-02-092818	1810072-20	0.24		200%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Molybdenum				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 9	Red	M12-XSG3-01-092818	936.2	0.0	245%	0	M12-XSG3-01-092818	1810122-9	0.1	J	200%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

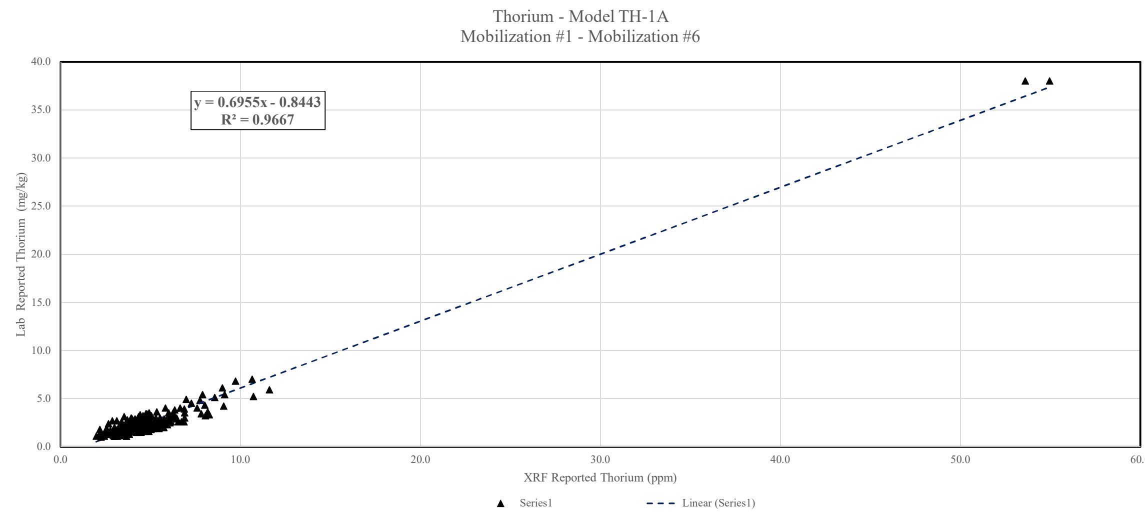
J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

U = Not detected

XRF = X-ray fluorescence



Data Included in Model TH-1A											
Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	M2-XS15-01-042418	3.0	3.0	20%	2	M2-XS15-01-042418	1805041-1	1.1		92%
Trip 1	Pink	M2-XS15-02-042418	3.1	3.3	23%	2	M2-XS15-02-042418	1805041-2	1.2		87%
Trip 1	Pink	M2-XS32-01-042418	3.3	3.3	19%	2	M2-XS32-01-042418	1805041-3	1.2		93%
Trip 1	Pink	M2-XS59-01-042418	3.2	3.2	20%	2	M2-XS59-01-042418	1805041-4	1.1		97%
Trip 1	Pink	M2-XS73-01-042418	3.0	3.0	6%	3	M2-XS73-01-042418	1805041-5	1.3		79%
Trip 1	Pink	M3-XS34-01-043018	4.4	4.2	14%	4	M3-XS34-01-043018	1805042-1	1.7		88%
Trip 1	Pink	M3-XS36-01-043018	4.5	4.4	21%	3	M3-XS36-01-043018	1805042-2	2.2		68%
Trip 1	Pink	M6-XS140-01-042818	4.1	4.3	13%	3	M6-XS140-01-042818	1805041-6	2.4		52%
Trip 1	Orange	M6-XS159-01-04262018	3.9	4.0	13%	3	M6-XS159-01-04262018	1805039-1	2.2		55%
Trip 1	Pink	M6-XS269-01-04262018	4.9	4.9	17%	4	M6-XS269-01-04262018	1805039-3	2.5		64%
Trip 1	Pink	M6-XS269-02-04262018	4.5	4.6	8%	4	M6-XS269-02-04262018	1805039-4	2.7		51%
Trip 1	Pink	M6-XS285-01-04272018	4.3	4.2	15%	3	M6-XS285-01-04272018	1805039-5	1.9		77%
Trip 1	Pink	T10-XS1-01-042518	6.1	5.7	6%	5	T10-XS1-01-042518	1805036-1	2.5		83%
Trip 1	Pink	T10-XS33-01-042518	5.0	5.0	7%	4	T10-XS33-01-042518	1805036-3	1.8		94%
Trip 1	Pink	T10-XS56-01-042518	6.5	6.6	9%	6	T10-XS56-01-042518	1805036-4	2.6		86%
Trip 1	Pink	T10-XS78-01-042518	5.4	5.3	14%	4	T10-XS78-01-042518	1805036-5	2.6	J	70%
Trip 1	Pink	T11-XS1-01-042518	6.8	6.6	9%	6	T11-XS1-01-042518	1805036-6	2.6		90%
Trip 1	Pink	T11-XS20-01-042518	5.8	5.9	9%	5	T11-XS20-01-042518	1805036-7	2.5		79%
Trip 1	Pink	T11-XS60-01-042518	3.6	3.6	11%	3	T11-XS60-01-042518	1805036-8	1.4		88%
Trip 1	Pink	T17-XS1-01-04262018	3.5	3.4	14%	3	T17-XS1-01-04262018	1805039-6	1.7		68%
Trip 1	Pink	T17-XS1-02-04262018	3.6	3.5	24%	3	T17-XS1-02-04262018	1805039-7	1.4		87%
Trip 1	Pink	T17-XS143-01-04262018	5.4	5.5	14%	4	T17-XS143-01-04262018	1805039-8	2.5		73%
Trip 1	Orange	T17-XS144-01-04262018	5.1	5.2	15%	4	T17-XS144-01-04262018	1805039-9	1.9		92%
Trip 1	Pink	T17-XS194-01-04272018	4.2	4.1	16%	4	T17-XS194-01-04272018	1805039-10	2.0		71%
Trip 1	Pink	T17-XS194-02-04272018	5.4	4.4	43%	3	T17-XS194-02-04272018	1805039-11	2.6		71%
Trip 1	Pink	T17-XS20-01-04262018	4.2	4.2	19%	3	T17-XS20-01-04262018	1805039-12	1.5		94%
Trip 1	Pink	T17-XS208-01-042818	5.3	5.4	7%	5	T17-XS208-01-042818	1805041-7	2.6		69%
Trip 1	Pink	T17-XS251-01-04272018	5.0	5.0	16%	4	T17-XS251-01-04272018	1805039-13	1.9		89%
Trip 1	Pink	T17-XS257-01-04272018	5.2	5.3	12%	4	T17-XS257-01-04272018	1805039-14	2.2		82%
Trip 1	Pink	T17-XS273-01-042818	4.7	4.6	12%	4	T17-XS273-01-042818	1805041-8	1.6		99%
Trip 1	Pink	T17-XS304-01-042818	5.3	5.1	16%	4	T17-XS304-01-042818	1805041-9	2.2		82%
Trip 1	Pink	T17-XS317-01-04272018	4.6	4.6	12%	4	T17-XS317-01-04272018	1805039-16	2.3		67%
Trip 1	Pink	T17-XS328-01-04272018	6.0	6.0	6%	5	T17-XS328-01-04272018	1805039-17	2.6		79%
Trip 1	Pink	T17-XS369-01-043018	6.0	6.1	5%	6	T17-XS369-01-043018	1805042-4	2.6		80%
Trip 1	Pink	T17-XS377-01-042818	5.3	5.3	12%	4	T17-XS377-01-042818	1805041-10	2.2		82%
Trip 1	Pink	T17-XS393-01-043018	4.8	4.6	16%	4	T17-XS393-01-043018	1805042-5	2.0	J	82%
Trip 1	Pink	T17-XS417-01-04272018	5.9	6.0	9%	5	T17-XS417-01-04272018	1805039-18	2.5	J	81%
Trip 1	Pink	T17-XS438-01-042818	3.3	3.3	14%	3	T17-XS438-01-042818	1805041-11	1.4		81%
Trip 1	Pink	T17-XS44-01-04262018	5.5	5.4	9%	5	T17-XS44-01-04262018	1805039-19	2.2		86%
Trip 1	Pink	T17-XS442-01-04272018	5.0	4.8	7%	5	T17-XS442-01-04272018	1805039-20	2.2		77%
Trip 1	Pink	T17-XS46-01-042618	5.3	5.3	4%	5	T17-XS46-01-042618	1805041-12	2.7		66%
Trip 1	Pink	T17-XS473-01-042818	5.9	5.9	14%	5	T17-XS473-01-042818	1805041-13	2.3		88%
Trip 1	Pink	T17-XS479-01-042818	5.7	5.5	16%	5	T17-XS479-01-042818	1805041-14	2.0		96%
Trip 1	Pink	T17-XS479-02-042818	5.5	5.4	9%	5	T17-XS479-02-042818	1805041-15	1.9		97%
Trip 1	Pink	T17-XS603-01-042818	5.5	5.4	9%	5	T17-XS603-01-042818	1805041-16	2.6		71%
Trip 1	Pink	T17-XS659-01-043018	4.5	4.5	12%	4	T17-XS659-01-043018	1805042-6	2.1		72%
Trip 1	Pink	T17-XS679-01-043018	4.6	4.6	14%	4	T17-XS679-01-043018	1805042-7	2.4		62%

Data Included in Model TH-1A											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	T17-XS704-01-043018	4.7	4.8	13%	4	T17-XS704-01-043018	1805042-8	2.0		81%
Trip 1	Pink	T7-XS11-01-042418	3.3	3.4	1%	3	T7-XS11-01-042418	1805036-9	1.2		94%
Trip 1	Pink	T7-XS5-01-042418	3.1	3.0	17%	3	T7-XS5-01-042418	1805036-10	1.1		95%
Trip 1	Pink	T7-XS58-01-042418	3.1	3.0	13%	3	T7-XS58-01-042418	1805036-11	1.2		88%
Trip 1	Pink	T7-XS7-01-042418	2.2	2.2	17%	2	T7-XS7-01-042418	1805036-12	1.0		77%
Trip 1	Pink	T7-XS9-01-042418	2.9	3.1	22%	2	T7-XS9-01-042418	1805036-13	1.2		83%
Trip 1	Pink	T8-XS15-01-042418	3.7	3.8	18%	3	T8-XS15-01-042418	1805036-14	1.5		84%
Trip 1	Pink	T8-XS23-01-042418	3.8	3.8	14%	3	T8-XS23-01-042418	1805036-15	1.6		82%
Trip 1	Pink	T8-XS6-01-042418	3.8	4.0	15%	3	T8-XS6-01-042418	1805036-16	1.3		98%
Trip 1	Pink	T9-XS217-01-042518	6.7	6.6	20%	5	T9-XS217-01-042518	1805036-17	2.6		88%
Trip 1	Pink	T9-XS61-01-042518	6.9	6.8	9%	6	T9-XS61-01-042518	1805036-18	3.0		79%
Trip 1	Orange	T9-XS61-02-042518	6.3	6.2	12%	5	T9-XS61-02-042518	1805041-17	2.9		74%
Trip 1	Pink	T9-XS86-01-042518	5.8	5.8	11%	5	T9-XS86-01-042518	1805036-19	2.4		83%
Trip 1	Pink	T9-XS93-01-042518	5.6	5.5	6%	5	T9-XS93-01-042518	1805036-20	2.3		84%
Trip 2	Orange	M1-XS31-01-051218	2.4	2.5	14%	2	M1-XS31-01-051218	1805328-1	1.1		75%
Trip 2	Pink	M1-XS32-01-051218	3.0	3.0	20%	2	M1-XS32-01-051218	1805328-2	1.1		92%
Trip 2	Pink	M4-XS136-01-050918	4.5	4.4	17%	3	M4-XS136-01-050918	1805322-1	1.7		90%
Trip 2	Pink	M4-XS18-01-050718	8.6	8.5	7%	8	M4-XS18-01-050718	1805322-2	5.1		51%
Trip 2	Orange	M4-XS219-01-051018	4.5	4.6	16%	3	M4-XS219-01-051018	1805322-3	2.6		53%
Trip 2	Pink	M4-XS4-01-050718	4.2	4.2	9%	4	M4-XS4-01-050718	1805322-5	2.0		71%
Trip 2	Pink	M4-XS45-01-050718	3.7	3.5	13%	3	M4-XS45-01-050718	1805322-6	1.8		68%
Trip 2	Pink	M4-XS63-01-050718	5.6	5.7	13%	4	M4-XS63-01-050718	1805322-7	2.5		77%
Trip 2	Pink	M4-XS63-02-050718	5.3	5.3	17%	4	M4-XS63-02-050718	1805322-8	3.0		55%
Trip 2	Pink	M4-XS78-01-051018	5.4	5.0	19%	5	M4-XS78-01-051018	1805322-9	2.4	J	78%
Trip 2	Orange	M5-XS115-01-051118	3.3	3.5	13%	3	M5-XS115-01-051118	1805322-10	1.7		65%
Trip 2	Pink	M5-XS385-01-051118	3.7	3.8	8%	3	M5-XS385-01-051118	1805322-11	1.5		85%
Trip 2	Pink	M5-XS69-01-051118	4.4	4.4	19%	3	M5-XS69-01-051118	1805322-12	1.8		83%
Trip 2	Orange	M6-XS41-01-051118	2.0	1.8	23%	2	M6-XS41-01-051118	1805322-13	1.1		57%
Trip 2	Pink	M6-XS44-01-051018	4.3	4.1	12%	4	M6-XS44-01-051018	1805322-14	2.6		50%
Trip 2	Pink	M6-XS81-01-051018	3.4	3.2	17%	3	M6-XS81-01-051018	1805322-15	1.2		96%
Trip 2	Pink	M7-XS181-01-051018	3.9	3.8	21%	3	M7-XS181-01-051018	1805322-16	1.9		68%
Trip 2	Orange	M7-XS181-02-051018	3.2	3.2	19%	2	M7-XS181-02-051018	1805322-17	1.8		55%
Trip 2	Orange	M7-XS39-01-051018	2.4	2.5	24%	1	M7-XS39-01-051018	1805322-18	1.4		54%
Trip 2	Orange	M7-XS74-01-051018	3.7	3.6	20%	3	M7-XS74-01-051018	1805322-19	2.4		42%
Trip 2	Orange	M7-XS77-01-051018	4.6	4.5	8%	4	M7-XS77-01-051018	1805322-20	3.2		35%
Trip 2	Pink	M8-XS100-01-050918	7.0	6.4	24%	5	M8-XS100-01-050918	1805328-3	4.9		35%
Trip 2	Pink	M8-XS102-01-050918	54.9	55.0	3%	52	M8-XS102-01-050918	1805328-4	38.0		36%
Trip 2	Pink	M8-XS102-02-050918	53.6	55.2	8%	45	M8-XS102-02-050918	1805328-5	38.0		34%
Trip 2	Pink	M8-XS110-01-050918	6.0	4.9	59%	3	M8-XS110-01-050918	1805328-6	3.1		63%
Trip 2	Orange	M8-XS19-01-051018	4.7	4.5	16%	4	M8-XS19-01-051018	1805328-7	2.5		62%
Trip 2	Orange	M8-XS32-01-051018	9.0	9.1	10%	8	M8-XS32-01-051018	1805328-8	6.1		38%
Trip 2	Pink	M8-XS94-01-050918	4.6	4.6	16%	4	M8-XS94-01-050918	1805328-9	2.3		67%
Trip 2	Pink	T13-XS12-01-050818	6.9	6.9	9%	6	T13-XS12-01-050818	1805322-21	3.5		65%
Trip 2	Pink	T13-XS24-01-050818	4.3	4.3	14%	3	T13-XS24-01-050818	1805322-22	2.0		72%
Trip 2	Pink	T14-XS12-01-050818	5.8	6.0	11%	5	T14-XS12-01-050818	1805322-23	2.7		73%
Trip 2	Pink	T14-XS27-01-050818	5.9	5.4	22%	5	T14-XS27-01-050818	1805322-24	2.6		77%
Trip 2	Pink	T15-XS2-01-050818	6.4	6.4	12%	6	T15-XS2-01-050818	1805322-25	3.0		73%
Trip 2	Pink	T15-XS45-01-050818	4.9	5.0	9%	4	T15-XS45-01-050818	1805322-26	2.6		61%
Trip 2	Pink	T17-XS122-01-050718	4.9	4.9	10%	4	T17-XS122-01-050718	1805322-27	2.5		65%
Trip 2	Pink	T17-XS176-01-050718	5.0	4.8	18%	4	T17-XS176-01-050718	1805322-28	2.6		63%
Trip 2	Pink	T17-XS178-01-050718	4.9	5.1	11%	4	T17-XS178-01-050718	1805322-29	2.1		80%
Trip 2	Pink	T17-XS619-01-050718	5.2	5.3	8%	5	T17-XS619-01-050718	1805322-30	2.4		74%
Trip 2	Pink	T17-XS619-02-050718	5.6	5.4	9%	5	T17-XS619-02-050718	1805322-31	2.5		76%
Trip 2	Pink	T17-XS645-01-050718	4.9	5.0	7%	4	T17-XS645-01-050718	1805322-32	2.4		69%
Trip 2	Pink	T17-XS669-01-050718	5.0	5.2	15%	4	T17-XS669-01-050718	1805322-33	2.2		77%
Trip 2	Pink	T1-XS104-01-051318	7.3	7.3	18%	5	T1-XS104-01-051318	1805328-10	4.5		47%
Trip 2	Pink	T1-XS20-01-051318	4.9	4.7	13%	4	T1-XS20-01-051318	1805328-11	2.3		73%
Trip 2	Pink	T1-XS54-01-051318	4.4	4.2	15%	4	T1-XS54-01-051318	1805328-12	2.1		70%
Trip 2	Pink	T1-XS54-02-051318	5.1	4.9	16%	4	T1-XS54-02-051318	1805328-13	2.1		83%
Trip 2	Pink	T1-XS69-01-051318	4.3	4.1	23%	3	T1-XS69-01-051318	1805328-14	3.1		33%
Trip 2	Orange	T3-XS10-01-051218	3.3	3.2	18%	2	T3-XS10-01-051218	1805328-15	1.5		74%
Trip 2	Orange	T3-XS5-01-051218	2.7	2.7	18%	2	T3-XS5-01-051218	1805328-16	1.4		64%
Trip 2	Pink	T4-XS23-01-051218	3.5	3.3	33%	2	T4-XS23-01-051218	1805328-17	1.3		93%
Trip 2	Orange	T4-XS32-01-051218	2.5	2.5	15%	2	T4-XS32-01-051218	1805328-18	1.3		64%
Trip 2	Pink	T4-XS43-01-051218	3.2	3.2	7%	3	T4-XS43-01-051218	1805328-19	1.6		66%
Trip 2	Pink	T5-XS18-01-051418	3.7	3.6	14%	3	T5-XS18-01-051418	1805328-20	1.4		90%
Trip 2	Pink	T6-XS2-01-051218	3.6	3.7	6%	3	T6-XS2-01-051218	1805328-21	1.1		107%
Trip 2	Orange	T6-XS25-01-051218	2.3	2.3	19%	2	T6-XS25-01-051218	1805328-22	1.2		63%
Trip 3	Pink	M14-XS36-01-052418	3.3	3.2	11%	3	M14-XS36-01-052418	1805632-1	1.6		70%
Trip 3	Pink	M14-XS40-01-052418	4.1	4.0	17%	3	M14-XS40-01-052418	1805632-2	1.6		88%
Trip 3	Pink	M14-XS64-01-052418	3.5	3.5	17%	3	M14-XS64-01-052418	1805632-3	1.4		86%

Data Included in Model TH-1A

Trip	XRF Color	XRF ID	XRF - Thorium Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Pink	M14-XS67-01-052418	3.0	3.0	26%	2	M14-XS67-01-052418	1805632-4	1.7		54%
Trip 3	Pink	M15-XS3-01-052118	4.8	4.8	14%	4	M15-XS3-01-052118	1805589-2	2.6		59%
Trip 3	Pink	M15-XS22-01-052118	3.7	3.9	30%	2	M15-XS22-01-052118	1805589-1	1.9		63%
Trip 3	Pink	M15-XS46-01-052118	3.8	3.7	14%	3	M15-XS46-01-052118	1805589-3	1.9		66%
Trip 3	Pink	M15-XS46-02-052118	3.8	3.9	27%	2	M15-XS46-02-052118	1805589-4	1.8		72%
Trip 3	Blue	M15-XS73-01-052118	4.0	4.1	14%	3	M15-XS73-01-052118	1805589-5	2.9		31%
Trip 3	Pink	M15-XS82-01-052118	9.1	9.1	7%	8	M15-XS82-01-052118	1805589-6	5.4		51%
Trip 3	Pink	M15-XS93-01-052118	3.4	3.3	32%	2	M15-XS93-01-052118	1805589-7	2.3		39%
Trip 3	Pink	M16-XS4-01-052118	5.2	5.0	28%	3	M16-XS4-01-052118	1805589-12	2.4		73%
Trip 3	Pink	M16-XS30-01-052118	4.4	4.3	23%	3	M16-XS30-01-052118	1805589-10	2.5		55%
Trip 3	Pink	M16-XS31-01-052118	3.2	3.2	22%	2	M16-XS31-01-052118	1805589-11	1.6		68%
Trip 3	Blue	M16-XS45-01-052118	3.9	3.9	10%	4	M16-XS45-01-052118	1805589-13	3		26%
Trip 3	Pink	M16-XS128-01-052118	6.6	6.8	13%	5	M16-XS128-01-052118	1805589-8	4		50%
Trip 3	Pink	M16-XS154-01-052618	5.2	5.1	16%	4	M16-XS154-01-052618	1806235-2	2.5		70%
Trip 3	Blue	M16-XS166-01-052118	4.1	4.1	6%	4	M16-XS166-01-052118	1805589-9	2.3		56%
Trip 3	Pink	M16-XS177-01-052618	3.9	4.1	15%	3	M16-XS177-01-052618	1806235-3	1.8		75%
Trip 3	Pink	M16-XS191-01-052618	4.7	4.6	11%	4	M16-XS191-01-052618	1806235-4	1.9		84%
Trip 3	Pink	M16-XS191-02-052618	4.2	4.0	32%	3	M16-XS191-02-052618	1806235-5	1.9		76%
Trip 3	Pink	M17-XS55-01-052618	3.7	3.6	14%	3	M17-XS55-01-052618	1806235-6	1.7		74%
Trip 3	Pink	M17-XS83-01-052618	3.4	3.6	22%	2	M17-XS83-01-052618	1806235-7	1.6		72%
Trip 3	Pink	M17-XS83-02-052618	3.7	4.1	29%	2	M17-XS83-02-052618	1806235-8	1.6		79%
Trip 3	Pink	M18-XS155-01-052518	3.0	3.0	5%	3	M18-XS155-01-052518	1805632-5	1.2		85%
Trip 3	Pink	M18-XS161-01-052518	4.9	5.0	16%	4	M18-XS161-01-052518	1805632-6	3.1		45%
Trip 3	Pink	M19-XS22-02-052318	3.7	3.8	12%	3	M19-XS22-02-052318	1805632-8	2		60%
Trip 3	Pink	M19-XS22-01-052318	3.0	2.9	20%	2	M19-XS22-01-052318	1805632-7	2		40%
Trip 3	Pink	M19-XS43-01-052318	4.7	4.9	19%	3	M19-XS43-01-052318	1805632-9	3.2		38%
Trip 3	Blue	T20-XS14-01-052218	4.1	4.1	8%	4	T20-XS14-01-052218	1805632-10	2.9		35%
Trip 3	Blue	T21-XS6-01-052118	3.9	3.8	16%	3	T21-XS6-01-052118	1805589-17	1.8		73%
Trip 3	Blue	T21-XS35-01-052118	4.0	4.2	14%	3	T21-XS35-01-052118	1805589-14	2.6		42%
Trip 3	Blue	T21-XS55-01-052118	4.0	4.1	8%	4	T21-XS55-01-052118	1805589-15	2.6		43%
Trip 3	Pink	T21-XS55-02-052118	4.9	4.9	20%	3	T21-XS55-02-052118	1805589-16	3	J	47%
Trip 3	Blue	T22-XS17-01-052118	4.2	4.1	12%	4	T22-XS17-01-052118	1805589-18	2.7		43%
Trip 3	Pink	T22-XS64-01-052218	5.2	5.3	11%	4	T22-XS64-01-052218	1805632-11	2.5		70%
Trip 3	Pink	T23-XS23-01-052118	5.5	5.6	5%	5	T23-XS23-01-052118	1805589-19	3		59%
Trip 3	Pink	T23-XS40-01-052118	5.4	5.2	16%	4	T23-XS40-01-052118	1805589-20	2.4		76%
Trip 3	Pink	T24-XS48-01-052418	11.6	11.1	13%	10	T24-XS48-01-052418	1805632-12	5.9		65%
Trip 4	Pink	M13-XS72-01-060618	7.9	8.3	12%	7	M13-XS72-01-060618	1806235-1	5.4		37%
Trip 4	Pink	M20-XS5-01-060518	7.8	7.5	13%	7	M20-XS5-01-060518	1806235-20	3.4		79%
Trip 4	Pink	M20-XS11-01-060618	4.0	4.0	19%	3	M20-XS11-01-060618	1806235-9	2.0		67%
Trip 4	Pink	M20-XS18-01-060618	3.9	4.1	16%	3	M20-XS18-01-060618	1806235-12	2.1		61%
Trip 4	Pink	M20-XS86-01-060618	3.1	3.0	19%	2	M20-XS86-01-060618	1806235-21	1.8		52%
Trip 4	Pink	M20-XS130-01-060418	4.9	4.8	9%	4	M20-XS130-01-060418	1806235-10	1.6		101%
Trip 4	Pink	M20-XS166-01-060518	4.1	3.8	27%	3	M20-XS166-01-060518	1806235-11	2.2		61%
Trip 4	Pink	M20-XS185-01-060418	3.5	3.7	11%	3	M20-XS185-01-060418	1806235-13	1.6		75%
Trip 4	Pink	M20-XS231-01-060418	4.9	4.6	25%	3	M20-XS231-01-060418	1806235-14	1.9		87%
Trip 4	Pink	M20-XS278-01-060418	9.0	9.0	5%	8	M20-XS278-01-060418	1806235-15	4.2		73%
Trip 4	Pink	M20-XS306-01-060518	7.6	7.4	16%	6	M20-XS306-01-060518	1806235-16	4.0		62%
Trip 4	Pink	M20-XS312-01-060518	3.4	3.4	16%	3	M20-XS312-01-060518	1806235-17	1.8		62%
Trip 4	Pink	M20-XS365-01-060618	3.6	3.7	15%	3	M20-XS365-01-060618	1806235-18	1.7		72%
Trip 4	Pink	M20-XS365-02-060618	3.5	3.4	5%	3	M20-XS365-02-060618	1806235-19	1.6		74%
Trip 4	Pink	M21-XS14-01-060818	8.0	8.1	13%	7	M21-XS14-01-060818	1806234-3	3.2		86%
Trip 4	Pink	M21-XS27-01-060818	3.5	3.7	26%	2	M21-XS27-01-060818	1806234-7	1.3		91%
Trip 4	Pink	M21-XS27-02-060818	2.7	2.8	25%	2	M21-XS27-02-060818	1806234-8	1.4		64%
Trip 4	Pink	M21-XS40-01-060818	6.0	6.1	17%	4	M21-XS40-01-060818	1806234-15	3.5		52%
Trip 4	Pink	M21-XS46-01-060818	4.4	4.4	16%	3	M21-XS46-01-060818	1806234-18	2.0		75%
Trip 4	Pink	M21-XS126-01-060818	5.2	4.9	25%	3	M21-XS126-01-060818	1806234-2	2.4		73%
Trip 4	Pink	M21-XS175-01-060818	6.1	5.6	16%	5	M21-XS175-01-060818	1806234-4	2.6		81%
Trip 4	Pink	M21-XS225-01-060518	5.5	5.4	18%	4	M21-XS225-01-060518	1806235-22	2.6		72%
Trip 4	Pink	M21-XS259-01-060918	5.3	5.1	8%	5	M21-XS259-01-060918	1806234-5	2.5		71%
Trip 4	Pink	M21-XS260-01-060918	6.3	6.3	11%	5	M21-XS260-01-060918	1806234-6	3.0		71%
Trip 4	Pink	M21-XS282-01-060918	3.6	3.7	9%	3	M21-XS282-01-060918	1806234-9	1.1		107%
Trip 4	Pink	M21-XS290-01-060918	10.7	11.1	11%	9	M21-XS290-01-060918	1806234-10	5.2		69%
Trip 4	Pink	M21-XS292-01-060518	2.8	2.9	18%	2	M21-XS292-01-060518	1806235-23	1.7		48%
Trip 4	Pink	M21-XS302-02-060918	3.3	3.1	21%	3	M21-XS302-02-060918	1806234-12	1.9		54%
Trip 4	Pink	M21-XS302-01-060918	4.1	4.3	24%	3	M21-XS302-01-060918	1806234-11	2.0		68%
Trip 4	Pink	M21-XS334-01-060918	8.2	8.3	12%	6	M21-XS334-01-060918	1806234-13	3.6		78%
Trip 4	Pink	M21-XS377-01-060918	4.5	4.4	15%	4	M21-XS377-01-060918	1806234-14	1.5		99%
Trip 4	Pink	M21-XS403-01-060818	3.0	3.2	26%	2	M21-XS403-01-060818	1806234-16	1.4		73%
Trip 4	Pink	M21-XS419-01-060818	8.3	8.4	6%	7	M21-XS419-01-060818	1806234-17	3.3		86%
Trip 4	Pink	M21-XS477-01-060818	5.7	5.8	9%	5	M21-XS477-01-060818	1806234-19	2.9		66%
Trip 4	Pink	M21-XS541-01-060818	3.5	3.5	23%	3	M21-XS541-01-060818	1806234-20	1.6		76%

Data Included in Model TH-1A											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M21-XS596-01-060518	3.9	4.1	20%	2	M21-XS596-01-060518	1806235-24	1.9		69%
Trip 4	Pink	M21-XS615-01-060518	3.2	3.2	14%	3	M21-XS615-01-060518	1806235-25	1.6		68%
Trip 4	Pink	M21-XS619-01-060618	5.0	4.8	14%	4	M21-XS619-01-060618	1806235-26	3.2		44%
Trip 4	Pink	M22-XS14-01-060418	6.0	5.7	16%	5	M22-XS14-01-060418	1806235-27	2.6		79%
Trip 4	Pink	M22-XS30-01-060418	3.7	3.7	25%	3	M22-XS30-01-060418	1806235-28	1.7		73%
Trip 4	Pink	M22-XS40-01-060518	8.0	8.9	27%	4	M22-XS40-01-060518	1806235-29	4.3		60%
Trip 4	Pink	M22-XS60-01-060418	3.4	3.3	31%	2	M22-XS60-01-060418	1806235-30	1.7		68%
Trip 4	Pink	M22-XS87-01-060418	6.3	6.4	9%	6	M22-XS87-01-060418	1806235-31	3.2		65%
Trip 4	Pink	M23-XS20-01-061018	5.3	5.2	17%	4	M23-XS20-01-061018	1806233-3	2.0		90%
Trip 4	Pink	M23-XS48-01-061018	5.6	5.7	12%	4	M23-XS48-01-061018	1806233-4	2.3		84%
Trip 4	Pink	M23-XS54-01-061118	3.5	3.6	21%	2	M23-XS54-01-061118	1806312-1	2.2		45%
Trip 4	Pink	M23-XS64-01-061018	3.4	3.3	16%	3	M23-XS64-01-061018	1806233-5	1.5		77%
Trip 4	Pink	M23-XS70-01-061018	4.6	4.2	19%	4	M23-XS70-01-061018	1806233-6	2.3	J	66%
Trip 4	Pink	M23-XS79-01-061018	4.3	4.3	17%	3	M23-XS79-01-061018	1806233-7	2.3		60%
Trip 4	Pink	M23-XS102-01-061018	6.9	6.7	12%	6	M23-XS102-01-061018	1806233-1	3.9		55%
Trip 4	Pink	M23-XS123-01-061018	3.5	3.6	15%	3	M23-XS123-01-061018	1806233-2	1.7		69%
Trip 4	Pink	M24-XS100-01-061118	4.3	4.0	16%	4	M24-XS100-01-061118	1806312-3	1.5		97%
Trip 4	Pink	M24-XS128-01-061118	6.2	6.1	9%	6	M24-XS128-01-061118	1806312-4	3.5		56%
Trip 4	Pink	T18-XS14-01-061118	4.6	4.7	16%	4	T18-XS14-01-061118	1806312-5	2.3		67%
Trip 4	Pink	T25-XS2-01-060618	4.7	4.8	15%	4	T25-XS2-01-060618	1806235-32	2.8		51%
Trip 4	Pink	T26-XS1-01-061018	4.4	4.6	18%	3	T26-XS1-01-061018	1806233-8	2.9		42%
Trip 4	Pink	T26-XS8-01-061018	3.7	3.6	21%	3	T26-XS8-01-061018	1806233-9	2.1		55%
Trip 4	Pink	T27-XS6-01-061018	5.4	5.2	20%	4	T27-XS6-01-061018	1806233-11	2.3		81%
Trip 4	Pink	T27-XS19-01-061018	3.9	3.7	14%	4	T27-XS19-01-061018	1806233-10	2.4		49%
Trip 5	Pink	M26-XS13-01-061818	2.2	2.1	28%	1	M26-XS13-01-061818	1806558-1	1.3		49%
Trip 5	Pink	M26-XS25-01-061818	2.9	3.0	34%	2	M26-XS25-01-061818	1806558-2	2.7		6%
Trip 5	Pink	M27-XS21-01-061918	4.9	5.1	16%	4	M27-XS21-01-061918	1806558-10	3.3		39%
Trip 5	Pink	M27-XS38-01-061918	3.7	3.5	29%	3	M27-XS38-01-061918	1806558-15	2.2		52%
Trip 5	Pink	M27-XS108-01-061918	4.4	4.6	13%	4	M27-XS108-01-061918	1806558-3	3.0		38%
Trip 5	Pink	M27-XS109-01-061918	3.7	3.7	21%	3	M27-XS109-01-061918	1806558-4	2.8	J	27%
Trip 5	Pink	M27-XS123-01-061818	2.8	2.8	36%	1	M27-XS123-01-061818	1806558-5	1.5		60%
Trip 5	Pink	M27-XS188-01-061918	4.7	4.9	27%	3	M27-XS188-01-061918	1806558-6	3.4		33%
Trip 5	Pink	M27-XS197-01-061918	3.1	3.3	20%	2	M27-XS197-01-061918	1806558-7	2.7		14%
Trip 5	Pink	M27-XS210-02-061818	3.8	3.8	17%	3	M27-XS210-02-061818	1806558-9	2.2		54%
Trip 5	Pink	M27-XS210-01-061818	2.6	2.5	34%	1	M27-XS210-01-061818	1806558-8	2.4		10%
Trip 5	Pink	M27-XS275-01-061918	4.3	4.3	13%	4	M27-XS275-01-061918	1806558-12	2.9		38%
Trip 5	Pink	M27-XS283-01-061818	4.8	4.8	14%	4	M27-XS283-01-061818	1806558-13	3.4		34%
Trip 5	Pink	M28-XS8-01-062018	2.2	2.1	37%	1	M28-XS8-01-062018	1806558-21	1.8	J	19%
Trip 5	Pink	M28-XS43-01-062018	3.3	3.3	22%	2	M28-XS43-01-062018	1806558-20	2.3		36%
Trip 5	Pink	M28-XS105-01-062018	4.0	4.2	11%	3	M28-XS105-01-062018	1806558-16	2.6		41%
Trip 5	Pink	M28-XS148-01-062018	4.6	4.4	33%	3	M28-XS148-01-062018	1806558-17	2.8		50%
Trip 5	Pink	M28-XS155-01-062018	3.7	3.9	21%	3	M28-XS155-01-062018	1806558-18	2.0		59%
Trip 5	Pink	M28-XS170-01-062018	9.7	9.9	12%	8	M28-XS170-01-062018	1806558-19	6.8		35%
Trip 5	Pink	M30-XS138-01-062218	5.0	5.1	13%	4	M30-XS138-01-062218	1806693-1	2.4		71%
Trip 5	Pink	M30-XS222-01-062218	6.1	5.9	10%	5	M30-XS222-01-062218	1806693-2	3.2		62%
Trip 5	Pink	T32-XS5-01-062018	2.5	2.5	20%	2	T32-XS5-01-062018	1806558-22	1.7		38%
Trip 6	Orange	M10-XS10A-01-071118	4.0	3.6	20%	3	M10-XS10A-01-071118	1807369-1	2.7		38%
Trip 6	Orange	M10-XS31-01-071118	3.8	4.1	24%	2	M10-XS31-01-071118	1807369-2	2.3		49%
Trip 6	Orange	M10-XS31-02-071118	4.0	3.9	14%	3	M10-XS31-02-071118	1807369-3	2.3		54%
Trip 6	Orange	M11-XS11-01-071118	3.6	3.5	35%	2	M11-XS11-01-071118	1807369-4	2.1		53%
Trip 6	Red	M11-XS7-01-071118	3.7	3.8	21%	3	M11-XS7-01-071118	1807369-5	2.1		54%
Trip 6	Red	M25-XS16-01-071718	2.9	3.1	16%	2	M25-XS16-01-071718	1807452-1	1.9		43%
Trip 6	Red	M25-XS23-01-071718	3.9	4.0	14%	3	M25-XS23-01-071718	1807452-2	2.0		63%
Trip 6	Red	M25-XS47-01-071718	3.2	3.3	25%	2	M25-XS47-01-071718	1807452-3	1.9		51%
Trip 6	Red	M25-XS88-01-071718	3.0	3.1	23%	2	M25-XS88-01-071718	1807452-4	1.7		56%
Trip 6	Orange	M30-XS170-01-071618	3.4	3.6	24%	2	M30-XS170-01-071618	1807369-10	2.6		26%
Trip 6	Red	M30-XS95-01-071618	3.5	3.4	11%	3	M30-XS95-01-071618	1807369-11	3.1		12%
Trip 6	Red	M31-XS9-01-071018	2.5	2.2	38%	2	M31-XS9-01-071018	1807369-12	1.9		29%
Trip 6	Orange	M32-XS58-01-071018	3.8	3.9	8%	3	M32-XS58-01-071018	1807369-13	2.1		58%
Trip 6	Red	M32-XS89-01-071018	5.3	5.7	21%	4	M32-XS89-01-071018	1807369-14	3.6		39%
Trip 6	Orange	M33-XS22-01-071218	4.3	4.3	16%	3	M33-XS22-01-071218	1807369-15	2.6		50%
Trip 6	Orange	M33-XS85-01-071218	4.4	4.2	18%	4	M33-XS85-01-071218	1807369-16	3.3		29%
Trip 6	Red	M33-XS93-01-071218	4.9	4.9	15%	4	M33-XS93-01-071218	1807369-17	3.5		33%
Trip 6	Red	T33-XS43-01-071718	7.7	7.8	14%	6	T33-XS43-01-071718	1807452-5	4.8		47%
Trip 1	Pink	M6-XS251-01-04272018	5.8	5.9	9%	5	M6-XS251-01-04272018	1805039-2	4.0		37%
Trip 1	Pink	T17-XS287-01-04272018	6.3	6.2	13%	5	T17-XS287-01-04272018	1805039-15	3.8		50%
Trip 4	Pink	M21-XS122-01-060818	10.6	10.5	9%	10	M21-XS122-01-060818	1806234-1	7.0		41%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental mg/kg = milligrams per kilogram XRF = X-ray fluorescence
J = Estimated value ppm = parts per million

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 4	Pink	T18-XS27-01-061118	1.5	1.7	50%	0	T18-XS27-01-061118	1806312-6	0.7		77%
Trip 5	Pink	M27-XS29-01-061818	2.7	3.4	57%	0	M27-XS29-01-061818	1806558-14	2.5		8%
Trip 5	Pink	M27-XS239-01-061818	0.8	0.7	114%	0	M27-XS239-01-061818	1806558-11	1.5		59%
Trip 6	Red	M12-XS27-01-071518	0.0	0.0	0%	0	M12-XS27-01-071518	1807369-6	0.8		200%
Trip 6	Orange	M30-XS127-01-071618	1.9	1.9	60%	0	M30-XS127-01-071618	1807369-9	1.5		21%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 2	Pink	M4-XS238-01-051018	11.1	11.2	10%	9	M4-XS238-01-051018	1805322-4	8.8		23%
Trip 6	Orange	M24-XS115-01-071418	9.4	9.0	10%	9	M24-XS115-01-071418	1807369-7	7.7		20%
Trip 1	Pink	T10-XS20-01-042518	7.0	5.1	69%	5	T10-XS20-01-042518	1805036-2	1.9		114%

Notes:

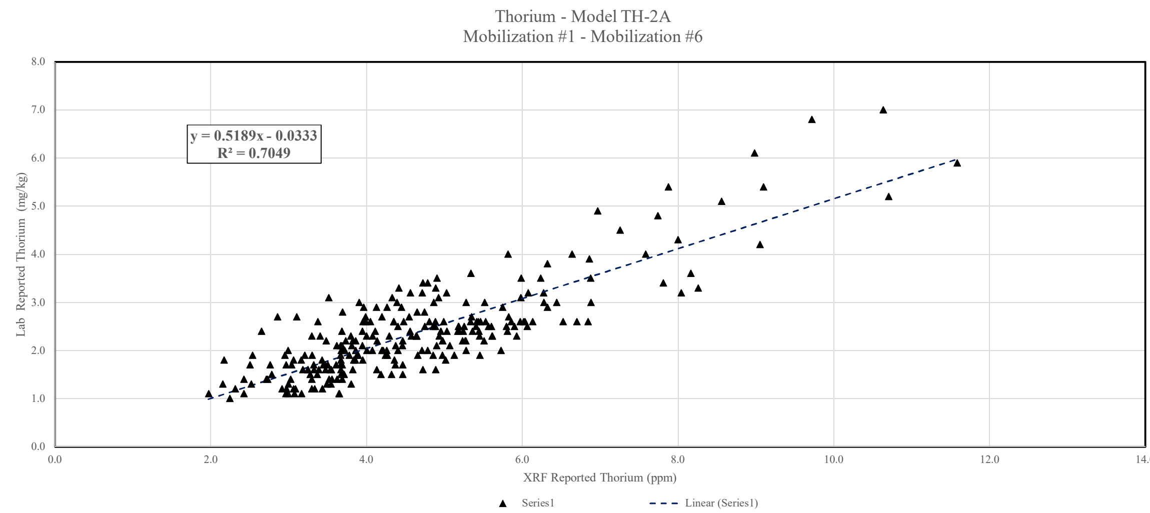
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model TH-2A											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	3.0	3.0	20%	2	M2-XS15-01-042418	1805041-1	1.1		92%
Trip 1	Pink	M2-XS15-02-042418	3.1	3.3	23%	2	M2-XS15-02-042418	1805041-2	1.2		87%
Trip 1	Pink	M2-XS32-01-042418	3.3	3.3	19%	2	M2-XS32-01-042418	1805041-3	1.2		93%
Trip 1	Pink	M2-XS59-01-042418	3.2	3.2	20%	2	M2-XS59-01-042418	1805041-4	1.1		97%
Trip 1	Pink	M2-XS73-01-042418	3.0	3.0	6%	3	M2-XS73-01-042418	1805041-5	1.3		79%
Trip 1	Pink	M3-XS34-01-043018	4.4	4.2	14%	4	M3-XS34-01-043018	1805042-1	1.7		88%
Trip 1	Pink	M3-XS36-01-043018	4.5	4.4	21%	3	M3-XS36-01-043018	1805042-2	2.2		68%
Trip 1	Pink	M6-XS140-01-042818	4.1	4.3	13%	3	M6-XS140-01-042818	1805041-6	2.4		52%
Trip 1	Orange	M6-XS159-01-04262018	3.9	4.0	13%	3	M6-XS159-01-04262018	1805039-1	2.2		55%
Trip 1	Pink	M6-XS269-01-04262018	4.9	4.9	17%	4	M6-XS269-01-04262018	1805039-3	2.5		64%
Trip 1	Pink	M6-XS269-02-04262018	4.5	4.6	8%	4	M6-XS269-02-04262018	1805039-4	2.7		51%
Trip 1	Pink	M6-XS285-01-04272018	4.3	4.2	15%	3	M6-XS285-01-04272018	1805039-5	1.9		77%
Trip 1	Pink	T10-XS1-01-042518	6.1	5.7	6%	5	T10-XS1-01-042518	1805036-1	2.5		83%
Trip 1	Pink	T10-XS33-01-042518	5.0	5.0	7%	4	T10-XS33-01-042518	1805036-3	1.8		94%
Trip 1	Pink	T10-XS56-01-042518	6.5	6.6	9%	6	T10-XS56-01-042518	1805036-4	2.6		86%
Trip 1	Pink	T10-XS78-01-042518	5.4	5.3	14%	4	T10-XS78-01-042518	1805036-5	2.6	J	70%
Trip 1	Pink	T11-XS1-01-042518	6.8	6.6	9%	6	T11-XS1-01-042518	1805036-6	2.6		90%
Trip 1	Pink	T11-XS20-01-042518	5.8	5.9	9%	5	T11-XS20-01-042518	1805036-7	2.5		79%
Trip 1	Pink	T11-XS60-01-042518	3.6	3.6	11%	3	T11-XS60-01-042518	1805036-8	1.4		88%
Trip 1	Pink	T17-XS1-01-04262018	3.5	3.4	14%	3	T17-XS1-01-04262018	1805039-6	1.7		68%
Trip 1	Pink	T17-XS1-02-04262018	3.6	3.5	24%	3	T17-XS1-02-04262018	1805039-7	1.4		87%
Trip 1	Pink	T17-XS143-01-04262018	5.4	5.5	14%	4	T17-XS143-01-04262018	1805039-8	2.5		73%
Trip 1	Orange	T17-XS144-01-04262018	5.1	5.2	15%	4	T17-XS144-01-04262018	1805039-9	1.9		92%
Trip 1	Pink	T17-XS194-01-04272018	4.2	4.1	16%	4	T17-XS194-01-04272018	1805039-10	2.0		71%
Trip 1	Pink	T17-XS194-02-04272018	5.4	4.4	43%	3	T17-XS194-02-04272018	1805039-11	2.6		71%
Trip 1	Pink	T17-XS20-01-04262018	4.2	4.2	19%	3	T17-XS20-01-04262018	1805039-12	1.5		94%
Trip 1	Pink	T17-XS208-01-042818	5.3	5.4	7%	5	T17-XS208-01-042818	1805041-7	2.6		69%
Trip 1	Pink	T17-XS251-01-04272018	5.0	5.0	16%	4	T17-XS251-01-04272018	1805039-13	1.9		89%
Trip 1	Pink	T17-XS257-01-04272018	5.2	5.3	12%	4	T17-XS257-01-04272018	1805039-14	2.2		82%
Trip 1	Pink	T17-XS273-01-042818	4.7	4.6	12%	4	T17-XS273-01-042818	1805041-8	1.6		99%
Trip 1	Pink	T17-XS304-01-042818	5.3	5.1	16%	4	T17-XS304-01-042818	1805041-9	2.2		82%
Trip 1	Pink	T17-XS317-01-04272018	4.6	4.6	12%	4	T17-XS317-01-04272018	1805039-16	2.3		67%
Trip 1	Pink	T17-XS328-01-04272018	6.0	6.0	6%	5	T17-XS328-01-04272018	1805039-17	2.6		79%
Trip 1	Pink	T17-XS369-01-043018	6.0	6.1	5%	6	T17-XS369-01-043018	1805042-4	2.6		80%
Trip 1	Pink	T17-XS377-01-042818	5.3	5.3	12%	4	T17-XS377-01-042818	1805041-10	2.2		82%
Trip 1	Pink	T17-XS393-01-043018	4.8	4.6	16%	4	T17-XS393-01-043018	1805042-5	2.0	J	82%
Trip 1	Pink	T17-XS417-01-04272018	5.9	6.0	9%	5	T17-XS417-01-04272018	1805039-18	2.5	J	81%
Trip 1	Pink	T17-XS438-01-042818	3.3	3.3	14%	3	T17-XS438-01-042818	1805041-11	1.4		81%
Trip 1	Pink	T17-XS44-01-04262018	5.5	5.4	9%	5	T17-XS44-01-04262018	1805039-19	2.2		86%
Trip 1	Pink	T17-XS442-01-04272018	5.0	4.8	7%	5	T17-XS442-01-04272018	1805039-20	2.2		77%
Trip 1	Pink	T17-XS46-01-042618	5.3	5.3	4%	5	T17-XS46-01-042618	1805041-12	2.7		66%
Trip 1	Pink	T17-XS473-01-042818	5.9	5.9	14%	5	T17-XS473-01-042818	1805041-13	2.3		88%
Trip 1	Pink	T17-XS479-01-042818	5.7	5.5	16%	5	T17-XS479-01-042818	1805041-14	2.0		96%
Trip 1	Pink	T17-XS479-02-042818	5.5	5.4	9%	5	T17-XS479-02-042818	1805041-15	1.9		97%
Trip 1	Pink	T17-XS603-01-042818	5.5	5.4	9%	5	T17-XS603-01-042818	1805041-16	2.6		71%
Trip 1	Pink	T17-XS659-01-043018	4.5	4.5	12%	4	T17-XS659-01-043018	1805042-6	2.1		72%
Trip 1	Pink	T17-XS679-01-043018	4.6	4.6	14%	4	T17-XS679-01-043018	1805042-7	2.4		62%

Data Included in Model TH-2A											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	T17-XS704-01-043018	4.7	4.8	13%	4	T17-XS704-01-043018	1805042-8	2.0		81%
Trip 1	Pink	T7-XS11-01-042418	3.3	3.4	1%	3	T7-XS11-01-042418	1805036-9	1.2		94%
Trip 1	Pink	T7-XS5-01-042418	3.1	3.0	17%	3	T7-XS5-01-042418	1805036-10	1.1		95%
Trip 1	Pink	T7-XS58-01-042418	3.1	3.0	13%	3	T7-XS58-01-042418	1805036-11	1.2		88%
Trip 1	Pink	T7-XS7-01-042418	2.2	2.2	17%	2	T7-XS7-01-042418	1805036-12	1.0		77%
Trip 1	Pink	T7-XS9-01-042418	2.9	3.1	22%	2	T7-XS9-01-042418	1805036-13	1.2		83%
Trip 1	Pink	T8-XS15-01-042418	3.7	3.8	18%	3	T8-XS15-01-042418	1805036-14	1.5		84%
Trip 1	Pink	T8-XS23-01-042418	3.8	3.8	14%	3	T8-XS23-01-042418	1805036-15	1.6		82%
Trip 1	Pink	T8-XS6-01-042418	3.8	4.0	15%	3	T8-XS6-01-042418	1805036-16	1.3		98%
Trip 1	Pink	T9-XS217-01-042518	6.7	6.6	20%	5	T9-XS217-01-042518	1805036-17	2.6		88%
Trip 1	Pink	T9-XS61-01-042518	6.9	6.8	9%	6	T9-XS61-01-042518	1805036-18	3.0		79%
Trip 1	Orange	T9-XS61-02-042518	6.3	6.2	12%	5	T9-XS61-02-042518	1805041-17	2.9		74%
Trip 1	Pink	T9-XS86-01-042518	5.8	5.8	11%	5	T9-XS86-01-042518	1805036-19	2.4		83%
Trip 1	Pink	T9-XS93-01-042518	5.6	5.5	6%	5	T9-XS93-01-042518	1805036-20	2.3		84%
Trip 2	Orange	M1-XS31-01-051218	2.4	2.5	14%	2	M1-XS31-01-051218	1805328-1	1.1		75%
Trip 2	Pink	M1-XS32-01-051218	3.0	3.0	20%	2	M1-XS32-01-051218	1805328-2	1.1		92%
Trip 2	Pink	M4-XS136-01-050918	4.5	4.4	17%	3	M4-XS136-01-050918	1805322-1	1.7		90%
Trip 2	Pink	M4-XS18-01-050718	8.6	8.5	7%	8	M4-XS18-01-050718	1805322-2	5.1		51%
Trip 2	Orange	M4-XS219-01-051018	4.5	4.6	16%	3	M4-XS219-01-051018	1805322-3	2.6		53%
Trip 2	Pink	M4-XS4-01-050718	4.2	4.2	9%	4	M4-XS4-01-050718	1805322-5	2.0		71%
Trip 2	Pink	M4-XS45-01-050718	3.7	3.5	13%	3	M4-XS45-01-050718	1805322-6	1.8		68%
Trip 2	Pink	M4-XS63-01-050718	5.6	5.7	13%	4	M4-XS63-01-050718	1805322-7	2.5		77%
Trip 2	Pink	M4-XS63-02-050718	5.3	5.3	17%	4	M4-XS63-02-050718	1805322-8	3.0		55%
Trip 2	Pink	M4-XS78-01-051018	5.4	5.0	19%	5	M4-XS78-01-051018	1805322-9	2.4	J	78%
Trip 2	Orange	M5-XS115-01-051118	3.3	3.5	13%	3	M5-XS115-01-051118	1805322-10	1.7		65%
Trip 2	Pink	M5-XS385-01-051118	3.7	3.8	8%	3	M5-XS385-01-051118	1805322-11	1.5		85%
Trip 2	Pink	M5-XS69-01-051118	4.4	4.4	19%	3	M5-XS69-01-051118	1805322-12	1.8		83%
Trip 2	Orange	M6-XS41-01-051118	2.0	1.8	23%	2	M6-XS41-01-051118	1805322-13	1.1		57%
Trip 2	Pink	M6-XS44-01-051018	4.3	4.1	12%	4	M6-XS44-01-051018	1805322-14	2.6		50%
Trip 2	Pink	M6-XS81-01-051018	3.4	3.2	17%	3	M6-XS81-01-051018	1805322-15	1.2		96%
Trip 2	Pink	M7-XS181-01-051018	3.9	3.8	21%	3	M7-XS181-01-051018	1805322-16	1.9		68%
Trip 2	Orange	M7-XS181-02-051018	3.2	3.2	19%	2	M7-XS181-02-051018	1805322-17	1.8		55%
Trip 2	Orange	M7-XS39-01-051018	2.4	2.5	24%	1	M7-XS39-01-051018	1805322-18	1.4		54%
Trip 2	Orange	M7-XS74-01-051018	3.7	3.6	20%	3	M7-XS74-01-051018	1805322-19	2.4		42%
Trip 2	Orange	M7-XS77-01-051018	4.6	4.5	8%	4	M7-XS77-01-051018	1805322-20	3.2		35%
Trip 2	Pink	M8-XS100-01-050918	7.0	6.4	24%	5	M8-XS100-01-050918	1805328-3	4.9		35%
Trip 2	Pink	M8-XS110-01-050918	6.0	4.9	59%	3	M8-XS110-01-050918	1805328-6	3.1		63%
Trip 2	Orange	M8-XS19-01-051018	4.7	4.5	16%	4	M8-XS19-01-051018	1805328-7	2.5		62%
Trip 2	Orange	M8-XS32-01-051018	9.0	9.1	10%	8	M8-XS32-01-051018	1805328-8	6.1		38%
Trip 2	Pink	M8-XS94-01-050918	4.6	4.6	16%	4	M8-XS94-01-050918	1805328-9	2.3		67%
Trip 2	Pink	T13-XS12-01-050818	6.9	6.9	9%	6	T13-XS12-01-050818	1805322-21	3.5		65%
Trip 2	Pink	T13-XS24-01-050818	4.3	4.3	14%	3	T13-XS24-01-050818	1805322-22	2.0		72%
Trip 2	Pink	T14-XS12-01-050818	5.8	6.0	11%	5	T14-XS12-01-050818	1805322-23	2.7		73%
Trip 2	Pink	T14-XS27-01-050818	5.9	5.4	22%	5	T14-XS27-01-050818	1805322-24	2.6		77%
Trip 2	Pink	T15-XS2-01-050818	6.4	6.4	12%	6	T15-XS2-01-050818	1805322-25	3.0		73%
Trip 2	Pink	T15-XS45-01-050818	4.9	5.0	9%	4	T15-XS45-01-050818	1805322-26	2.6		61%
Trip 2	Pink	T17-XS122-01-050718	4.9	4.9	10%	4	T17-XS122-01-050718	1805322-27	2.5		65%
Trip 2	Pink	T17-XS176-01-050718	5.0	4.8	18%	4	T17-XS176-01-050718	1805322-28	2.6		63%
Trip 2	Pink	T17-XS178-01-050718	4.9	5.1	11%	4	T17-XS178-01-050718	1805322-29	2.1		80%
Trip 2	Pink	T17-XS619-01-050718	5.2	5.3	8%	5	T17-XS619-01-050718	1805322-30	2.4		74%
Trip 2	Pink	T17-XS619-02-050718	5.6	5.4	9%	5	T17-XS619-02-050718	1805322-31	2.5		76%
Trip 2	Pink	T17-XS645-01-050718	4.9	5.0	7%	4	T17-XS645-01-050718	1805322-32	2.4		69%
Trip 2	Pink	T17-XS669-01-050718	5.0	5.2	15%	4	T17-XS669-01-050718	1805322-33	2.2		77%
Trip 2	Pink	T1-XS104-01-051318	7.3	7.3	18%	5	T1-XS104-01-051318	1805328-10	4.5		47%
Trip 2	Pink	T1-XS20-01-051318	4.9	4.7	13%	4	T1-XS20-01-051318	1805328-11	2.3		73%
Trip 2	Pink	T1-XS54-01-051318	4.4	4.2	15%	4	T1-XS54-01-051318	1805328-12	2.1		70%
Trip 2	Pink	T1-XS54-02-051318	5.1	4.9	16%	4	T1-XS54-02-051318	1805328-13	2.1		83%
Trip 2	Pink	T1-XS69-01-051318	4.3	4.1	23%	3	T1-XS69-01-051318	1805328-14	3.1		33%
Trip 2	Orange	T3-XS10-01-051218	3.3	3.2	18%	2	T3-XS10-01-051218	1805328-15	1.5		74%
Trip 2	Orange	T3-XS5-01-051218	2.7	2.7	18%	2	T3-XS5-01-051218	1805328-16	1.4		64%
Trip 2	Pink	T4-XS23-01-051218	3.5	3.3	33%	2	T4-XS23-01-051218	1805328-17	1.3		93%
Trip 2	Orange	T4-XS32-01-051218	2.5	2.5	15%	2	T4-XS32-01-051218	1805328-18	1.3		64%
Trip 2	Pink	T4-XS43-01-051218	3.2	3.2	7%	3	T4-XS43-01-051218	1805328-19	1.6		66%
Trip 2	Pink	T5-XS18-01-051418	3.7	3.6	14%	3	T5-XS18-01-051418	1805328-20	1.4		90%
Trip 2	Pink	T6-XS2-01-051218	3.6	3.7	6%	3	T6-XS2-01-051218	1805328-21	1.1		107%
Trip 2	Orange	T6-XS25-01-051218	2.3	2.3	19%	2	T6-XS25-01-051218	1805328-22	1.2		63%
Trip 3	Pink	M14-XS36-01-052418	3.3	3.2	11%	3	M14-XS36-01-052418	1805632-1	1.6		70%
Trip 3	Pink	M14-XS40-01-052418	4.1	4.0	17%	3	M14-XS40-01-052418	1805632-2	1.6		88%
Trip 3	Pink	M14-XS64-01-052418	3.5	3.5	17%	3	M14-XS64-01-052418	1805632-3	1.4		86%
Trip 3	Pink	M14-XS67-01-052418	3.0	3.0	26%	2	M14-XS67-01-052418	1805632-4	1.7		54%
Trip 3	Pink	M15-XS3-01-052118	4.8	4.8	14%	4	M15-XS3-01-052118	1805589-2	2.6		59%

Data Included in Model TH-2A											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Pink	M15-XS22-01-052118	3.7	3.9	30%	2	M15-XS22-01-052118	1805589-1	1.9		63%
Trip 3	Pink	M15-XS46-01-052118	3.8	3.7	14%	3	M15-XS46-01-052118	1805589-3	1.9		66%
Trip 3	Pink	M15-XS46-02-052118	3.8	3.9	27%	2	M15-XS46-02-052118	1805589-4	1.8		72%
Trip 3	Blue	M15-XS73-01-052118	4.0	4.1	14%	3	M15-XS73-01-052118	1805589-5	2.9		31%
Trip 3	Pink	M15-XS82-01-052118	9.1	9.1	7%	8	M15-XS82-01-052118	1805589-6	5.4		51%
Trip 3	Pink	M15-XS93-01-052118	3.4	3.3	32%	2	M15-XS93-01-052118	1805589-7	2.3		39%
Trip 3	Pink	M16-XS4-01-052118	5.2	5.0	28%	3	M16-XS4-01-052118	1805589-12	2.4		73%
Trip 3	Pink	M16-XS30-01-052118	4.4	4.3	23%	3	M16-XS30-01-052118	1805589-10	2.5		55%
Trip 3	Pink	M16-XS31-01-052118	3.2	3.2	22%	2	M16-XS31-01-052118	1805589-11	1.6		68%
Trip 3	Blue	M16-XS45-01-052118	3.9	3.9	10%	4	M16-XS45-01-052118	1805589-13	3		26%
Trip 3	Pink	M16-XS128-01-052118	6.6	6.8	13%	5	M16-XS128-01-052118	1805589-8	4		50%
Trip 3	Pink	M16-XS154-01-052618	5.2	5.1	16%	4	M16-XS154-01-052618	1806235-2	2.5		70%
Trip 3	Blue	M16-XS166-01-052118	4.1	4.1	6%	4	M16-XS166-01-052118	1805589-9	2.3		56%
Trip 3	Pink	M16-XS177-01-052618	3.9	4.1	15%	3	M16-XS177-01-052618	1806235-3	1.8		75%
Trip 3	Pink	M16-XS191-01-052618	4.7	4.6	11%	4	M16-XS191-01-052618	1806235-4	1.9		84%
Trip 3	Pink	M16-XS191-02-052618	4.2	4.0	32%	3	M16-XS191-02-052618	1806235-5	1.9		76%
Trip 3	Pink	M17-XS55-01-052618	3.7	3.6	14%	3	M17-XS55-01-052618	1806235-6	1.7		74%
Trip 3	Pink	M17-XS83-01-052618	3.4	3.6	22%	2	M17-XS83-01-052618	1806235-7	1.6		72%
Trip 3	Pink	M17-XS83-02-052618	3.7	4.1	29%	2	M17-XS83-02-052618	1806235-8	1.6		79%
Trip 3	Pink	M18-XS155-01-052518	3.0	3.0	5%	3	M18-XS155-01-052518	1805632-5	1.2		85%
Trip 3	Pink	M18-XS161-01-052518	4.9	5.0	16%	4	M18-XS161-01-052518	1805632-6	3.1		45%
Trip 3	Pink	M19-XS22-02-052318	3.7	3.8	12%	3	M19-XS22-02-052318	1805632-8	2		60%
Trip 3	Pink	M19-XS22-01-052318	3.0	2.9	20%	2	M19-XS22-01-052318	1805632-7	2		40%
Trip 3	Pink	M19-XS43-01-052318	4.7	4.9	19%	3	M19-XS43-01-052318	1805632-9	3.2		38%
Trip 3	Blue	T20-XS14-01-052218	4.1	4.1	8%	4	T20-XS14-01-052218	1805632-10	2.9		35%
Trip 3	Blue	T21-XS6-01-052118	3.9	3.8	16%	3	T21-XS6-01-052118	1805589-17	1.8		73%
Trip 3	Blue	T21-XS35-01-052118	4.0	4.2	14%	3	T21-XS35-01-052118	1805589-14	2.6		42%
Trip 3	Blue	T21-XS55-01-052118	4.0	4.1	8%	4	T21-XS55-01-052118	1805589-15	2.6		43%
Trip 3	Pink	T21-XS55-02-052118	4.9	4.9	20%	3	T21-XS55-02-052118	1805589-16	3	J	47%
Trip 3	Blue	T22-XS17-01-052118	4.2	4.1	12%	4	T22-XS17-01-052118	1805589-18	2.7		43%
Trip 3	Pink	T22-XS64-01-052218	5.2	5.3	11%	4	T22-XS64-01-052218	1805632-11	2.5		70%
Trip 3	Pink	T23-XS23-01-052118	5.5	5.6	5%	5	T23-XS23-01-052118	1805589-19	3		59%
Trip 3	Pink	T23-XS40-01-052118	5.4	5.2	16%	4	T23-XS40-01-052118	1805589-20	2.4		76%
Trip 3	Pink	T24-XS48-01-052418	11.6	11.1	13%	10	T24-XS48-01-052418	1805632-12	5.9		65%
Trip 4	Pink	M13-XS72-01-060618	7.9	8.3	12%	7	M13-XS72-01-060618	1806235-1	5.4		37%
Trip 4	Pink	M20-XS5-01-060518	7.8	7.5	13%	7	M20-XS5-01-060518	1806235-20	3.4		79%
Trip 4	Pink	M20-XS11-01-060618	4.0	4.0	19%	3	M20-XS11-01-060618	1806235-9	2.0		67%
Trip 4	Pink	M20-XS18-01-060618	3.9	4.1	16%	3	M20-XS18-01-060618	1806235-12	2.1		61%
Trip 4	Pink	M20-XS86-01-060618	3.1	3.0	19%	2	M20-XS86-01-060618	1806235-21	1.8		52%
Trip 4	Pink	M20-XS130-01-060418	4.9	4.8	9%	4	M20-XS130-01-060418	1806235-10	1.6		101%
Trip 4	Pink	M20-XS166-01-060518	4.1	3.8	27%	3	M20-XS166-01-060518	1806235-11	2.2		61%
Trip 4	Pink	M20-XS185-01-060418	3.5	3.7	11%	3	M20-XS185-01-060418	1806235-13	1.6		75%
Trip 4	Pink	M20-XS231-01-060418	4.9	4.6	25%	3	M20-XS231-01-060418	1806235-14	1.9		87%
Trip 4	Pink	M20-XS278-01-060418	9.0	9.0	5%	8	M20-XS278-01-060418	1806235-15	4.2		73%
Trip 4	Pink	M20-XS306-01-060518	7.6	7.4	16%	6	M20-XS306-01-060518	1806235-16	4.0		62%
Trip 4	Pink	M20-XS312-01-060518	3.4	3.4	16%	3	M20-XS312-01-060518	1806235-17	1.8		62%
Trip 4	Pink	M20-XS365-01-060618	3.6	3.7	15%	3	M20-XS365-01-060618	1806235-18	1.7		72%
Trip 4	Pink	M20-XS365-02-060618	3.5	3.4	5%	3	M20-XS365-02-060618	1806235-19	1.6		74%
Trip 4	Pink	M21-XS14-01-060818	8.0	8.1	13%	7	M21-XS14-01-060818	1806234-3	3.2		86%
Trip 4	Pink	M21-XS27-01-060818	3.5	3.7	26%	2	M21-XS27-01-060818	1806234-7	1.3		91%
Trip 4	Pink	M21-XS27-02-060818	2.7	2.8	25%	2	M21-XS27-02-060818	1806234-8	1.4		64%
Trip 4	Pink	M21-XS40-01-060818	6.0	6.1	17%	4	M21-XS40-01-060818	1806234-15	3.5		52%
Trip 4	Pink	M21-XS46-01-060818	4.4	4.4	16%	3	M21-XS46-01-060818	1806234-18	2.0		75%
Trip 4	Pink	M21-XS126-01-060818	5.2	4.9	25%	3	M21-XS126-01-060818	1806234-2	2.4		73%
Trip 4	Pink	M21-XS175-01-060818	6.1	5.6	16%	5	M21-XS175-01-060818	1806234-4	2.6		81%
Trip 4	Pink	M21-XS225-01-060518	5.5	5.4	18%	4	M21-XS225-01-060518	1806235-22	2.6		72%
Trip 4	Pink	M21-XS259-01-060918	5.3	5.1	8%	5	M21-XS259-01-060918	1806234-5	2.5		71%
Trip 4	Pink	M21-XS260-01-060918	6.3	6.3	11%	5	M21-XS260-01-060918	1806234-6	3.0		71%
Trip 4	Pink	M21-XS282-01-060918	3.6	3.7	9%	3	M21-XS282-01-060918	1806234-9	1.1		107%
Trip 4	Pink	M21-XS290-01-060918	10.7	11.1	11%	9	M21-XS290-01-060918	1806234-10	5.2		69%
Trip 4	Pink	M21-XS292-01-060518	2.8	2.9	18%	2	M21-XS292-01-060518	1806235-23	1.7		48%
Trip 4	Pink	M21-XS302-02-060918	3.3	3.1	21%	3	M21-XS302-02-060918	1806234-12	1.9		54%
Trip 4	Pink	M21-XS302-01-060918	4.1	4.3	24%	3	M21-XS302-01-060918	1806234-11	2.0		68%
Trip 4	Pink	M21-XS334-01-060918	8.2	8.3	12%	6	M21-XS334-01-060918	1806234-13	3.6		78%
Trip 4	Pink	M21-XS377-01-060918	4.5	4.4	15%	4	M21-XS377-01-060918	1806234-14	1.5		99%
Trip 4	Pink	M21-XS403-01-060818	3.0	3.2	26%	2	M21-XS403-01-060818	1806234-16	1.4		73%
Trip 4	Pink	M21-XS419-01-060818	8.3	8.4	6%	7	M21-XS419-01-060818	1806234-17	3.3		86%
Trip 4	Pink	M21-XS477-01-060818	5.7	5.8	9%	5	M21-XS477-01-060818	1806234-19	2.9		66%
Trip 4	Pink	M21-XS541-01-060818	3.5	3.5	23%	3	M21-XS541-01-060818	1806234-20	1.6		76%
Trip 4	Pink	M21-XS596-01-060518	3.9	4.1	20%	2	M21-XS596-01-060518	1806235-24	1.9		69%
Trip 4	Pink	M21-XS615-01-060518	3.2	3.2	14%	3	M21-XS615-01-060518	1806235-25	1.6		68%

Data Included in Model TH-2A

Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 4	Pink	M21-XS619-01-060618	5.0	4.8	14%	4	M21-XS619-01-060618	1806235-26	3.2		44%
Trip 4	Pink	M22-XS14-01-060418	6.0	5.7	16%	5	M22-XS14-01-060418	1806235-27	2.6		79%
Trip 4	Pink	M22-XS30-01-060418	3.7	3.7	25%	3	M22-XS30-01-060418	1806235-28	1.7		73%
Trip 4	Pink	M22-XS40-01-060518	8.0	8.9	27%	4	M22-XS40-01-060518	1806235-29	4.3		60%
Trip 4	Pink	M22-XS60-01-060418	3.4	3.3	31%	2	M22-XS60-01-060418	1806235-30	1.7		68%
Trip 4	Pink	M22-XS87-01-060418	6.3	6.4	9%	6	M22-XS87-01-060418	1806235-31	3.2		65%
Trip 4	Pink	M23-XS20-01-061018	5.3	5.2	17%	4	M23-XS20-01-061018	1806233-3	2.0		90%
Trip 4	Pink	M23-XS48-01-061018	5.6	5.7	12%	4	M23-XS48-01-061018	1806233-4	2.3		84%
Trip 4	Pink	M23-XS54-01-061118	3.5	3.6	21%	2	M23-XS54-01-061118	1806312-1	2.2		45%
Trip 4	Pink	M23-XS64-01-061018	3.4	3.3	16%	3	M23-XS64-01-061018	1806233-5	1.5		77%
Trip 4	Pink	M23-XS70-01-061018	4.6	4.2	19%	4	M23-XS70-01-061018	1806233-6	2.3	J	66%
Trip 4	Pink	M23-XS79-01-061018	4.3	4.3	17%	3	M23-XS79-01-061018	1806233-7	2.3		60%
Trip 4	Pink	M23-XS102-01-061018	6.9	6.7	12%	6	M23-XS102-01-061018	1806233-1	3.9		55%
Trip 4	Pink	M23-XS123-01-061018	3.5	3.6	15%	3	M23-XS123-01-061018	1806233-2	1.7		69%
Trip 4	Pink	M24-XS100-01-061118	4.3	4.0	16%	4	M24-XS100-01-061118	1806312-3	1.5		97%
Trip 4	Pink	M24-XS128-01-061118	6.2	6.1	9%	6	M24-XS128-01-061118	1806312-4	3.5		56%
Trip 4	Pink	T18-XS14-01-061118	4.6	4.7	16%	4	T18-XS14-01-061118	1806312-5	2.3		67%
Trip 4	Pink	T25-XS2-01-060618	4.7	4.8	15%	4	T25-XS2-01-060618	1806235-32	2.8		51%
Trip 4	Pink	T26-XS1-01-061018	4.4	4.6	18%	3	T26-XS1-01-061018	1806233-8	2.9		42%
Trip 4	Pink	T26-XS8-01-061018	3.7	3.6	21%	3	T26-XS8-01-061018	1806233-9	2.1		55%
Trip 4	Pink	T27-XS6-01-061018	5.4	5.2	20%	4	T27-XS6-01-061018	1806233-11	2.3		81%
Trip 4	Pink	T27-XS19-01-061018	3.9	3.7	14%	4	T27-XS19-01-061018	1806233-10	2.4		49%
Trip 5	Pink	M26-XS13-01-061818	2.2	2.1	28%	1	M26-XS13-01-061818	1806558-1	1.3		49%
Trip 5	Pink	M26-XS25-01-061818	2.9	3.0	34%	2	M26-XS25-01-061818	1806558-2	2.7		6%
Trip 5	Pink	M27-XS21-01-061918	4.9	5.1	16%	4	M27-XS21-01-061918	1806558-10	3.3		39%
Trip 5	Pink	M27-XS38-01-061918	3.7	3.5	29%	3	M27-XS38-01-061918	1806558-15	2.2		52%
Trip 5	Pink	M27-XS108-01-061918	4.4	4.6	13%	4	M27-XS108-01-061918	1806558-3	3.0		38%
Trip 5	Pink	M27-XS109-01-061918	3.7	3.7	21%	3	M27-XS109-01-061918	1806558-4	2.8	J	27%
Trip 5	Pink	M27-XS123-01-061818	2.8	2.8	36%	1	M27-XS123-01-061818	1806558-5	1.5		60%
Trip 5	Pink	M27-XS188-01-061918	4.7	4.9	27%	3	M27-XS188-01-061918	1806558-6	3.4		33%
Trip 5	Pink	M27-XS197-01-061918	3.1	3.3	20%	2	M27-XS197-01-061918	1806558-7	2.7		14%
Trip 5	Pink	M27-XS210-02-061818	3.8	3.8	17%	3	M27-XS210-02-061818	1806558-9	2.2		54%
Trip 5	Pink	M27-XS210-01-061818	2.6	2.5	34%	1	M27-XS210-01-061818	1806558-8	2.4		10%
Trip 5	Pink	M27-XS275-01-061918	4.3	4.3	13%	4	M27-XS275-01-061918	1806558-12	2.9		38%
Trip 5	Pink	M27-XS283-01-061818	4.8	4.8	14%	4	M27-XS283-01-061818	1806558-13	3.4		34%
Trip 5	Pink	M28-XS8-01-062018	2.2	2.1	37%	1	M28-XS8-01-062018	1806558-21	1.8	J	19%
Trip 5	Pink	M28-XS43-01-062018	3.3	3.3	22%	2	M28-XS43-01-062018	1806558-20	2.3		36%
Trip 5	Pink	M28-XS105-01-062018	4.0	4.2	11%	3	M28-XS105-01-062018	1806558-16	2.6		41%
Trip 5	Pink	M28-XS148-01-062018	4.6	4.4	33%	3	M28-XS148-01-062018	1806558-17	2.8		50%
Trip 5	Pink	M28-XS155-01-062018	3.7	3.9	21%	3	M28-XS155-01-062018	1806558-18	2.0		59%
Trip 5	Pink	M28-XS170-01-062018	9.7	9.9	12%	8	M28-XS170-01-062018	1806558-19	6.8		35%
Trip 5	Pink	M30-XS138-01-062218	5.0	5.1	13%	4	M30-XS138-01-062218	1806693-1	2.4		71%
Trip 5	Pink	M30-XS222-01-062218	6.1	5.9	10%	5	M30-XS222-01-062218	1806693-2	3.2		62%
Trip 5	Pink	T32-XS5-01-062018	2.5	2.5	20%	2	T32-XS5-01-062018	1806558-22	1.7		38%
Trip 6	Orange	M10-XS10A-01-071118	4.0	3.6	20%	3	M10-XS10A-01-071118	1807369-1	2.7		38%
Trip 6	Orange	M10-XS31-01-071118	3.8	4.1	24%	2	M10-XS31-01-071118	1807369-2	2.3		49%
Trip 6	Orange	M10-XS31-02-071118	4.0	3.9	14%	3	M10-XS31-02-071118	1807369-3	2.3		54%
Trip 6	Orange	M11-XS11-01-071118	3.6	3.5	35%	2	M11-XS11-01-071118	1807369-4	2.1		53%
Trip 6	Red	M11-XS7-01-071118	3.7	3.8	21%	3	M11-XS7-01-071118	1807369-5	2.1		54%
Trip 6	Red	M25-XS16-01-071718	2.9	3.1	16%	2	M25-XS16-01-071718	1807452-1	1.9		43%
Trip 6	Red	M25-XS23-01-071718	3.9	4.0	14%	3	M25-XS23-01-071718	1807452-2	2.0		63%
Trip 6	Red	M25-XS47-01-071718	3.2	3.3	25%	2	M25-XS47-01-071718	1807452-3	1.9		51%
Trip 6	Red	M25-XS88-01-071718	3.0	3.1	23%	2	M25-XS88-01-071718	1807452-4	1.7		56%
Trip 6	Orange	M30-XS170-01-071618	3.4	3.6	24%	2	M30-XS170-01-071618	1807369-10	2.6		26%
Trip 6	Red	M30-XS95-01-071618	3.5	3.4	11%	3	M30-XS95-01-071618	1807369-11	3.1		12%
Trip 6	Red	M31-XS9-01-071018	2.5	2.2	38%	2	M31-XS9-01-071018	1807369-12	1.9		29%
Trip 6	Orange	M32-XS58-01-071018	3.8	3.9	8%	3	M32-XS58-01-071018	1807369-13	2.1		58%
Trip 6	Red	M32-XS89-01-071018	5.3	5.7	21%	4	M32-XS89-01-071018	1807369-14	3.6		39%
Trip 6	Orange	M33-XS22-01-071218	4.3	4.3	16%	3	M33-XS22-01-071218	1807369-15	2.6		50%
Trip 6	Orange	M33-XS85-01-071218	4.4	4.2	18%	4	M33-XS85-01-071218	1807369-16	3.3		29%
Trip 6	Red	M33-XS93-01-071218	4.9	4.9	15%	4	M33-XS93-01-071218	1807369-17	3.5		33%
Trip 6	Red	T33-XS43-01-071718	7.7	7.8	14%	6	T33-XS43-01-071718	1807452-5	4.8		47%
Trip 1	Pink	M6-XS251-01-04272018	5.8	5.9	9%	5	M6-XS251-01-04272018	1805039-2	4.0		37%
Trip 1	Pink	T17-XS287-01-04272018	6.3	6.2	13%	5	T17-XS287-01-04272018	1805039-15	3.8		50%
Trip 4	Pink	M21-XS122-01-060818	10.6	10.5	9%	10	M21-XS122-01-060818	1806234-1	7.0		41%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental XRF = X-ray fluorescence
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 4	Pink	T18-XS27-01-061118	1.5	1.7	50%	0	T18-XS27-01-061118	1806312-6	0.7		77%
Trip 5	Pink	M27-XS29-01-061818	2.7	3.4	57%	0	M27-XS29-01-061818	1806558-14	2.5		8%
Trip 5	Pink	M27-XS239-01-061818	0.8	0.7	114%	0	M27-XS239-01-061818	1806558-11	1.5		59%
Trip 6	Red	M12-XS27-01-071518	0.0	0.0	#DIV/0!	0	M12-XS27-01-071518	1807369-6	0.8		200%
Trip 6	Orange	M30-XS127-01-071618	1.9	1.9	60%	0	M30-XS127-01-071618	1807369-9	1.5		21%

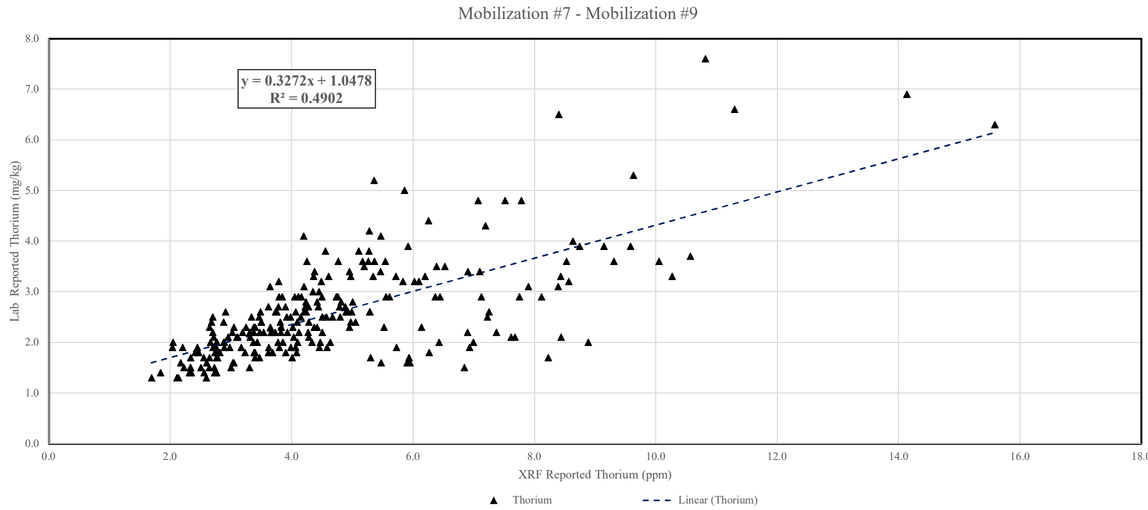
Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 2	Pink	M4-XS238-01-051018	11.1	11.2	10%	9	M4-XS238-01-051018	1805322-4	8.8		23%
Trip 6	Orange	M24-XS115-01-071418	9.4	9.0	10%	9	M24-XS115-01-071418	1807369-7	7.7		20%
Trip 1	Pink	T10-XS20-01-042518	7.0	5.1	69%	5	T10-XS20-01-042518	1805036-2	1.9		114%

Removed Data - Above 12 ppm

Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 2	Pink	M8-XS102-01-050918	54.9	55.0	3%	52	M8-XS102-01-050918	1805328-4	38.0		36%
Trip 2	Pink	M8-XS102-02-050918	53.6	55.2	8%	45	M8-XS102-02-050918	1805328-5	38.0		34%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence



Data Included											
Trip	XRF Color	XRF ID	XRF - Thorium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 7	Red	M10-XS22-01-082118	2.8	2.8	19%	2	M10-XS22-01-082118	1808494-1	1.7		48%
Trip 7	Red	M10-XS39-01-082118	3.6	3.8	18%	3	M10-XS39-01-082118	1808494-2	1.8		67%
Trip 7	Red	M10-XS43-01-082118	2.9	2.7	28%	2	M10-XS43-01-082118	1808494-3	1.9		41%
Trip 7	Red	M1-XSG2-01-081918	3.6	3.7	22%	2	M1-XSG2-01-081918	1808483-1	2.3		45%
Trip 7	Pink	M34-XS110-01-081218	4.3	4.0	36%	2	M34-XS110-01-081218	1808303-1	2.1		68%
Trip 7	Pink	M34-XS22-01-081218	4.9	4.9	15%	4	M34-XS22-01-081218	1808303-2	2.6		61%
Trip 7	Pink	M34-XS43-01-081218	4.6	4.6	17%	3	M34-XS43-01-081218	1808303-3	2.0		79%
Trip 7	Pink	M34-XS50-01-081218	6.9	7.1	15%	5	M34-XS50-01-081218	1808303-4	3.4		68%
Trip 7	Pink	M34-XS68-01-081218	14.1	13.6	12%	13	M34-XS68-01-081218	1808303-5	6.9		69%
Trip 7	Pink	M35-XS11-01-081218	9.6	9.8	15%	8	M35-XS11-01-081218	1808303-6	5.3		58%
Trip 7	Pink	M35-XS20-01-081318	15.6	15.6	17%	12	M35-XS20-01-081318	1808303-7	6.3		85%
Trip 7	Pink	M35-XS31-01-081218	8.4	8.3	7%	8	M35-XS31-01-081218	1808303-8	3.1		92%
Trip 7	Pink	M35-XS63-01-081218	2.6	2.7	15%	2	M35-XS63-01-081218	1808303-9	1.4		58%
Trip 7	Pink	M35-XS74-01-081318	6.3	6.7	15%	5	M35-XS74-01-081318	1808303-10	1.8		111%
Trip 7	Pink	M35-XS74-02-081318	6.4	6.5	11%	5	M35-XS74-02-081318	1808303-11	2.0		105%
Trip 7	Pink	M36-XS20-01-081218	5.5	5.4	9%	5	M36-XS20-01-081218	1808303-12	1.6		109%
Trip 7	Pink	M36-XS2-01-081218	4.3	4.0	29%	3	M36-XS2-01-081218	1808303-13	2.2		64%
Trip 7	Pink	M36-XS3-01-081218	2.6	2.8	28%	2	M36-XS3-01-081218	1808303-14	1.5		55%
Trip 7	Pink	M36-XS31-01-081218	7.2	7.3	21%	5	M36-XS31-01-081218	1808303-15	2.5		97%
Trip 7	Pink	M37-XS124A-01-081318	9.3	9.5	10%	8	M37-XS124A-01-081318	1808303-16	3.6		88%
Trip 7	Pink	M37-XS144-01-081318	10.1	9.5	15%	9	M37-XS144-01-081318	1808303-17	3.6		95%
Trip 7	Pink	M37-XS2-01-081318	10.6	10.8	9%	9	M37-XS2-01-081318	1808303-18	3.7		96%
Trip 7	Pink	M37-XS23-01-081318	5.9	5.7	13%	5	M37-XS23-01-081318	1808303-19	1.6		115%
Trip 7	Pink	M37-XS38-01-081318	5.9	5.9	7%	5	M37-XS38-01-081318	1808356-1	1.6		115%
Trip 7	Pink	M37-XS44-01-081318	7.7	7.6	9%	7	M37-XS44-01-081318	1808356-2	2.1		114%
Trip 7	Pink	M37-XS50-01-081318	8.7	8.7	7%	8	M37-XS50-01-081318	1808356-3	3.9		77%
Trip 7	Pink	M37-XS7-01-081318	8.5	8.7	14%	7	M37-XS7-01-081318	1808356-4	3.6		81%
Trip 7	Red	M38-XS20-01-081818	3.8	3.9	28%	2	M38-XS20-01-081818	1808483-2	2.6		36%
Trip 7	Red	M3-XS19-01-081718	3.2	3.2	19%	2	M3-XS19-01-081718	1808476-1	1.9		50%
Trip 7	Red	M3-XS41-01-081718	3.0	3.2	37%	1	M3-XS41-01-081718	1808476-2	2.2		31%
Trip 7	Red	M4-XSG2-01-081818	2.0	1.9	17%	2	M4-XSG2-01-081818	1808483-5	2.0		2%
Trip 7	Red	M5-XS131-01-082018	2.5	2.7	29%	1	M5-XS131-01-082018	1808487-1	1.7		40%
Trip 7	Red	M5-XS192-01-081818	5.9	5.9	11%	5	M5-XS192-01-081818	1808483-7	5.0		16%
Trip 7	Red	M5-XS207A-01-082018	2.9	2.6	30%	2	M5-XS207A-01-082018	1808487-3	2.4		18%
Trip 7	Red	M5-XS261-01-082018	2.8	2.9	19%	2	M5-XS261-01-082018	1808487-4	1.9		37%
Trip 7	Red	M5-XS305-01-082018	2.6	2.5	26%	2	M5-XS305-01-082018	1808487-6	1.6		48%
Trip 7	Red	M5-XS476-01-082018	3.9	4.1	20%	3	M5-XS476-01-082018	1808487-7	2.2		56%
Trip 7	Red	M5-XS488-01-082018	3.9	3.8	26%	3	M5-XS488-01-082018	1808487-8	2.0		63%
Trip 7	Red	M6-XS108-01-081618	5.3	5.2	20%	4	M6-XS108-01-081618	1808476-3	3.8		32%
Trip 7	Red	M6-XS108-02-081618	5.3	5.4	11%	4	M6-XS108-02-081618	1808476-4	4.2		23%
Trip 7	Red	M6-XS198-01-081618	3.8	4.0	12%	3	M6-XS198-01-081618	1808476-5	2.9		27%
Trip 7	Red	M6-XS249-01-081618	3.4	3.6	29%	2	M6-XS249-01-081618	1808476-6	2.3		38%
Trip 7	Red	M6-XS289-01-081618	2.2	2.1	19%	2	M6-XS289-01-081618	1808476-7	1.6		30%
Trip 7	Red	M6-XS324-01-081618	4.1	4.4	30%	3	M6-XS324-01-081618	1808476-8	2.9		35%
Trip 7	Red	M6-XS60-01-081618	2.3	2.4	29%	2	M6-XS60-01-081618	1808476-9	1.7		31%
Trip 7	Red	M6-XS72-01-081618	6.9	7.0	26%	4	M6-XS72-01-081618	1808476-10	2.2		103%
Trip 7	Pink	M7-XS162A-01-081518	5.3	4.7	23%	4	M7-XS162A-01-081518	1808356-5	3.6		37%

Data Included												
			XRF - Thorium						ALS Results			
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Pink	M7-XS203-01-081418	7.7	7.8	14%	7	M7-XS203-01-081418	1808356-6	2.9		91%
Trip 7	Pink	M7-XS213-01-081518	2.6	2.8	31%	1	M7-XS213-01-081518	1808356-7	2.3		14%
Trip 7	Pink	M7-XS214-01-081518	3.5	3.3	16%	3	M7-XS214-01-081518	1808356-8	2.2		45%
Trip 7	Pink	M7-XS235A-01-081418	9.6	9.5	8%	9	M7-XS235A-01-081418	1808356-9	3.9		84%
Trip 7	Pink	M7-XS244-01-081518	4.6	4.6	29%	2	M7-XS244-01-081518	1808356-10	1.9		83%
Trip 7	Pink	M8-XS55-01-081418	8.2	7.7	17%	7	M8-XS55-01-081418	1808356-20	1.7		131%
Trip 7	Red	M8-XS83-01-081418	3.1	3.2	19%	2	M8-XS83-01-081418	1808476-12	2.1		38%
Trip 7	Pink	M8-XSG16-01-081518	7.0	7.0	8%	6	M8-XSG16-01-081518	1808356-11	2.0		111%
Trip 7	Pink	M8-XSG28-01-081418	5.3	5.2	14%	4	M8-XSG28-01-081418	1808356-12	2.6		68%
Trip 7	Pink	M8-XSG31-01-081518	8.6	8.4	16%	7	M8-XSG31-01-081518	1808356-13	3.2		91%
Trip 7	Pink	M8-XSG37-01-081418	4.7	4.7	13%	4	M8-XSG37-01-081418	1808356-14	2.9		48%
Trip 7	Pink	M8-XSG40-01-081418	7.2	7.1	14%	6	M8-XSG40-01-081418	1808356-15	2.6		94%
Trip 7	Pink	M8-XSG4-01-081518	8.1	8.3	15%	7	M8-XSG4-01-081518	1808356-16	2.9		95%
Trip 7	Pink	M8-XSG44-01-081418	5.7	5.6	10%	5	M8-XSG44-01-081418	1808356-17	1.9		100%
Trip 7	Pink	M8-XSG44-02-081418	4.5	4.4	9%	4	M8-XSG44-02-081418	1808356-18	1.9		80%
Trip 7	Pink	M8-XSG47-01-081418	8.4	8.6	8%	7	M8-XSG47-01-081418	1808356-19	3.3		87%
Trip 7	Red	M9-XS19A-01-081718	6.4	6.3	31%	4	M9-XS19A-01-081718	1808483-8	2.9		75%
Trip 7	Red	M9-XS28A-01-081718	7.1	7.0	10%	6	M9-XS28A-01-081718	1808483-9	2.9		84%
Trip 7	Red	T10-XSG1-01-081818	4.2	4.6	30%	2	T10-XSG1-01-081818	1808483-10	2.6		47%
Trip 7	Red	T13-XSG16-01-081618	8.9	9.1	12%	7	T13-XSG16-01-081618	1808476-13	2.0		127%
Trip 7	Red	T13-XSG26-01-081618	6.2	6.2	13%	5	T13-XSG26-01-081618	1808476-14	3.3		61%
Trip 7	Red	T13-XSG7-01-081618	4.9	4.9	15%	4	T13-XSG7-01-081618	1808476-15	2.3		73%
Trip 7	Red	T15-XS20-01-081718	3.6	3.6	20%	3	T15-XS20-01-081718	1808483-11	3.1		16%
Trip 7	Red	T15-XSG5-01-081718	5.0	5.0	19%	4	T15-XSG5-01-081718	1808483-12	3.3		40%
Trip 7	Red	T17-XSG17-01-081618	5.5	5.3	33%	3	T17-XSG17-01-081618	1808476-16	2.3		82%
Trip 7	Red	T17-XSG27-01-081618	7.9	7.6	19%	6	T17-XSG27-01-081618	1808476-17	3.1		87%
Trip 7	Red	T17-XSG31-01-081518	7.6	7.8	15%	6	T17-XSG31-01-081518	1808476-18	2.1	J	113%
Trip 7	Red	T17-XSG7-01-081618	8.6	9.1	14%	6	T17-XSG7-01-081618	1808476-19	4.0		73%
Trip 7	Red	T17-XSG7-02-081618	5.4	5.6	9%	5	T17-XSG7-02-081618	1808476-20	3.6		39%
Trip 7	Red	T1-XSG38-01-081918	3.5	3.6	39%	2	T1-XSG38-01-081918	1808483-13	2.5		32%
Trip 7	Red	T1-XSG49A-01-081918	2.7	2.5	26%	2	T1-XSG49A-01-081918	1808483-14	1.8		41%
Trip 7	Red	T4-XS15A-01-081918	11.3	11.4	9%	10	T4-XS15A-01-081918	1808487-9	6.6		52%
Trip 7	Red	T4-XSG10-01-081918	2.3	2.2	31%	2	T4-XSG10-01-081918	1808483-16	1.4		49%
Trip 7	Red	T4-XSG50A-01-081918	8.4	8.2	7%	8	T4-XSG50A-01-081918	1808483-18	6.5		25%
Trip 7	Red	T5-XSG10-01-081918	4.6	4.5	13%	4	T5-XSG10-01-081918	1808483-19	3.8		18%
Trip 7	Red	T6-XSG6-01-081918	2.1	1.8	32%	1	T6-XSG6-01-081918	1808487-10	1.3		47%
Trip 7	Red	T9-XSG12-01-081818	4.9	4.9	18%	4	T9-XSG12-01-081818	1808483-20	3.4		37%
Trip 8	Red	M13-XS112-01-091518	3.4	3.8	28%	2	M13-XS112-01-091518	1809475-1	2.0		53%
Trip 8	Red	M14-XS62-01-091818	2.7	2.8	11%	2	M14-XS62-01-091818	1809475-21	1.4		64%
Trip 8	Red	M14-XSG14A-01-091818	2.6	2.5	18%	2	M14-XSG14A-01-091818	1809475-22	1.3		66%
Trip 8	Red	M14-XSG27A-01-091818	3.0	2.9	12%	3	M14-XSG27A-01-091818	1809475-23	1.5		67%
Trip 8	Red	M14-XSG41-01-091818	5.0	5.0	9%	4	M14-XSG41-01-091818	1809475-24	2.6		63%
Trip 8	Red	M14-XSG49-01-091818	4.9	4.9	11%	4	M14-XSG49-01-091818	1809475-25	2.7		57%
Trip 8	Red	M14-XSG58-01-091818	5.8	6.1	17%	4	M14-XSG58-01-091818	1809475-26	3.2		58%
Trip 8	Red	M14-XSG6-01-091818	4.0	4.0	13%	3	M14-XSG6-01-091818	1809475-27	1.9		71%
Trip 8	Red	M15-XSG20-01-091118	6.1	6.7	31%	3	M15-XSG20-01-091118	1809473-20	2.3		91%
Trip 8	Red	M15-XSG2-01-091118	3.7	3.7	23%	2	M15-XSG2-01-091118	1809473-21	1.8		69%
Trip 8	Red	M16-XSG13-01-091118	6.4	6.2	7%	6	M16-XSG13-01-091118	1809473-22	3.5		58%
Trip 8	Red	M16-XSG24-01-091118	7.5	7.3	11%	6	M16-XSG24-01-091118	1809473-23	4.8		44%
Trip 8	Red	M16-XSG30-01-091518	1.8	1.9	23%	1	M16-XSG30-01-091518	1809475-3	1.4		27%
Trip 8	Red	M17-XS79-01-091318	3.0	3.2	17%	2	M17-XS79-01-091318	1809473-1	1.6		62%
Trip 8	Red	M17-XSG1-01-091318	4.9	4.9	17%	4	M17-XSG1-01-091318	1809473-2	2.6		62%
Trip 8	Red	M17-XSG27-01-091318	3.5	3.5	18%	2	M17-XSG27-01-091318	1809473-3	1.7		68%
Trip 8	Red	M17-XSG36-02-091318	2.1	2.2	27%	1	M17-XSG36-02-091318	1809473-5	1.3		49%
Trip 8	Red	M18-XSG16-01-091318	4.5	4.4	18%	3	M18-XSG16-01-091318	1809473-6	2.0		76%
Trip 8	Red	M18-XSG30-01-091318	3.3	3.3	26%	2	M18-XSG30-01-091318	1809473-7	2.2		40%
Trip 8	Red	M18-XSG32-01-091318	3.3	3.3	16%	3	M18-XSG32-01-091318	1809473-8	2.2		40%
Trip 8	Red	M19-XSG11-01-091318	4.4	4.4	17%	3	M19-XSG11-01-091318	1809473-9	2.7		49%
Trip 8	Red	M19-XSG19-01-091318	2.9	2.7	24%	2	M19-XSG19-01-091318	1809473-10	2.0		36%
Trip 8	Red	M19-XSG25-01-091318	4.9	5.1	15%	4	M19-XSG25-01-091318	1809473-11	2.6		62%
Trip 8	Red	M19-XSG29-01-091318	3.7	3.8	15%	3	M19-XSG29-01-091318	1809473-12	2.6		36%
Trip 8	Red	M19-XSG39-01-091318	5.3	5.1	28%	3	M19-XSG39-01-091318	1809473-13	3.3		47%
Trip 8	Red	M19-XSG43-01-091318	4.0	4.2	20%	3	M19-XSG43-01-091318	1809473-14	2.9		33%
Trip 8	Red	M20-XS247-01-091718	4.1	4.3	25%	2	M20-XS247-01-091718	1809475-30	1.9		73%
Trip 8	Red	M20-XS267-01-091718	2.7	2.7	22%	2	M20-XS267-01-091718	1809475-31	2.4		11%
Trip 8	Red	M20-XS271-01-091718	2.4	2.5	27%	1	M20-XS271-01-091718	1809475-32	1.8		29%
Trip 8	Red	M20-XS30-01-091718	3.1	3.3	21%	2	M20-XS30-01-091718	1809475-33	2.1		39%
Trip 8	Red	M20-XS335-01-091418	2.7	2.8	14%	2	M20-XS335-01-091418	1809475-5	1.5		58%
Trip 8	Red	M20-XS422-01-091418	4.1	4.5	21%	3	M20-XS422-01-091418	1809475-6	2.5		50%
Trip 8	Red	M20-XS58-01-091718	3.7	3.3	23%	3	M20-XS58-01-091718	1809475-34	2.2		50%
Trip 8	Red	M20-XS60-01-091718	4.0	3.6	29%	3	M20-XS60-01-091718	1809475-35	2.1		63%

Data Included											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M20-XSG15-01-091418	4.8	4.7	14%	4	M20-XSG15-01-091418	1809475-7	2.7		56%
Trip 8	Red	M20-XSG28-01-091418	2.8	2.8	25%	2	M20-XSG28-01-091418	1809475-8	2.0		32%
Trip 8	Red	M21-XS1-01-091218	6.4	6.7	23%	4	M21-XS1-01-091218	1809473-24	2.9		76%
Trip 8	Red	M21-XS317-01-091218	3.9	3.8	27%	2	M21-XS317-01-091218	1809473-25	2.5		44%
Trip 8	Red	M21-XS323-01-091218	3.4	3.4	18%	3	M21-XS323-01-091218	1809473-26	1.8		61%
Trip 8	Red	M21-XS465-01-091218	4.3	4.4	14%	3	M21-XS465-01-091218	1809473-27	2.7		45%
Trip 8	Red	M21-XS503-01-091218	6.9	7.0	10%	6	M21-XS503-01-091218	1809473-28	1.9		114%
Trip 8	Red	M21-XS511-01-091218	3.8	3.7	14%	3	M21-XS511-01-091218	1809473-29	2.0		61%
Trip 8	Red	M21-XS536-01-091218	6.1	6.1	7%	6	M21-XS536-01-091218	1809473-30	3.2		62%
Trip 8	Red	M21-XSG16-01-091218	10.3	10.3	7%	9	M21-XSG16-01-091218	1809473-31	3.3		103%
Trip 8	Red	M21-XSG38-01-091418	5.6	5.6	20%	4	M21-XSG38-01-091418	1809475-12	2.9		64%
Trip 8	Red	M21-XSG7-01-091218	5.9	5.7	22%	4	M21-XSG7-01-091218	1809473-32	1.7		111%
Trip 8	Red	M22-XS112-01-091418	3.4	3.5	12%	3	M22-XS112-01-091418	1809475-14	2.2		42%
Trip 8	Red	M22-XS115-01-091418	5.0	5.1	6%	4	M22-XS115-01-091418	1809475-15	2.4		71%
Trip 8	Red	M22-XS121-01-091418	4.1	4.3	16%	3	M22-XS121-01-091418	1809475-16	2.0		69%
Trip 8	Red	M22-XS94-01-091418	3.0	3.2	29%	1	M22-XS94-01-091418	1809475-17	1.6		62%
Trip 8	Red	M23-XSG1-01-091418	4.5	4.6	6%	4	M23-XSG1-01-091418	1809475-18	3.2		33%
Trip 8	Red	M23-XSG20-01-091418	4.5	4.5	6%	4	M23-XSG20-01-091418	1809475-19	2.5		57%
Trip 8	Red	M23-XSG5-01-091418	3.2	3.2	17%	2	M23-XSG5-01-091418	1809475-20	2.3		34%
Trip 8	Red	M6-XS164-01-091118	5.3	5.7	27%	2	M6-XS164-01-091118	1809473-33	1.7		103%
Trip 8	Red	M6-XS224-01-091118	9.1	8.5	17%	8	M6-XS224-01-091118	1809473-34	3.9		80%
Trip 8	Red	M6-XS353A-01-091618	5.2	5.0	22%	4	M6-XS353A-01-091618	1809475-36	3.5		39%
Trip 8	Red	M6-XS369-01-091618	2.0	1.7	32%	1	M6-XS369-01-091618	1809475-37	1.9		7%
Trip 8	Red	M6-XS52-01-091118	6.0	5.3	25%	5	M6-XS52-01-091118	1809473-35	3.2		61%
Trip 8	Red	M6-XSG13A-01-091618	4.4	4.5	17%	3	M6-XSG13A-01-091618	1809475-38	3.4		25%
Trip 8	Red	M6-XSG22-01-091618	3.8	3.8	15%	3	M6-XSG22-01-091618	1809475-39	2.9		28%
Trip 8	Red	M7-XSG34-01-091618	4.5	4.3	10%	4	M7-XSG34-01-091618	1809475-40	2.2		69%
Trip 8	Red	M7-XSG41-01-091618	3.0	3.0	22%	2	M7-XSG41-01-091618	1809475-41	1.9		44%
Trip 8	Red	T18-XSG7-01-091518	3.2	3.3	28%	2	T18-XSG7-01-091518	1809475-42	1.8		57%
Trip 8	Red	T19-XS9-01-091118	8.4	8.1	9%	8	T19-XS9-01-091118	1809473-36	2.1		120%
Trip 8	Red	T20-XSG3-01-091118	7.1	7.5	27%	4	T20-XSG3-01-091118	1809473-37	3.4		70%
Trip 8	Red	T21-XSG13-01-091118	5.6	5.3	14%	5	T21-XSG13-01-091118	1809473-38	2.9		63%
Trip 8	Red	T21-XSG26-01-091118	4.1	4.0	22%	3	T21-XSG26-01-091118	1809473-39	2.4	J	52%
Trip 8	Red	T22-XS20-01-091118	7.4	7.2	15%	6	T22-XS20-01-091118	1809473-15	2.2		108%
Trip 8	Red	T23-XSG26-01-091118	4.0	3.8	22%	3	T23-XSG26-01-091118	1809473-16	1.7		81%
Trip 8	Red	T23-XSG7-01-091118	4.4	4.3	16%	4	T23-XSG7-01-091118	1809473-17	2.3		63%
Trip 8	Red	T24-XSG2-01-091118	4.0	3.9	26%	2	T24-XSG2-01-091118	1809473-18	2.3		54%
Trip 8	Red	T24-XSG26-01-091118	6.8	6.9	11%	6	T24-XSG26-01-091118	1809473-19	1.5		128%
Trip 8	Red	T26-XSG2-01-091518	3.0	2.7	31%	2	T26-XSG2-01-091518	1809475-43	2.3		28%
Trip 8	Red	T26-XSG9-01-091518	3.7	3.5	21%	3	T26-XSG9-01-091518	1809475-44	2.2		50%
Trip 9	Red	M10-XSG2-01-092818	3.6	3.6	22%	3	M10-XSG2-01-092818	1810122-1	2.7		29%
Trip 9	Blue	M10-XSG4-01-092818	5.3	5.3	17%	4	M10-XSG4-01-092818	1810122-2	2.6		68%
Trip 9	Blue	M11-XSG2-01-092818	3.8	3.8	20%	3	M11-XSG2-01-092818	1810122-4	2.4		45%
Trip 9	Blue	M11-XSG25-01-092818	3.9	3.9	25%	3	M11-XSG25-01-092818	1810122-5	1.8		74%
Trip 9	Blue	M11-XSG28-01-092818	7.2	7.3	15%	6	M11-XSG28-01-092818	1810122-6	4.3		50%
Trip 9	Red	M11-XSG33-01-092818	3.0	3.1	18%	2	M11-XSG33-01-092818	1810122-7	2.1		34%
Trip 9	Red	M12-XSG26-01-092818	4.2	4.2	23%	3	M12-XSG26-01-092818	1810122-8	2.9		36%
Trip 9	Blue	M14-XSR1-01-093018	4.3	3.8	30%	3	M14-XSR1-01-093018	1810072-21	2.0		74%
Trip 9	White	M15-XSR1-01-093018	3.4	3.3	17%	3	M15-XSR1-01-093018	1810072-22	2.0		51%
Trip 9	White	M16-XSR1-01-093018	3.4	3.3	20%	2	M16-XSR1-01-093018	1810072-23	1.8		61%
Trip 9	White	M16-XSR6-01-093018	4.1	4.2	14%	3	M16-XSR6-01-093018	1810072-24	1.8		77%
Trip 9	Blue	M17-XSR1-01-093018	5.0	5.2	12%	4	M17-XSR1-01-093018	1810072-25	2.4		70%
Trip 9	Red	M19-XSR2-01-093018	4.4	4.6	16%	3	M19-XSR2-01-093018	1810072-26	2.8		45%
Trip 9	Blue	M19-XSR2-02-093018	5.0	4.8	15%	4	M19-XSR2-02-093018	1810072-27	2.8		56%
Trip 9	Red	M1-XSG4-01-092818	2.3	2.4	19%	2	M1-XSG4-01-092818	1810072-1	1.4		50%
Trip 9	Blue	M20-XSR2-01-093018	4.8	4.8	26%	3	M20-XSR2-01-093018	1810072-28	2.8		53%
Trip 9	White	M23-XSR4-01-093018	4.7	4.8	20%	3	M23-XSR4-01-093018	1810072-29	2.5		60%
Trip 9	Red	M24-XS112-01-092518	4.2	4.6	34%	2	M24-XS112-01-092518	1810032-1	3.1		30%
Trip 9	Red	M24-XS114-01-092518	3.5	3.4	22%	2	M24-XS114-01-092518	1810032-2	2.4		37%
Trip 9	Red	M24-XSG15-01-092518	3.5	3.4	15%	3	M24-XSG15-01-092518	1810032-3	2.4		37%
Trip 9	Red	M24-XSG3-01-092518	2.5	2.5	10%	2	M24-XSG3-01-092518	1810032-4	1.5		50%
Trip 9	Red	M24-XSG32-01-092518	2.2	2.1	30%	2	M24-XSG32-01-092518	1810032-5	1.5		39%
Trip 9	Red	M24-XSR1-01-093018	3.8	3.8	26%	2	M24-XSR1-01-093018	1810072-30	3.2		17%
Trip 9	Blue	M25-XSG12-01-092818	2.4	2.6	18%	2	M25-XSG12-01-092818	1810122-10	1.9		25%
Trip 9	Blue	M25-XSG19-01-092818	3.8	3.7	20%	3	M25-XSG19-01-092818	1810122-11	2.7		33%
Trip 9	Blue	M25-XSG19-02-092818	3.9	3.8	30%	2	M25-XSG19-02-092818	1810122-12	2.7		36%
Trip 9	Blue	M25-XSG5-01-092818	2.8	2.9	23%	2	M25-XSG5-01-092818	1810122-13	1.4		65%
Trip 9	Red	M27-XS116-01-092618	2.9	2.6	20%	2	M27-XS116-01-092618	1810072-2	2.0		36%
Trip 9	Red	M27-XS149-01-092618	2.7	2.5	24%	2	M27-XS149-01-092618	1810072-3	2.2		20%
Trip 9	Red	M27-XS150-01-092618	2.5	2.6	28%	1	M27-XS150-01-092618	1810072-4	1.8	J	31%
Trip 9	Red	M27-XS163-01-092618	4.2	4.1	16%	3	M27-XS163-01-092618	1810072-5	2.6		48%

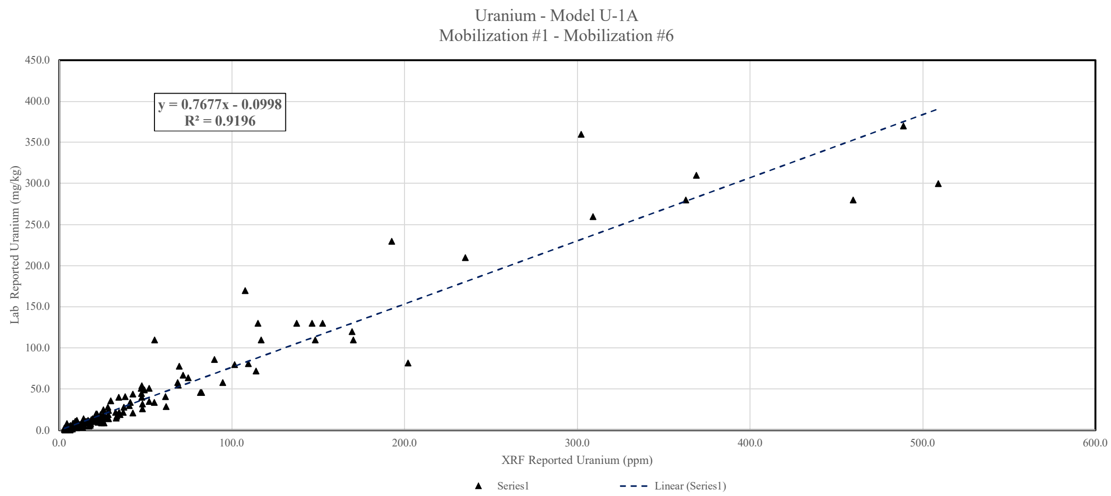
Data Included												
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	Red	M27-XSG28-01-092618	2.7	2.5	21%	2	M27-XSG28-01-092618	1810072-6	2.0		28%
Trip 9	Red	M27-XSG28-02-092618	2.2	2.1	35%	1	M27-XSG28-02-092618	1810072-7	1.9		15%
Trip 9	Red	M27-XSG48-01-092618	7.1	7.1	8%	6	M27-XSG48-01-092618	1810072-8	4.8		38%
Trip 9	Red	M27-XSG6-01-092618	2.6	2.8	26%	2	M27-XSG6-01-092618	1810072-9	1.7		43%
Trip 9	Red, Blue	M28-XS162-01-092818	10.8	10.9	14%	9	M28-XS162-01-092818	1810122-14	7.6		35%
Trip 9	White	M28-XS19-01-092918	4.8	4.4	32%	3	M28-XS19-01-092918	1810122-15	3.6		28%
Trip 9	Red	M28-XS29-01-092618	2.9	2.7	28%	2	M28-XS29-01-092618	1810032-6	2.6		11%
Trip 9	Blue	M28-XSG18-01-092918	3.3	3.3	16%	3	M28-XSG18-01-092918	1810122-16	1.5		75%
Trip 9	Red	M28-XSG49-01-092618	4.4	4.1	32%	3	M28-XSG49-01-092618	1810032-7	3.3		28%
Trip 9	Red, White	M28-XSG54-01-092918	5.9	6.1	11%	5	M28-XSG54-01-092918	1810122-17	3.9		41%
Trip 9	White	M28-XSG76-01-092918	4.5	4.4	17%	4	M28-XSG76-01-092918	1810122-18	2.9		43%
Trip 9	Blue	M28-XSR1-01-093018	3.5	3.4	30%	2	M28-XSR1-01-093018	1810072-31	2.2		47%
Trip 9	Red	M28-XSR1-02-093018	3.2	3.1	23%	2	M28-XSR1-02-093018	1810072-32	2.2		37%
Trip 9	Red	M29-XS19-01-092518	5.5	5.5	14%	4	M29-XS19-01-092518	1810032-9	4.1		29%
Trip 9	Red	M29-XS42-01-092518	3.8	3.7	19%	3	M29-XS42-01-092518	1810032-10	1.9		66%
Trip 9	Red	M29-XS59-01-092518	4.2	3.9	28%	3	M29-XS59-01-092518	1810032-11	3.6		17%
Trip 9	Red	M29-XS64-01-092518	2.3	2.4	23%	2	M29-XS64-01-092518	1810032-12	1.5		44%
Trip 9	Red	M29-XSG25-01-092518	1.7	1.8	21%	1	M29-XSG25-01-092518	1810032-14	1.3		26%
Trip 9	Red	M29-XSG35-01-092518	4.4	4.1	24%	3	M29-XSG35-01-092518	1810032-15	2.3		62%
Trip 9	Blue	M29-XSR4-01-093018	6.5	6.0	20%	5	M29-XSR4-01-093018	1810072-33	3.5		60%
Trip 9	Red	M29-XSR7-01-093018	5.4	5.2	23%	4	M29-XSR7-01-093018	1810072-34	5.2		3%
Trip 9	White	M30-XS144-01-092918	4.8	4.7	19%	3	M30-XS144-01-092918	1810122-19	2.9		49%
Trip 9	White	M30-XS185-01-092918	7.8	7.5	17%	6	M30-XS185-01-092918	1810122-20	4.8		47%
Trip 9	White	M30-XS62-01-092918	4.1	4.5	16%	3	M30-XS62-01-092918	1810122-21	2.2		61%
Trip 9	White	M30-XSG18-01-092918	5.2	5.1	22%	4	M30-XSG18-01-092918	1810122-22	3.6		36%
Trip 9	White	M30-XSG29-01-092918	5.5	5.5	10%	5	M30-XSG29-01-092918	1810122-23	3.6		42%
Trip 9	White	M30-XSG43-01-092918	3.6	3.4	28%	3	M30-XSG43-01-092918	1810122-24	1.9		62%
Trip 9	White	M30-XSG45-01-092918	2.7	2.7	46%	1	M30-XSG45-01-092918	1810122-25	2.1		25%
Trip 9	Red, White	M30-XSG6-01-092918	3.3	3.1	21%	2	M30-XSG6-01-092918	1810122-26	2.5		29%
Trip 9	Blue	M30-XSG61-01-092918	3.4	3.4	31%	2	M30-XSG61-01-092918	1810122-27	1.7		67%
Trip 9	White	M30-XSR5-01-093018	4.1	3.8	20%	3	M30-XSR5-01-093018	1810072-36	2.9		34%
Trip 9	Red	M31-XS1-01-092918	4.6	4.5	19%	4	M31-XS1-01-092918	1810122-28	3.3		33%
Trip 9	Blue	M31-XS39-01-092918	4.2	4.1	39%	2	M31-XS39-01-092918	1810122-29	2.8		41%
Trip 9	White	M31-XS8-01-092918	5.7	5.7	8%	5	M31-XS8-01-092918	1810122-30	3.3		54%
Trip 9	White	M31-XSG1-01-092918	2.8	2.6	22%	2	M31-XSG1-01-092918	1810122-31	1.8		42%
Trip 9	White	M31-XSG12-01-092918	4.4	4.6	15%	3	M31-XSG12-01-092918	1810122-32	3.0		39%
Trip 9	White	M31-XSG17-01-092918	3.3	3.4	21%	2	M31-XSG17-01-092918	1810122-33	2.1		45%
Trip 9	Red	M31-XSG9-01-092918	2.3	2.4	14%	2	M31-XSG9-01-092918	1810122-34	1.5		43%
Trip 9	Red	M32-XSG23-01-092918	5.5	5.6	19%	4	M32-XSG23-01-092918	1810072-10	3.4		47%
Trip 9	Red	M32-XSG26-01-092918	3.8	3.9	23%	2	M32-XSG26-01-092918	1810072-11	2.2		54%
Trip 9	Red	M32-XSG34-01-092918	5.1	5.3	10%	4	M32-XSG34-01-092918	1810072-12	3.8		29%
Trip 9	Red	M32-XSG46-01-092918	3.5	3.5	17%	3	M32-XSG46-01-092918	1810072-13	2.6		29%
Trip 9	Red	M32-XSG9-01-092918	4.0	3.8	30%	2	M32-XSG9-01-092918	1810072-14	2.5		46%
Trip 9	Red	M34-XSG15-01-092718	4.1	4.2	15%	3	M34-XSG15-01-092718	1810072-15	2.6		44%
Trip 9	Red	M35-XSG20-01-092718	4.2	4.2	19%	3	M35-XSG20-01-092718	1810072-16	4.1		2%
Trip 9	Red	M35-XSG4-01-092718	2.7	2.4	51%	2	M35-XSG4-01-092718	1810072-17	2.5		8%
Trip 9	Red	M36-XSG1-01-092718	4.3	4.3	12%	4	M36-XSG1-01-092718	1810072-18	3.0		37%
Trip 9	White	M6-XSR1-01-093018	2.8	2.7	18%	2	M6-XSR1-01-093018	1810072-37	1.7		48%
Trip 9	White	M7-XSR1-01-093018	4.6	4.4	15%	4	M7-XSR1-01-093018	1810072-38	2.5		59%
Trip 9	White	M7-XSR1-02-093018	4.3	4.1	10%	4	M7-XSR1-02-093018	1810072-39	2.4		56%
Trip 9	Blue	M8-XSR1-01-093018	6.3	6.4	29%	3	M8-XSR1-01-093018	1810072-40	4.4		35%
Trip 9	White	T17-XSR1-01-093018	2.8	2.8	13%	2	T17-XSR1-01-093018	1810072-41	1.8		44%
Trip 9	Red	T30-XS20-01-092518	4.8	4.9	23%	3	T30-XS20-01-092518	1810032-16	2.5		63%
Trip 9	Red	T30-XS28-01-092518	4.2	4.1	14%	4	T30-XS28-01-092518	1810032-17	2.7		44%
Trip 9	Red	T30-XS8-01-092518	3.8	3.9	23%	2	T30-XS8-01-092518	1810032-18	2.3		50%
Trip 9	Red	T31-XSG7-01-092518	3.4	3.4	22%	3	T31-XSG7-01-092518	1810032-19	2.3		38%
Trip 9	Red	T31-XSG9-01-092518	3.7	3.4	30%	3	T31-XSG9-01-092518	1810032-20	2.2		51%
Trip 9	Red	T5-XSG3-01-092818	2.8	2.7	17%	2	T5-XSG3-01-092818	1810072-19	2.0		32%
Trip 9	Red	T5-XSG3-02-092818	2.7	2.7	37%	2	T5-XSG3-02-092818	1810072-20	1.9		35%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Pink	M37-XS31-01-081318	1.8	2.0	52%	0	M37-XS31-01-081318	1808303-20	1.0		55%
Trip 7	Red	M4-XS210-01-081818	1.2	1.2	55%	0	M4-XS210-01-081818	1808483-3	1.2		4%
Trip 7	Red	M4-XSG11-01-081818	1.7	1.7	58%	0	M4-XSG11-01-081818	1808483-4	1.2		32%
Trip 7	Red	M5-XS15-01-081818	1.5	1.7	57%	0	M5-XS15-01-081818	1808483-6	1.4		9%
Trip 7	Red	M5-XS199-01-082018	1.4	1.8	82%	0	M5-XS199-01-082018	1808487-2	1.6		13%
Trip 7	Red	M5-XS263-01-082018	1.9	2.4	75%	0	M5-XS263-01-082018	1808487-5	1.9		1%
Trip 7	Red	M8-XSG6-01-081518	2.0	2.0	65%	0	M8-XSG6-01-081518	1808476-11	1.9		7%
Trip 7	Red	T4-XSG39-01-081918	1.5	1.7	54%	0	T4-XSG39-01-081918	1808483-17	1.3		16%
Trip 7	Red	T6-XSG6-02-081918	1.2	1.4	90%	0	T6-XSG6-02-081918	1808487-11	1.3		5%
Trip 8	Red	M13-XS258-01-091518	2.0	2.3	61%	0	M13-XS258-01-091518	1809475-2	1.4		36%
Trip 8	Red	M16-XSG38-01-091518	0.3	0.0	245%	0	M16-XSG38-01-091518	1809475-4	0.8		84%
Trip 8	Red	M17-XSG36-01-091318	1.6	1.8	89%	0	M17-XSG36-01-091318	1809473-4	1.2		29%
Trip 8	Red	M20-XS146-01-091718	1.7	2.1	51%	0	M20-XS146-01-091718	1809475-28	1.9	J	9%
Trip 8	Red	M20-XS243-01-091718	2.1	2.3	54%	0	M20-XS243-01-091718	1809475-29	1.7		19%
Trip 8	Red	M20-XSG7-01-091418	1.3	1.6	82%	0	M20-XSG7-01-091418	1809475-9	1.3		2%
Trip 8	Red	M21-XS366-01-091418	1.7	1.7	57%	0	M21-XS366-01-091418	1809475-10	1.4		19%
Trip 8	Red	M21-XS366-02-091418	1.6	1.8	51%	0	M21-XS366-02-091418	1809475-11	1.4		12%
Trip 8	Red	M21-XSG43-01-091418	1.8	2.0	56%	0	M21-XSG43-01-091418	1809475-13	1.2		37%
Trip 9	Red	M11-XS47-01-092818	1.8	2.3	81%	0	M11-XS47-01-092818	1810122-3	2.1		16%
Trip 9	White	M2-XSR3-01-093018	2.4	2.6	54%	0	M2-XSR3-01-093018	1810072-35	1.4		54%
Trip 9	Red	M28-XSG7-01-092618	1.6	1.8	84%	0	M28-XSG7-01-092618	1810032-8	1.7		7%
Trip 9	Red	M29-XSG1-01-092518	0.7	0.7	110%	0	M29-XSG1-01-092518	1810032-13	1.1		42%

Removed Data - Outliers											
			XRF - Thorium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	T1-XSG5A-01-081918	19.9	2.8	227%	2	T1-XSG5A-01-081918	1808483-15	1.9		165%
Trip 9	Red	M12-XSG3-01-092818	29.0	5.5	200%	5	M12-XSG3-01-092818	1810122-9	3.4		158%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence



Data Included in Model U-1A												
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS32-01-042418	5.8	5.9	22%	4	M2-XS32-01-042418	1805041-3	4.8		19%
Trip 1	Pink	M3-XS34-01-043018	19.5	19.9	14%	16	M3-XS34-01-043018	1805042-1	11.0		56%
Trip 1	Pink	M3-XS36-01-043018	25.6	25.2	11%	22	M3-XS36-01-043018	1805042-2	25.0		2%
Trip 1	Pink	M6-XS140-01-042818	21.8	21.2	24%	16	M6-XS140-01-042818	1805041-6	20.0		9%
Trip 1	Orange	M6-XS159-01-04262018	52.0	52.5	13%	44	M6-XS159-01-04262018	1805039-1	51.0		2%
Trip 1	Pink	M6-XS251-01-04272018	10.0	9.6	10%	9	M6-XS251-01-04272018	1805039-2	7.6		28%
Trip 1	Pink	M6-XS269-02-04262018	21.3	20.7	24%	17	M6-XS269-02-04262018	1805039-4	20.0	J	6%
Trip 1	Pink	M6-XS285-01-04272018	235.1	211.9	34%	173	M6-XS285-01-04272018	1805039-5	210.0		11%
Trip 1	Pink	T10-XS1-01-042518	3.3	3.2	4%	3	T10-XS1-01-042518	1805036-1	0.9		116%
Trip 1	Pink	T10-XS56-01-042518	3.3	3.3	18%	3	T10-XS56-01-042518	1805036-4	0.6		135%
Trip 1	Pink	T10-XS78-01-042518	3.7	3.7	20%	2	T10-XS78-01-042518	1805036-5	0.7		136%
Trip 1	Pink	T11-XS1-01-042518	3.3	3.2	32%	2	T11-XS1-01-042518	1805036-6	0.5		151%
Trip 1	Pink	T17-XS1-01-04262018	3.9	4.0	10%	3	T17-XS1-01-04262018	1805039-6	2.1		60%
Trip 1	Pink	T17-XS1-02-04262018	4.3	4.2	25%	3	T17-XS1-02-04262018	1805039-7	1.9		77%
Trip 1	Pink	T17-XS143-01-04262018	47.9	46.6	9%	44	T17-XS143-01-04262018	1805039-8	40.0		18%
Trip 1	Orange	T17-XS144-01-04262018	68.6	67.2	11%	59	T17-XS144-01-04262018	1805039-9	58.0		17%
Trip 1	Pink	T17-XS194-01-04272018	3.0	2.8	36%	2	T17-XS194-01-04272018	1805039-10	2.7	J	10%
Trip 1	Pink	T17-XS194-02-04272018	3.5	3.3	27%	2	T17-XS194-02-04272018	1805039-11	1.4	J	86%
Trip 1	Pink	T17-XS20-01-04262018	17.3	17.5	12%	14	T17-XS20-01-04262018	1805039-12	11.0		44%
Trip 1	Pink	T17-XS251-01-04272018	23.9	24.7	11%	20	T17-XS251-01-04272018	1805039-13	19.0		23%
Trip 1	Pink	T17-XS257-01-04272018	15.0	15.3	10%	13	T17-XS257-01-04272018	1805039-14	9.2		48%
Trip 1	Pink	T17-XS273-01-042818	4.5	4.2	33%	3	T17-XS273-01-042818	1805041-8	2.5		56%
Trip 1	Pink	T17-XS287-01-04272018	26.7	26.4	14%	22	T17-XS287-01-04272018	1805039-15	16.0		50%
Trip 1	Pink	T17-XS317-01-04272018	23.0	23.4	11%	19	T17-XS317-01-04272018	1805039-16	16.0		36%
Trip 1	Pink	T17-XS328-01-04272018	7.9	8.0	22%	6	T17-XS328-01-04272018	1805039-17	4.1		63%
Trip 1	Pink	T17-XS369-01-043018	3.4	3.5	19%	2	T17-XS369-01-043018	1805042-4	0.7		131%
Trip 1	Pink	T17-XS377-01-042818	37.1	35.5	12%	32	T17-XS377-01-042818	1805041-10	22.0		51%
Trip 1	Pink	T17-XS393-01-043018	4.6	4.7	29%	3	T17-XS393-01-043018	1805042-5	2.2	J	71%
Trip 1	Pink	T17-XS417-01-04272018	4.9	4.5	25%	4	T17-XS417-01-04272018	1805039-18	2.9	J	52%
Trip 1	Pink	T17-XS438-01-042818	5.4	5.5	39%	2	T17-XS438-01-042818	1805041-11	2.8		64%
Trip 1	Pink	T17-XS44-01-04262018	5.4	4.9	34%	4	T17-XS44-01-04262018	1805039-19	2.8		64%
Trip 1	Pink	T17-XS442-01-04272018	15.6	15.5	17%	12	T17-XS442-01-04272018	1805039-20	11.0		35%
Trip 1	Pink	T17-XS46-01-042618	6.1	6.1	13%	5	T17-XS46-01-042618	1805041-12	2.7		78%
Trip 1	Pink	T17-XS473-01-042818	19.3	18.7	24%	13	T17-XS473-01-042818	1805041-13	14.0		32%
Trip 1	Pink	T17-XS479-01-042818	6.5	6.5	15%	6	T17-XS479-01-042818	1805041-14	5.8		12%
Trip 1	Pink	T17-XS479-02-042818	8.4	8.3	11%	7	T17-XS479-02-042818	1805041-15	4.7		56%
Trip 1	Pink	T17-XS679-01-043018	5.5	6.1	21%	4	T17-XS679-01-043018	1805042-7	2.0		94%
Trip 1	Pink	T17-XS704-01-043018	3.6	3.6	33%	2	T17-XS704-01-043018	1805042-8	0.5		148%
Trip 1	Pink	T9-XS217-01-042518	3.8	3.9	13%	3	T9-XS217-01-042518	1805036-17	0.6		148%
Trip 1	Pink	T9-XS61-01-042518	21.2	21.1	22%	16	T9-XS61-01-042518	1805036-18	13.0		48%
Trip 1	Orange	T9-XS61-02-042518	15.8	15.6	16%	13	T9-XS61-02-042518	1805041-17	9.7		48%
Trip 1	Pink	T9-XS86-01-042518	6.5	6.3	16%	6	T9-XS86-01-042518	1805036-19	1.6		121%
Trip 1	Pink	T9-XS93-01-042518	16.5	16.4	5%	15	T9-XS93-01-042518	1805036-20	11.0		40%
Trip 2	Pink	M1-XS32-01-051218	25.6	23.9	25%	20	M1-XS32-01-051218	1805328-2	19.0		30%
Trip 2	Pink	M4-XS136-01-050918	47.8	47.1	6%	44	M4-XS136-01-050918	1805322-1	54.0		12%
Trip 2	Pink	M4-XS18-01-050718	4.9	4.3	36%	3	M4-XS18-01-050718	1805322-2	1.4		112%
Trip 2	Orange	M4-XS219-01-051018	16.3	15.0	29%	13	M4-XS219-01-051018	1805322-3	11.0		39%
Trip 2	Pink	M4-XS238-01-051018	18.2	16.8	26%	14	M4-XS238-01-051018	1805322-4	8.0		78%
Trip 2	Pink	M4-XS4-01-050718	3.7	3.6	35%	2	M4-XS4-01-050718	1805322-5	1.6		79%
Trip 2	Pink	M4-XS45-01-050718	18.5	15.3	49%	10	M4-XS45-01-050718	1805322-6	12.0		43%

Data Included in Model U-1A											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 2	Pink	M4-XS63-02-050718	116.9	114.4	12%	98	M4-XS63-02-050718	1805322-8	110.0	J	6%
Trip 2	Pink	M4-XS78-01-051018	69.4	69.7	17%	57	M4-XS78-01-051018	1805322-9	78.0		12%
Trip 2	Orange	M5-XS115-01-051118	47.5	46.8	4%	45	M5-XS115-01-051118	1805322-10	51.0		7%
Trip 2	Pink	M5-XS385-01-051118	3.0	3.1	18%	2	M5-XS385-01-051118	1805322-11	1.2		86%
Trip 2	Pink	M5-XS69-01-051118	9.8	9.3	15%	8	M5-XS69-01-051118	1805322-12	6.0		48%
Trip 2	Pink	M7-XS181-01-051018	41.2	43.3	17%	29	M7-XS181-01-051018	1805322-16	34.0		19%
Trip 2	Orange	M7-XS181-02-051018	29.8	30.0	18%	22	M7-XS181-02-051018	1805322-17	36.0		19%
Trip 2	Orange	M7-XS39-01-051018	4.4	4.3	16%	4	M7-XS39-01-051018	1805322-18	1.7		88%
Trip 2	Orange	M7-XS74-01-051018	8.7	8.3	13%	8	M7-XS74-01-051018	1805322-19	5.7		41%
Trip 2	Orange	M7-XS77-01-051018	8.9	8.3	19%	7	M7-XS77-01-051018	1805322-20	3.7		83%
Trip 2	Pink	M8-XS100-01-050918	4.8	5.0	16%	4	M8-XS100-01-050918	1805328-3	1.9		86%
Trip 2	Pink	M8-XS102-01-050918	24.4	24.5	10%	21	M8-XS102-01-050918	1805328-4	8.8		94%
Trip 2	Pink	M8-XS102-02-050918	26.0	25.6	5%	25	M8-XS102-02-050918	1805328-5	8.8		99%
Trip 2	Orange	M8-XS19-01-051018	6.6	6.4	6%	6	M8-XS19-01-051018	1805328-7	2.8		81%
Trip 2	Orange	M8-XS32-01-051018	22.5	23.1	8%	19	M8-XS32-01-051018	1805328-8	11.0		69%
Trip 2	Pink	M8-XS94-01-050918	34.4	35.1	23%	23	M8-XS94-01-050918	1805328-9	40.0		15%
Trip 2	Pink	T14-XS12-01-050818	3.4	3.7	17%	3	T14-XS12-01-050818	1805322-23	0.5		152%
Trip 2	Pink	T15-XS2-01-050818	3.7	3.4	38%	2	T15-XS2-01-050818	1805322-25	0.7		137%
Trip 2	Pink	T17-XS122-01-050718	5.6	4.2	55%	3	T17-XS122-01-050718	1805322-27	2.3		83%
Trip 2	Pink	T17-XS176-01-050718	4.7	4.7	30%	3	T17-XS176-01-050718	1805322-28	3.1		42%
Trip 2	Pink	T17-XS645-01-050718	4.2	4.6	26%	2	T17-XS645-01-050718	1805322-32	1.7		85%
Trip 2	Pink	T17-XS669-01-050718	3.4	3.6	21%	2	T17-XS669-01-050718	1805322-33	2.5		30%
Trip 2	Pink	T1-XS104-01-051318	10.8	10.6	15%	9	T1-XS104-01-051318	1805328-10	4.6		81%
Trip 2	Pink	T1-XS20-01-051318	5.8	6.1	18%	4	T1-XS20-01-051318	1805328-11	2.2		90%
Trip 2	Pink	T1-XS54-01-051318	17.9	18.4	10%	15	T1-XS54-01-051318	1805328-12	9.5		61%
Trip 2	Pink	T1-XS54-02-051318	16.8	17.1	9%	15	T1-XS54-02-051318	1805328-13	11.0		42%
Trip 2	Pink	T1-XS69-01-051318	101.6	99.2	11%	90	T1-XS69-01-051318	1805328-14	80.0		24%
Trip 2	Orange	T3-XS10-01-051218	4.3	4.6	27%	2	T3-XS10-01-051218	1805328-15	0.8		138%
Trip 2	Orange	T3-XS5-01-051218	3.7	3.7	15%	3	T3-XS5-01-051218	1805328-16	0.5		152%
Trip 2	Pink	T4-XS23-01-051218	7.5	7.2	14%	6	T4-XS23-01-051218	1805328-17	3.1		83%
Trip 2	Orange	T4-XS32-01-051218	8.3	8.3	6%	7	T4-XS32-01-051218	1805328-18	4.5		59%
Trip 2	Pink	T4-XS43-01-051218	34.4	34.5	3%	33	T4-XS43-01-051218	1805328-19	20.0		53%
Trip 2	Pink	T5-XS18-01-051418	7.4	7.5	17%	6	T5-XS18-01-051418	1805328-20	3.1		82%
Trip 2	Orange	T6-XS25-01-051218	3.9	4.2	25%	3	T6-XS25-01-051218	1805328-22	0.9		123%
Trip 3	Pink	M14-XS36-01-052418	148.2	146.8	5%	137	M14-XS36-01-052418	1805632-1	110.0		30%
Trip 3	Pink	M14-XS40-01-052418	146.4	138.0	19%	121	M14-XS40-01-052418	1805632-2	130.0		12%
Trip 3	Pink	M14-XS64-01-052418	69.0	71.7	11%	56	M14-XS64-01-052418	1805632-3	55.0	J	23%
Trip 3	Pink	M14-XS67-01-052418	169.5	144.0	38%	129	M14-XS67-01-052418	1805632-4	120.0		34%
Trip 3	Pink	M15-XS22-01-052118	152.6	150.7	8%	138	M15-XS22-01-052118	1805589-1	130.0		16%
Trip 3	Pink	M15-XS3-01-052118	42.7	41.3	11%	38	M15-XS3-01-052118	1805589-2	44.0		3%
Trip 3	Pink	M15-XS46-01-052118	13.8	13.6	10%	12	M15-XS46-01-052118	1805589-3	9.7		35%
Trip 3	Pink	M15-XS46-02-052118	14.6	14.1	19%	11	M15-XS46-02-052118	1805589-4	9.6		41%
Trip 3	Pink	M15-XS82-01-052118	23.6	23.8	5%	22	M15-XS82-01-052118	1805589-6	13.0		58%
Trip 3	Pink	M15-XS93-01-052118	115.0	107.5	29%	83	M15-XS93-01-052118	1805589-7	130.0		12%
Trip 3	Pink	M16-XS128-01-052118	137.5	141.9	34%	68	M16-XS128-01-052118	1805589-8	130.0		6%
Trip 3	Pink	M16-XS154-01-052618	61.4	61.0	7%	56	M16-XS154-01-052618	1806235-2	41.0		40%
Trip 3	Pink	M16-XS177-01-052618	40.6	41.6	12%	32	M16-XS177-01-052618	1806235-3	30.0		30%
Trip 3	Pink	M16-XS191-01-052618	48.1	49.1	4%	44	M16-XS191-01-052618	1806235-4	32.0		40%
Trip 3	Pink	M16-XS30-01-052118	28.6	27.6	12%	25	M16-XS30-01-052118	1805589-10	24.0		17%
Trip 3	Pink	M16-XS31-01-052118	12.0	11.6	13%	11	M16-XS31-01-052118	1805589-11	7.1		51%
Trip 3	Pink	M16-XS4-01-052118	14.0	13.5	10%	13	M16-XS4-01-052118	1805589-12	14.0		0%
Trip 3	Pink	M17-XS55-01-052618	309.1	310.3	6%	286	M17-XS55-01-052618	1806235-6	260.0		17%
Trip 3	Pink	M17-XS83-01-052618	362.7	361.3	3%	353	M17-XS83-01-052618	1806235-7	280.0		26%
Trip 3	Pink	M17-XS83-02-052618	368.8	365.1	7%	335	M17-XS83-02-052618	1806235-8	310.0		17%
Trip 3	Pink	M18-XS155-01-052518	6.5	6.1	21%	5	M18-XS155-01-052518	1805632-5	3.4		63%
Trip 3	Pink	M19-XS22-01-052318	488.7	466.7	15%	421	M19-XS22-01-052318	1805632-7	370.0		28%
Trip 3	Pink	M19-XS43-01-052318	52.0	53.0	27%	34	M19-XS43-01-052318	1805632-9	35.0		39%
Trip 3	Blue	T20-XS14-01-052218	6.3	6.2	13%	5	T20-XS14-01-052218	1805632-10	0.5		170%
Trip 3	Blue	T21-XS35-01-052118	9.3	9.3	4%	9	T21-XS35-01-052118	1805589-14	11.0		17%
Trip 3	Blue	T21-XS55-01-052118	7.9	7.7	6%	7	T21-XS55-01-052118	1805589-15	8.7		10%
Trip 3	Pink	T21-XS55-02-052118	11.4	10.5	23%	9	T21-XS55-02-052118	1805589-16	6.7		52%
Trip 3	Blue	T21-XS6-01-052118	8.1	7.9	12%	7	T21-XS6-01-052118	1805589-17	3.7		75%
Trip 3	Blue	T22-XS17-01-052118	7.7	7.5	10%	7	T22-XS17-01-052118	1805589-18	1.5		134%
Trip 3	Pink	T23-XS23-01-052118	21.3	20.9	12%	18	T23-XS23-01-052118	1805589-19	17.0		22%
Trip 3	Pink	T23-XS40-01-052118	20.5	19.2	20%	17	T23-XS40-01-052118	1805589-20	15.0		31%
Trip 3	Pink	T24-XS48-01-052418	13.5	13.1	12%	12	T24-XS48-01-052418	1805632-12	3.6		116%
Trip 3	Pink	M19-XS22-02-052318	459.6	418.7	17%	399	M19-XS22-02-052318	1805632-8	280.0		49%
Trip 3	Pink	M18-XS161-01-052518	509.1	521.9	35%	285	M18-XS161-01-052518	1805632-6	300.0		52%
Trip 4	Pink	M13-XS72-01-060618	5.8	5.2	26%	4	M13-XS72-01-060618	1806235-1	1.5		118%
Trip 4	Pink	M20-XS11-01-060618	6.8	6.9	19%	5	M20-XS11-01-060618	1806235-9	3.8		56%
Trip 4	Pink	M20-XS130-01-060418	3.6	3.8	26%	2	M20-XS130-01-060418	1806235-10	1.4		88%
Trip 4	Pink	M20-XS166-01-060518	35.3	34.5	7%	32	M20-XS166-01-060518	1806235-11	19.0		60%
Trip 4	Pink	M20-XS18-01-060618	33.0	24.2	55%	21	M20-XS18-01-060618	1806235-12	15.0		75%
Trip 4	Pink	M20-XS231-01-060418	3.5	3.6	15%	3	M20-XS231-01-060418	1806235-14	1.1		104%

Data Included in Model U-1A											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M20-XS306-01-060518	4.7	4.9	19%	3	M20-XS306-01-060518	1806235-16	1.0		133%
Trip 4	Pink	M20-XS312-01-060518	14.7	13.9	20%	12	M20-XS312-01-060518	1806235-17	9.6		42%
Trip 4	Pink	M20-XS365-01-060618	74.7	74.7	5%	70	M20-XS365-01-060618	1806235-18	64.0		15%
Trip 4	Pink	M20-XS365-02-060618	82.5	81.0	13%	70	M20-XS365-02-060618	1806235-19	46.0		57%
Trip 4	Pink	M20-XS5-01-060518	10.7	10.4	17%	9	M20-XS5-01-060518	1806235-20	4.2		87%
Trip 4	Pink	M20-XS86-01-060618	8.9	8.3	22%	7	M20-XS86-01-060618	1806235-21	5.0		56%
Trip 4	Pink	M21-XS122-01-060818	4.8	5.1	24%	3	M21-XS122-01-060818	1806234-1	0.9		139%
Trip 4	Pink	M21-XS126-01-060818	33.3	32.9	19%	23	M21-XS126-01-060818	1806234-2	17.0		65%
Trip 4	Pink	M21-XS14-01-060818	22.4	22.3	13%	19	M21-XS14-01-060818	1806234-3	9.8		78%
Trip 4	Pink	M21-XS175-01-060818	4.7	4.7	28%	3	M21-XS175-01-060818	1806234-4	1.6		99%
Trip 4	Pink	M21-XS225-01-060518	28.6	28.0	22%	21	M21-XS225-01-060518	1806235-22	14.0		68%
Trip 4	Pink	M21-XS259-01-060918	38.2	37.0	12%	33	M21-XS259-01-060918	1806234-5	41.0		7%
Trip 4	Pink	M21-XS260-01-060918	17.5	17.7	7%	16	M21-XS260-01-060918	1806234-6	10.0		55%
Trip 4	Pink	M21-XS27-01-060818	8.2	8.1	8%	7	M21-XS27-01-060818	1806234-7	4.3		63%
Trip 4	Pink	M21-XS27-02-060818	8.3	8.2	16%	6	M21-XS27-02-060818	1806234-8	4.6		57%
Trip 4	Pink	M21-XS282-01-060918	26.7	26.9	2%	26	M21-XS282-01-060918	1806234-9	16.0		50%
Trip 4	Pink	M21-XS290-01-060918	10.2	10.2	10%	9	M21-XS290-01-060918	1806234-10	3.3		102%
Trip 4	Pink	M21-XS292-01-060518	18.9	19.5	10%	16	M21-XS292-01-060518	1806235-23	11.0		53%
Trip 4	Pink	M21-XS302-01-060918	55.0	54.5	14%	45	M21-XS302-01-060918	1806234-11	34.0	J	47%
Trip 4	Pink	M21-XS334-01-060918	12.9	12.6	12%	11	M21-XS334-01-060918	1806234-13	6.3		69%
Trip 4	Pink	M21-XS377-01-060918	11.6	12.0	8%	10	M21-XS377-01-060918	1806234-14	4.8		83%
Trip 4	Pink	M21-XS40-01-060818	48.1	48.3	6%	44	M21-XS40-01-060818	1806234-15	26.0		60%
Trip 4	Pink	M21-XS403-01-060818	109.6	108.6	29%	62	M21-XS403-01-060818	1806234-16	81.0		30%
Trip 4	Pink	M21-XS419-01-060818	10.6	10.4	10%	9	M21-XS419-01-060818	1806234-17	3.4		103%
Trip 4	Pink	M21-XS477-01-060818	114.0	106.4	21%	89	M21-XS477-01-060818	1806234-19	72.0		45%
Trip 4	Pink	M21-XS541-01-060818	6.6	6.5	19%	5	M21-XS541-01-060818	1806234-20	2.9		77%
Trip 4	Pink	M21-XS596-01-060518	18.6	18.3	17%	14	M21-XS596-01-060518	1806235-24	13.0		35%
Trip 4	Pink	M21-XS615-01-060518	11.0	11.1	10%	10	M21-XS615-01-060518	1806235-25	6.0		59%
Trip 4	Pink	M21-XS619-01-060618	24.4	25.5	21%	17	M21-XS619-01-060618	1806235-26	15.0		48%
Trip 4	Pink	M22-XS14-01-060418	25.2	25.6	8%	22	M22-XS14-01-060418	1806235-27	14.0		57%
Trip 4	Pink	M22-XS30-01-060418	13.2	12.9	16%	11	M22-XS30-01-060418	1806235-28	7.2		59%
Trip 4	Pink	M22-XS40-01-060518	12.5	13.4	26%	6	M22-XS40-01-060518	1806235-29	6.7		60%
Trip 4	Pink	M22-XS87-01-060418	15.8	15.4	9%	14	M22-XS87-01-060418	1806235-31	8.4		61%
Trip 4	Pink	M23-XS102-01-061018	4.6	4.9	24%	2	M23-XS102-01-061018	1806233-1	1.3		112%
Trip 4	Pink	M23-XS54-01-061118	89.9	90.2	7%	80	M23-XS54-01-061118	1806312-1	86.0		4%
Trip 4	Pink	M23-XS79-01-061018	18.3	17.0	36%	9	M23-XS79-01-061018	1806233-7	11.0		50%
Trip 4	Pink	T25-XS2-01-060618	3.1	2.8	23%	2	T25-XS2-01-060618	1806235-32	0.9		113%
Trip 4	Pink	T26-XS1-01-061018	9.3	8.9	15%	8	T26-XS1-01-061018	1806233-8	4.4		72%
Trip 4	Pink	T26-XS8-01-061018	9.5	9.4	17%	8	T26-XS8-01-061018	1806233-9	4.8		66%
Trip 5	Pink	M26-XS13-01-061818	37.4	37.6	4%	35	M26-XS13-01-061818	1806558-1	28.0		29%
Trip 5	Pink	M26-XS25-01-061818	49.3	48.2	8%	46	M26-XS25-01-061818	1806558-2	49.0		1%
Trip 5	Pink	M27-XS108-01-061918	7.7	7.7	19%	6	M27-XS108-01-061918	1806558-3	3.8		68%
Trip 5	Pink	M27-XS109-01-061918	8.2	7.9	19%	7	M27-XS109-01-061918	1806558-4	3.5	J	81%
Trip 5	Pink	M27-XS123-01-061818	6.2	5.0	69%	3	M27-XS123-01-061818	1806558-5	4.1		40%
Trip 5	Pink	M27-XS188-01-061918	8.2	8.2	7%	7	M27-XS188-01-061918	1806558-6	3.4		82%
Trip 5	Pink	M27-XS197-01-061918	9.6	10.0	9%	8	M27-XS197-01-061918	1806558-7	5.4		56%
Trip 5	Pink	M27-XS210-01-061818	3.3	3.1	30%	2	M27-XS210-01-061818	1806558-8	1.5		74%
Trip 5	Pink	M27-XS210-02-061818	3.4	3.5	26%	2	M27-XS210-02-061818	1806558-9	1.5		77%
Trip 5	Pink	M27-XS21-01-061918	34.7	30.6	37%	24	M27-XS21-01-061918	1806558-10	22.0		45%
Trip 5	Pink	M27-XS275-01-061918	71.6	69.3	16%	60	M27-XS275-01-061918	1806558-12	67.0		7%
Trip 5	Pink	M27-XS283-01-061818	94.7	77.2	46%	75	M27-XS283-01-061818	1806558-13	58.0		48%
Trip 5	Pink	M27-XS29-01-061818	10.2	9.3	25%	8	M27-XS29-01-061818	1806558-14	12.0		17%
Trip 5	Pink	M27-XS38-01-061918	170.3	170.0	7%	155	M27-XS38-01-061918	1806558-15	110.0		43%
Trip 5	Pink	M28-XS155-01-062018	23.0	22.5	15%	19	M28-XS155-01-062018	1806558-18	13.0		55%
Trip 5	Pink	M28-XS170-01-062018	18.1	18.2	13%	14	M28-XS170-01-062018	1806558-19	6.2		98%
Trip 5	Pink	M28-XS43-01-062018	32.6	32.1	14%	27	M28-XS43-01-062018	1806558-20	22.0		39%
Trip 5	Pink	M30-XS138-01-062218	42.6	41.0	11%	37	M30-XS138-01-062218	1806693-1	21.0		68%
Trip 5	Pink	M30-XS222-01-062218	8.6	8.9	14%	7	M30-XS222-01-062218	1806693-2	3.7		80%
Trip 6	Pink	M10-XS10A-01-071118	47.6	46.5	10%	41.864	M10-XS10A-01-071118	1807369-1	45.0		6%
Trip 6	Pink	M10-XS31-01-071118	5.8	5.8	9%	5.237	M10-XS31-01-071118	1807369-2	3.2		58%
Trip 6	Pink	M10-XS31-02-071118	5.2	5.1	10%	4.458	M10-XS31-02-071118	1807369-3	3.1		50%
Trip 6	Pink	M11-XS7-01-071118	12.5	12.4	8%	11.128	M11-XS7-01-071118	1807369-5	5.3		81%
Trip 6	Red	M12-XS27-01-071518	4.4	4.6	26%	3	M12-XS27-01-071518	1807369-6	4.0		8%
Trip 6	Pink	M24-XS115-01-071418	20.7	20.7	4%	19.919	M24-XS115-01-071418	1807369-7	12.0		53%
Trip 6	Red	M25-XS23-01-071718	8.6	7.7	23%	7	M25-XS23-01-071718	1807452-2	4.3		67%
Trip 6	Red	M25-XS47-01-071718	11.0	7.7	65%	7	M25-XS47-01-071718	1807452-3	3.8		97%
Trip 6	Red	M25-XS88-01-071718	21.7	22.2	12%	18	M25-XS88-01-071718	1807452-4	17.0		24%
Trip 6	Orange	M30-XS127-01-071618	302.2	296.9	5%	287	M30-XS127-01-071618	1807369-9	360.0		17%
Trip 6	Orange	M30-XS170-01-071618	107.6	99.3	33%	81	M30-XS170-01-071618	1807369-10	170.0		45%
Trip 6	Red	M30-XS95-01-071618	28.2	28.7	21%	22	M30-XS95-01-071618	1807369-11	28.0		1%
Trip 6	Red	M31-XS9-01-071018	13.2	10.1	71%	5	M31-XS9-01-071018	1807369-12	6.2		72%
Trip 6	Orange	M32-XS58-01-071018	16.6	15.5	21%	13	M32-XS58-01-071018	1807369-13	12.0		32%
Trip 6	Red	M32-XS89-01-071018	81.7	78.9	14%	72	M32-XS89-01-071018	1807369-14	46.0	J	56%
Trip 6	Orange	M33-XS22-01-071218	21.8	21.6	10%	20	M33-XS22-01-071218	1807369-15	17.0		25%

Data Included in Model U-1A

Trip	XRF Color	XRF ID	XRF - Uranium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 6	Orange	M33-XS85-01-071218	28.4	22.2	52%	19	M33-XS85-01-071218	1807369-16	19.0		40%
Trip 6	Red	M33-XS93-01-071218	13.6	13.2	9%	12	M33-XS93-01-071218	1807369-17	6.7		68%
Trip 6	Red	T33-XS43-01-071718	14.5	14.2	13%	12	T33-XS43-01-071718	1807452-5	5.3		93%
Trip 6	Pink	M11-XS11-01-071118	192.6	152.1	62%	106.384	M11-XS11-01-071118	1807369-4	230.0		18%
Trip 2	Pink	M8-XS110-01-050918	55.2	51.4	20%	43	M8-XS110-01-050918	1805328-6	110.0		66%
Trip 3	Pink	M16-XS191-02-052618	62.0	63.1	18%	44	M16-XS191-02-052618	1806235-5	29.0		72%
Trip 4	Pink	M20-XS278-01-060418	17.2	18.7	17%	12	M20-XS278-01-060418	1806235-15	5.0		110%
Trip 4	Pink	M21-XS46-01-060818	202.0	191.1	21%	163	M21-XS46-01-060818	1806234-18	82.0		85%
Trip 4	Pink	M24-XS128-01-061118	4.4	4.1	15%	4	M24-XS128-01-061118	1806312-4	8.3		61%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

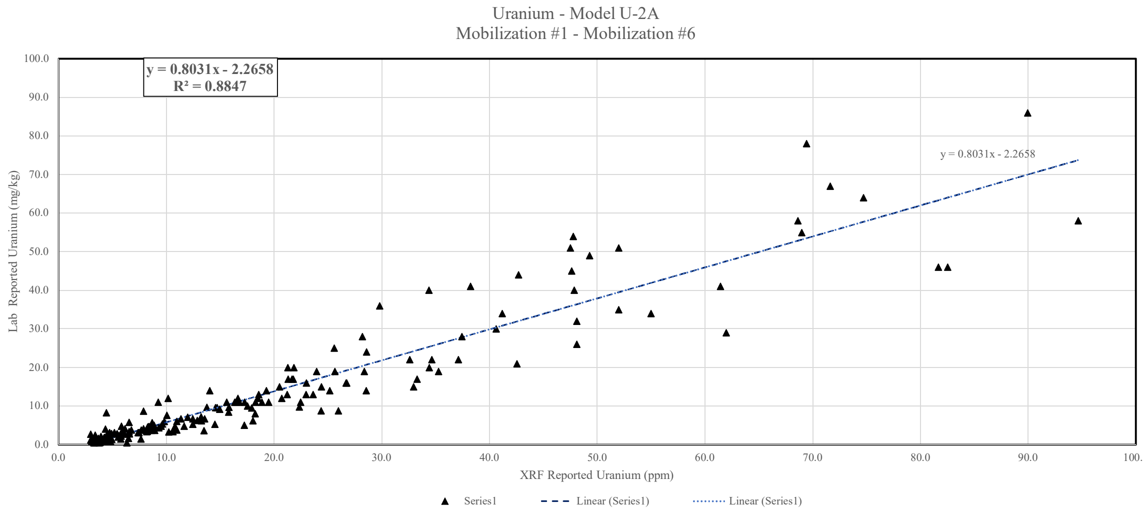
Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Uranium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	M2-XS15-01-042418	0.9	0.0	156%	0	M2-XS15-01-042418	1805041-1	0.7		14%
Trip 1	Pink	M2-XS15-02-042418	0.8	0.0	158%	0	M2-XS15-02-042418	1805041-2	0.6		20%
Trip 1	Pink	M2-XS59-01-042418	0.4	0.0	245%	0	M2-XS59-01-042418	1805041-4	0.7		44%
Trip 1	Pink	M2-XS73-01-042418	1.0	0.0	160%	0	M2-XS73-01-042418	1805041-5	0.6		47%
Trip 1	Pink	T10-XS20-01-042518	1.2	0.0	156%	0	T10-XS20-01-042518	1805036-2	0.4		92%
Trip 1	Pink	T10-XS33-01-042518	2.4	2.5	53%	0	T10-XS33-01-042518	1805036-3	0.8		101%
Trip 1	Pink	T11-XS20-01-042518	2.0	2.3	89%	0	T11-XS20-01-042518	1805036-7	0.4		135%
Trip 1	Pink	T11-XS60-01-042518	0.6	0.0	155%	0	T11-XS60-01-042518	1805036-8	0.2		88%
Trip 1	Pink	T17-XS208-01-042818	3.3	3.1	61%	0	T17-XS208-01-042818	1805041-7	2.0		50%
Trip 1	Pink	T17-XS304-01-042818	2.5	3.1	54%	0	T17-XS304-01-042818	1805041-9	0.8		103%
Trip 1	Pink	T17-XS603-01-042818	2.9	2.6	66%	0	T17-XS603-01-042818	1805041-16	0.6		130%
Trip 1	Pink	T17-XS659-01-043018	2.3	2.6	53%	0	T17-XS659-01-043018	1805042-6	0.6		121%
Trip 1	Pink	T7-XS11-01-042418	1.4	1.9	30%	0	T7-XS11-01-042418	1805036-9	0.4		114%
Trip 1	Pink	T7-XS5-01-042418	1.4	1.7	83%	0	T7-XS5-01-042418	1805036-10	0.4		113%
Trip 1	Pink	T7-XS58-01-042418	0.7	0.0	155%	0	T7-XS58-01-042418	1805036-11	0.4		54%
Trip 1	Pink	T7-XS7-01-042418	1.1	1.0	110%	0	T7-XS7-01-042418	1805036-12	0.4		96%
Trip 1	Pink	T7-XS9-01-042418	0.4	0.0	245%	0	T7-XS9-01-042418	1805036-13	0.4		2%
Trip 1	Pink	T8-XS15-01-042418	1.7	2.2	82%	0	T8-XS15-01-042418	1805036-14	0.7		84%
Trip 1	Pink	T8-XS23-01-042418	2.7	3.1	52%	0	T8-XS23-01-042418	1805036-15	0.7		116%
Trip 1	Pink	T8-XS6-01-042418	1.4	1.8	82%	0	T8-XS6-01-042418	1805036-16	0.4		108%
Trip 2	Orange	M6-XS41-01-051118	1.5	1.8	81%	0	M6-XS41-01-051118	1805322-13	0.4		114%
Trip 2	Pink	M6-XS44-01-051018	2.0	2.7	80%	0	M6-XS44-01-051018	1805322-14	0.7		95%
Trip 2	Pink	M6-XS81-01-051018	1.2	1.8	96%	0	M6-XS81-01-051018	1805322-15	0.6		60%
Trip 2	Pink	T13-XS12-01-050818	2.5	3.2	55%	0	T13-XS12-01-050818	1805322-21	0.7		109%
Trip 2	Pink	T13-XS24-01-050818	2.2	2.3	57%	0	T13-XS24-01-050818	1805322-22	0.3		155%
Trip 2	Pink	T14-XS27-01-050818	1.5	1.1	113%	0	T14-XS27-01-050818	1805322-24	0.5		106%
Trip 2	Pink	T15-XS45-01-050818	0.5	0.0	245%	0	T15-XS45-01-050818	1805322-26	0.4		10%
Trip 2	Pink	T17-XS178-01-050718	2.1	2.7	81%	0	T17-XS178-01-050718	1805322-29	1.5		32%
Trip 2	Pink	T17-XS619-01-050718	1.4	1.0	130%	0	T17-XS619-01-050718	1805322-30	0.7		75%
Trip 2	Pink	T17-XS619-02-050718	2.3	2.9	51%	0	T17-XS619-02-050718	1805322-31	0.7		111%
Trip 2	Pink	T6-XS2-01-051218	0.7	0.0	159%	0	T6-XS2-01-051218	1805328-21	0.5		28%
Trip 3	Pink	T22-XS64-01-052218	2.7	3.0	51%	0	T22-XS64-01-052218	1805632-11	0.6		127%
Trip 4	Pink	M20-XS185-01-060418	2.2	2.7	55%	0	M20-XS185-01-060418	1806235-13	1.2		61%
Trip 4	Pink	M23-XS123-01-061018	0.5	0.0	245%	0	M23-XS123-01-061018	1806233-2	0.6		26%
Trip 4	Pink	M23-XS20-01-061018	2.5	3.0	83%	0	M23-XS20-01-061018	1806233-3	0.9		94%
Trip 4	Pink	M23-XS48-01-061018	2.0	2.6	81%	0	M23-XS48-01-061018	1806233-4	0.5		124%
Trip 4	Pink	M23-XS64-01-061018	0.7	0.0	161%	0	M23-XS64-01-061018	1806233-5	0.7		11%
Trip 4	Pink	M23-XS70-01-061018	1.5	2.0	82%	0	M23-XS70-01-061018	1806233-6	0.5		101%
Trip 4	Pink	M24-XS100-01-061118	0.0	0.0	0%	0	M24-XS100-01-061118	1806312-3	0.6		200%
Trip 4	Pink	T18-XS14-01-061118	1.2	1.2	110%	0	T18-XS14-01-061118	1806312-5	0.5		82%
Trip 4	Pink	T18-XS27-01-061118	0.0	0.0	0%	0	T18-XS27-01-061118	1806312-6	0.3		200%
Trip 4	Pink	T27-XS19-01-061018	0.0	0.0	0%	0	T27-XS19-01-061018	1806233-10	0.4		200%
Trip 4	Pink	T27-XS6-01-061018	1.5	2.0	78%	0	T27-XS6-01-061018	1806233-11	0.7		69%
Trip 5	Pink	M27-XS239-01-061818	1.6	1.7	96%	0	M27-XS239-01-061818	1806558-11	1.1		38%
Trip 5	Pink	M28-XS8-01-062018	0.6	0.0	158%	0	M28-XS8-01-062018	1806558-21	0.3		79%
Trip 5	Pink	M28-XS105-01-062018	2.2	2.6	86%	0	M28-XS105-01-062018	1806558-16	1.2		60%
Trip 5	Pink	T32-XS5-01-062018	0.8	0.8	110%	0	T32-XS5-01-062018	1806558-22	0.6		41%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Uranium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 4	Pink	M21-XS302-02-060918	47.8	47.7	16%	40	M21-XS302-02-060918	1806234-12	350.0	J	152%
Trip 2	Pink	M4-XS63-01-050718	126.9	126.4	18%	96	M4-XS63-01-050718	1805322-7	320.0	J	86%
Trip 1	Pink	M6-XS269-01-04262018	20.0	19.7	10%	18	M6-XS269-01-04262018	1805039-3	240.0	J	169%
Trip 5	Pink	M28-XS148-01-062018	476.8	335.7	70%	305	M28-XS148-01-062018	1806558-17	240.0		66%
Trip 3	Blue	M16-XS166-01-052118	47.4	40.6	35%	36	M16-XS166-01-052118	1805589-9	100.0		71%
Trip 3	Blue	M16-XS45-01-052118	31.3	31.6	11%	27	M16-XS45-01-052118	1805589-13	83.0		90%
Trip 6	Red	M25-XS16-01-071718	10.6	10.7	17%	8	M25-XS16-01-071718	1807452-1	74.0	J	150%
Trip 4	Pink	M22-XS60-01-060418	34.7	35.0	11%	30	M22-XS60-01-060418	1806235-30	67.0		63%
Trip 2	Orange	M1-XS31-01-051218	17.0	16.9	11%	14.6	M1-XS31-01-051218	1805328-1	38.0		76%
Trip 3	Blue	M15-XS73-01-052118	21.0	20.9	4%	20	M15-XS73-01-052118	1805589-5	49.0		80%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence



Data Included in Model U-2A											
Trip	XRF Color	XRF ID	XRF - Uranium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	M2-XS32-01-042418	5.8	5.9	22%	4	M2-XS32-01-042418	1805041-3	4.8		19%
Trip 1	Pink	M3-XS34-01-043018	19.5	19.9	14%	16	M3-XS34-01-043018	1805042-1	11.0		56%
Trip 1	Pink	M3-XS36-01-043018	25.6	25.2	11%	22	M3-XS36-01-043018	1805042-2	25.0		2%
Trip 1	Pink	M6-XS140-01-042818	21.8	21.2	24%	16	M6-XS140-01-042818	1805041-6	20.0		9%
Trip 1	Orange	M6-XS159-01-04262018	52.0	52.5	13%	44	M6-XS159-01-04262018	1805039-1	51.0		2%
Trip 1	Pink	M6-XS251-01-04272018	10.0	9.6	10%	9	M6-XS251-01-04272018	1805039-2	7.6		28%
Trip 1	Pink	M6-XS269-02-04262018	21.3	20.7	24%	17	M6-XS269-02-04262018	1805039-4	20.0	J	6%
Trip 1	Pink	T10-XS1-01-042518	3.3	3.2	4%	3	T10-XS1-01-042518	1805036-1	0.9		116%
Trip 1	Pink	T10-XS56-01-042518	3.3	3.3	18%	3	T10-XS56-01-042518	1805036-4	0.6		135%
Trip 1	Pink	T10-XS78-01-042518	3.7	3.7	20%	2	T10-XS78-01-042518	1805036-5	0.7		136%
Trip 1	Pink	T11-XS1-01-042518	3.3	3.2	32%	2	T11-XS1-01-042518	1805036-6	0.5		151%
Trip 1	Pink	T17-XS1-01-04262018	3.9	4.0	10%	3	T17-XS1-01-04262018	1805039-6	2.1		60%
Trip 1	Pink	T17-XS1-02-04262018	4.3	4.2	25%	3	T17-XS1-02-04262018	1805039-7	1.9		77%
Trip 1	Pink	T17-XS143-01-04262018	47.9	46.6	9%	44	T17-XS143-01-04262018	1805039-8	40.0		18%
Trip 1	Orange	T17-XS144-01-04262018	68.6	67.2	11%	59	T17-XS144-01-04262018	1805039-9	58.0		17%
Trip 1	Pink	T17-XS194-01-04272018	3.0	2.8	36%	2	T17-XS194-01-04272018	1805039-10	2.7	J	10%
Trip 1	Pink	T17-XS194-02-04272018	3.5	3.3	27%	2	T17-XS194-02-04272018	1805039-11	1.4	J	86%
Trip 1	Pink	T17-XS20-01-04262018	17.3	17.5	12%	14	T17-XS20-01-04262018	1805039-12	11.0		44%
Trip 1	Pink	T17-XS251-01-04272018	23.9	24.7	11%	20	T17-XS251-01-04272018	1805039-13	19.0		23%
Trip 1	Pink	T17-XS257-01-04272018	15.0	15.3	10%	13	T17-XS257-01-04272018	1805039-14	9.2		48%
Trip 1	Pink	T17-XS273-01-042818	4.5	4.2	33%	3	T17-XS273-01-042818	1805041-8	2.5		56%
Trip 1	Pink	T17-XS287-01-04272018	26.7	26.4	14%	22	T17-XS287-01-04272018	1805039-15	16.0		50%
Trip 1	Pink	T17-XS317-01-04272018	23.0	23.4	11%	19	T17-XS317-01-04272018	1805039-16	16.0		36%
Trip 1	Pink	T17-XS328-01-04272018	7.9	8.0	22%	6	T17-XS328-01-04272018	1805039-17	4.1		63%
Trip 1	Pink	T17-XS369-01-043018	3.4	3.5	19%	2	T17-XS369-01-043018	1805042-4	0.7		131%
Trip 1	Pink	T17-XS377-01-042818	37.1	35.5	12%	32	T17-XS377-01-042818	1805041-10	22.0		51%
Trip 1	Pink	T17-XS393-01-043018	4.6	4.7	29%	3	T17-XS393-01-043018	1805042-5	2.2	J	71%
Trip 1	Pink	T17-XS417-01-04272018	4.9	4.5	25%	4	T17-XS417-01-04272018	1805039-18	2.9	J	52%
Trip 1	Pink	T17-XS438-01-042818	5.4	5.5	39%	2	T17-XS438-01-042818	1805041-11	2.8		64%
Trip 1	Pink	T17-XS44-01-04262018	5.4	4.9	34%	4	T17-XS44-01-04262018	1805039-19	2.8		64%
Trip 1	Pink	T17-XS442-01-04272018	15.6	15.5	17%	12	T17-XS442-01-04272018	1805039-20	11.0		35%
Trip 1	Pink	T17-XS46-01-042618	6.1	6.1	13%	5	T17-XS46-01-042618	1805041-12	2.7		78%
Trip 1	Pink	T17-XS473-01-042818	19.3	18.7	24%	13	T17-XS473-01-042818	1805041-13	14.0		32%
Trip 1	Pink	T17-XS479-01-042818	6.5	6.5	15%	6	T17-XS479-01-042818	1805041-14	5.8		12%
Trip 1	Pink	T17-XS479-02-042818	8.4	8.3	11%	7	T17-XS479-02-042818	1805041-15	4.7		56%
Trip 1	Pink	T17-XS679-01-043018	5.5	6.1	21%	4	T17-XS679-01-043018	1805042-7	2.0		94%
Trip 1	Pink	T17-XS704-01-043018	3.6	3.6	33%	2	T17-XS704-01-043018	1805042-8	0.5		148%
Trip 1	Pink	T9-XS217-01-042518	3.8	3.9	13%	3	T9-XS217-01-042518	1805036-17	0.6		148%
Trip 1	Pink	T9-XS61-01-042518	21.2	21.1	22%	16	T9-XS61-01-042518	1805036-18	13.0		48%
Trip 1	Orange	T9-XS61-02-042518	15.8	15.6	16%	13	T9-XS61-02-042518	1805041-17	9.7		48%
Trip 1	Pink	T9-XS86-01-042518	6.5	6.3	16%	6	T9-XS86-01-042518	1805036-19	1.6		121%
Trip 1	Pink	T9-XS93-01-042518	16.5	16.4	5%	15	T9-XS93-01-042518	1805036-20	11.0		40%
Trip 2	Pink	M1-XS32-01-051218	25.6	23.9	25%	20	M1-XS32-01-051218	1805328-2	19.0		30%
Trip 2	Pink	M4-XS136-01-050918	47.8	47.1	6%	44	M4-XS136-01-050918	1805322-1	54.0		12%
Trip 2	Pink	M4-XS18-01-050718	4.9	4.3	36%	3	M4-XS18-01-050718	1805322-2	1.4		112%
Trip 2	Orange	M4-XS219-01-051018	16.3	15.0	29%	13	M4-XS219-01-051018	1805322-3	11.0		39%
Trip 2	Pink	M4-XS238-01-051018	18.2	16.8	26%	14	M4-XS238-01-051018	1805322-4	8.0		78%

Data Included in Model U-2A											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 2	Pink	M4-XS4-01-050718	3.7	3.6	35%	2	M4-XS4-01-050718	1805322-5	1.6		79%
Trip 2	Pink	M4-XS45-01-050718	18.5	15.3	49%	10	M4-XS45-01-050718	1805322-6	12.0		43%
Trip 2	Pink	M4-XS78-01-051018	69.4	69.7	17%	57	M4-XS78-01-051018	1805322-9	78.0		12%
Trip 2	Orange	M5-XS115-01-051118	47.5	46.8	4%	45	M5-XS115-01-051118	1805322-10	51.0		7%
Trip 2	Pink	M5-XS385-01-051118	3.0	3.1	18%	2	M5-XS385-01-051118	1805322-11	1.2		86%
Trip 2	Pink	M5-XS69-01-051118	9.8	9.3	15%	8	M5-XS69-01-051118	1805322-12	6.0		48%
Trip 2	Pink	M7-XS181-01-051018	41.2	43.3	17%	29	M7-XS181-01-051018	1805322-16	34.0		19%
Trip 2	Orange	M7-XS181-02-051018	29.8	30.0	18%	22	M7-XS181-02-051018	1805322-17	36.0		19%
Trip 2	Orange	M7-XS39-01-051018	4.4	4.3	16%	4	M7-XS39-01-051018	1805322-18	1.7		88%
Trip 2	Orange	M7-XS74-01-051018	8.7	8.3	13%	8	M7-XS74-01-051018	1805322-19	5.7		41%
Trip 2	Orange	M7-XS77-01-051018	8.9	8.3	19%	7	M7-XS77-01-051018	1805322-20	3.7		83%
Trip 2	Pink	M8-XS100-01-050918	4.8	5.0	16%	4	M8-XS100-01-050918	1805328-3	1.9		86%
Trip 2	Pink	M8-XS102-01-050918	24.4	24.5	10%	21	M8-XS102-01-050918	1805328-4	8.8		94%
Trip 2	Pink	M8-XS102-02-050918	26.0	25.6	5%	25	M8-XS102-02-050918	1805328-5	8.8		99%
Trip 2	Orange	M8-XS19-01-051018	6.6	6.4	6%	6	M8-XS19-01-051018	1805328-7	2.8		81%
Trip 2	Orange	M8-XS32-01-051018	22.5	23.1	8%	19	M8-XS32-01-051018	1805328-8	11.0		69%
Trip 2	Pink	M8-XS94-01-050918	34.4	35.1	23%	23	M8-XS94-01-050918	1805328-9	40.0		15%
Trip 2	Pink	T14-XS12-01-050818	3.4	3.7	17%	3	T14-XS12-01-050818	1805322-23	0.5		152%
Trip 2	Pink	T15-XS2-01-050818	3.7	3.4	38%	2	T15-XS2-01-050818	1805322-25	0.7		137%
Trip 2	Pink	T17-XS122-01-050718	5.6	4.2	55%	3	T17-XS122-01-050718	1805322-27	2.3		83%
Trip 2	Pink	T17-XS176-01-050718	4.7	4.7	30%	3	T17-XS176-01-050718	1805322-28	3.1		42%
Trip 2	Pink	T17-XS645-01-050718	4.2	4.6	26%	2	T17-XS645-01-050718	1805322-32	1.7		85%
Trip 2	Pink	T17-XS669-01-050718	3.4	3.6	21%	2	T17-XS669-01-050718	1805322-33	2.5		30%
Trip 2	Pink	T1-XS104-01-051318	10.8	10.6	15%	9	T1-XS104-01-051318	1805328-10	4.6		81%
Trip 2	Pink	T1-XS20-01-051318	5.8	6.1	18%	4	T1-XS20-01-051318	1805328-11	2.2		90%
Trip 2	Pink	T1-XS54-01-051318	17.9	18.4	10%	15	T1-XS54-01-051318	1805328-12	9.5		61%
Trip 2	Pink	T1-XS54-02-051318	16.8	17.1	9%	15	T1-XS54-02-051318	1805328-13	11.0		42%
Trip 2	Orange	T3-XS10-01-051218	4.3	4.6	27%	2	T3-XS10-01-051218	1805328-15	0.8		138%
Trip 2	Orange	T3-XS5-01-051218	3.7	3.7	15%	3	T3-XS5-01-051218	1805328-16	0.5		152%
Trip 2	Pink	T4-XS23-01-051218	7.5	7.2	14%	6	T4-XS23-01-051218	1805328-17	3.1		83%
Trip 2	Orange	T4-XS32-01-051218	8.3	8.3	6%	7	T4-XS32-01-051218	1805328-18	4.5		59%
Trip 2	Pink	T4-XS43-01-051218	34.4	34.5	3%	33	T4-XS43-01-051218	1805328-19	20.0		53%
Trip 2	Pink	T5-XS18-01-051418	7.4	7.5	17%	6	T5-XS18-01-051418	1805328-20	3.1		82%
Trip 2	Orange	T6-XS25-01-051218	3.9	4.2	25%	3	T6-XS25-01-051218	1805328-22	0.9		123%
Trip 3	Pink	M14-XS64-01-052418	69.0	71.7	11%	56	M14-XS64-01-052418	1805632-3	55.0	J	23%
Trip 3	Pink	M15-XS3-01-052118	42.7	41.3	11%	38	M15-XS3-01-052118	1805589-2	44.0		3%
Trip 3	Pink	M15-XS46-01-052118	13.8	13.6	10%	12	M15-XS46-01-052118	1805589-3	9.7		35%
Trip 3	Pink	M15-XS46-02-052118	14.6	14.1	19%	11	M15-XS46-02-052118	1805589-4	9.6		41%
Trip 3	Pink	M15-XS82-01-052118	23.6	23.8	5%	22	M15-XS82-01-052118	1805589-6	13.0		58%
Trip 3	Pink	M16-XS154-01-052618	61.4	61.0	7%	56	M16-XS154-01-052618	1806235-2	41.0		40%
Trip 3	Pink	M16-XS177-01-052618	40.6	41.6	12%	32	M16-XS177-01-052618	1806235-3	30.0		30%
Trip 3	Pink	M16-XS191-01-052618	48.1	49.1	4%	44	M16-XS191-01-052618	1806235-4	32.0		40%
Trip 3	Pink	M16-XS30-01-052118	28.6	27.6	12%	25	M16-XS30-01-052118	1805589-10	24.0		17%
Trip 3	Pink	M16-XS31-01-052118	12.0	11.6	13%	11	M16-XS31-01-052118	1805589-11	7.1		51%
Trip 3	Pink	M16-XS4-01-052118	14.0	13.5	10%	13	M16-XS4-01-052118	1805589-12	14.0		0%
Trip 3	Pink	M18-XS155-01-052518	6.5	6.1	21%	5	M18-XS155-01-052518	1805632-5	3.4		63%
Trip 3	Pink	M19-XS43-01-052318	52.0	53.0	27%	34	M19-XS43-01-052318	1805632-9	35.0		39%
Trip 3	Blue	T20-XS14-01-052218	6.3	6.2	13%	5	T20-XS14-01-052218	1805632-10	0.5		170%
Trip 3	Blue	T21-XS35-01-052118	9.3	9.3	4%	9	T21-XS35-01-052118	1805589-14	11.0		17%
Trip 3	Blue	T21-XS55-01-052118	7.9	7.7	6%	7	T21-XS55-01-052118	1805589-15	8.7		10%
Trip 3	Pink	T21-XS55-02-052118	11.4	10.5	23%	9	T21-XS55-02-052118	1805589-16	6.7		52%
Trip 3	Blue	T21-XS6-01-052118	8.1	7.9	12%	7	T21-XS6-01-052118	1805589-17	3.7		75%
Trip 3	Blue	T22-XS17-01-052118	7.7	7.5	10%	7	T22-XS17-01-052118	1805589-18	1.5		134%
Trip 3	Pink	T23-XS23-01-052118	21.3	20.9	12%	18	T23-XS23-01-052118	1805589-19	17.0		22%
Trip 3	Pink	T23-XS40-01-052118	20.5	19.2	20%	17	T23-XS40-01-052118	1805589-20	15.0		31%
Trip 3	Pink	T24-XS48-01-052418	13.5	13.1	12%	12	T24-XS48-01-052418	1805632-12	3.6		116%
Trip 4	Pink	M13-XS72-01-060618	5.8	5.2	26%	4	M13-XS72-01-060618	1806235-1	1.5		118%
Trip 4	Pink	M20-XS11-01-060618	6.8	6.9	19%	5	M20-XS11-01-060618	1806235-9	3.8		56%
Trip 4	Pink	M20-XS130-01-060418	3.6	3.8	26%	2	M20-XS130-01-060418	1806235-10	1.4		88%
Trip 4	Pink	M20-XS166-01-060518	35.3	34.5	7%	32	M20-XS166-01-060518	1806235-11	19.0		60%
Trip 4	Pink	M20-XS18-01-060618	33.0	24.2	55%	21	M20-XS18-01-060618	1806235-12	15.0		75%
Trip 4	Pink	M20-XS231-01-060418	3.5	3.6	15%	3	M20-XS231-01-060418	1806235-14	1.1		104%
Trip 4	Pink	M20-XS306-01-060518	4.7	4.9	19%	3	M20-XS306-01-060518	1806235-16	1.0		133%
Trip 4	Pink	M20-XS312-01-060518	14.7	13.9	20%	12	M20-XS312-01-060518	1806235-17	9.6		42%
Trip 4	Pink	M20-XS365-01-060618	74.7	74.7	5%	70	M20-XS365-01-060618	1806235-18	64.0		15%
Trip 4	Pink	M20-XS365-02-060618	82.5	81.0	13%	70	M20-XS365-02-060618	1806235-19	46.0		57%
Trip 4	Pink	M20-XS5-01-060518	10.7	10.4	17%	9	M20-XS5-01-060518	1806235-20	4.2		87%
Trip 4	Pink	M20-XS86-01-060618	8.9	8.3	22%	7	M20-XS86-01-060618	1806235-21	5.0		56%
Trip 4	Pink	M21-XS122-01-060818	4.8	5.1	24%	3	M21-XS122-01-060818	1806234-1	0.9		139%
Trip 4	Pink	M21-XS126-01-060818	33.3	32.9	19%	23	M21-XS126-01-060818	1806234-2	17.0		65%
Trip 4	Pink	M21-XS14-01-060818	22.4	22.3	13%	19	M21-XS14-01-060818	1806234-3	9.8		78%

Data Included in Model U-2A											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M21-XS175-01-060818	4.7	4.7	28%	3	M21-XS175-01-060818	1806234-4	1.6		99%
Trip 4	Pink	M21-XS225-01-060518	28.6	28.0	22%	21	M21-XS225-01-060518	1806235-22	14.0		68%
Trip 4	Pink	M21-XS259-01-060918	38.2	37.0	12%	33	M21-XS259-01-060918	1806234-5	41.0		7%
Trip 4	Pink	M21-XS260-01-060918	17.5	17.7	7%	16	M21-XS260-01-060918	1806234-6	10.0		55%
Trip 4	Pink	M21-XS27-01-060818	8.2	8.1	8%	7	M21-XS27-01-060818	1806234-7	4.3		63%
Trip 4	Pink	M21-XS27-02-060818	8.3	8.2	16%	6	M21-XS27-02-060818	1806234-8	4.6		57%
Trip 4	Pink	M21-XS282-01-060918	26.7	26.9	2%	26	M21-XS282-01-060918	1806234-9	16.0		50%
Trip 4	Pink	M21-XS290-01-060918	10.2	10.2	10%	9	M21-XS290-01-060918	1806234-10	3.3		102%
Trip 4	Pink	M21-XS292-01-060518	18.9	19.5	10%	16	M21-XS292-01-060518	1806235-23	11.0		53%
Trip 4	Pink	M21-XS302-01-060918	55.0	54.5	14%	45	M21-XS302-01-060918	1806234-11	34.0	J	47%
Trip 4	Pink	M21-XS334-01-060918	12.9	12.6	12%	11	M21-XS334-01-060918	1806234-13	6.3		69%
Trip 4	Pink	M21-XS377-01-060918	11.6	12.0	8%	10	M21-XS377-01-060918	1806234-14	4.8		83%
Trip 4	Pink	M21-XS40-01-060818	48.1	48.3	6%	44	M21-XS40-01-060818	1806234-15	26.0		60%
Trip 4	Pink	M21-XS419-01-060818	10.6	10.4	10%	9	M21-XS419-01-060818	1806234-17	3.4		103%
Trip 4	Pink	M21-XS541-01-060818	6.6	6.5	19%	5	M21-XS541-01-060818	1806234-20	2.9		77%
Trip 4	Pink	M21-XS596-01-060518	18.6	18.3	17%	14	M21-XS596-01-060518	1806235-24	13.0		35%
Trip 4	Pink	M21-XS615-01-060518	11.0	11.1	10%	10	M21-XS615-01-060518	1806235-25	6.0		59%
Trip 4	Pink	M21-XS619-01-060618	24.4	25.5	21%	17	M21-XS619-01-060618	1806235-26	15.0		48%
Trip 4	Pink	M22-XS14-01-060418	25.2	25.6	8%	22	M22-XS14-01-060418	1806235-27	14.0		57%
Trip 4	Pink	M22-XS30-01-060418	13.2	12.9	16%	11	M22-XS30-01-060418	1806235-28	7.2		59%
Trip 4	Pink	M22-XS40-01-060518	12.5	13.4	26%	6	M22-XS40-01-060518	1806235-29	6.7		60%
Trip 4	Pink	M22-XS87-01-060418	15.8	15.4	9%	14	M22-XS87-01-060418	1806235-31	8.4		61%
Trip 4	Pink	M23-XS102-01-061018	4.6	4.9	24%	2	M23-XS102-01-061018	1806233-1	1.3		112%
Trip 4	Pink	M23-XS54-01-061118	89.9	90.2	7%	80	M23-XS54-01-061118	1806312-1	86.0		4%
Trip 4	Pink	M23-XS79-01-061018	18.3	17.0	36%	9	M23-XS79-01-061018	1806233-7	11.0		50%
Trip 4	Pink	T25-XS2-01-060618	3.1	2.8	23%	2	T25-XS2-01-060618	1806235-32	0.9		113%
Trip 4	Pink	T26-XS1-01-061018	9.3	8.9	15%	8	T26-XS1-01-061018	1806233-8	4.4		72%
Trip 4	Pink	T26-XS8-01-061018	9.5	9.4	17%	8	T26-XS8-01-061018	1806233-9	4.8		66%
Trip 5	Pink	M26-XS13-01-061818	37.4	37.6	4%	35	M26-XS13-01-061818	1806558-1	28.0		29%
Trip 5	Pink	M26-XS25-01-061818	49.3	48.2	8%	46	M26-XS25-01-061818	1806558-2	49.0		1%
Trip 5	Pink	M27-XS108-01-061918	7.7	7.7	19%	6	M27-XS108-01-061918	1806558-3	3.8		68%
Trip 5	Pink	M27-XS109-01-061918	8.2	7.9	19%	7	M27-XS109-01-061918	1806558-4	3.5	J	81%
Trip 5	Pink	M27-XS123-01-061818	6.2	5.0	69%	3	M27-XS123-01-061818	1806558-5	4.1		40%
Trip 5	Pink	M27-XS188-01-061918	8.2	8.2	7%	7	M27-XS188-01-061918	1806558-6	3.4		82%
Trip 5	Pink	M27-XS197-01-061918	9.6	10.0	9%	8	M27-XS197-01-061918	1806558-7	5.4		56%
Trip 5	Pink	M27-XS210-01-061818	3.3	3.1	30%	2	M27-XS210-01-061818	1806558-8	1.5		74%
Trip 5	Pink	M27-XS210-02-061818	3.4	3.5	26%	2	M27-XS210-02-061818	1806558-9	1.5		77%
Trip 5	Pink	M27-XS21-01-061918	34.7	30.6	37%	24	M27-XS21-01-061918	1806558-10	22.0		45%
Trip 5	Pink	M27-XS275-01-061918	71.6	69.3	16%	60	M27-XS275-01-061918	1806558-12	67.0		7%
Trip 5	Pink	M27-XS283-01-061818	94.7	77.2	46%	75	M27-XS283-01-061818	1806558-13	58.0		48%
Trip 5	Pink	M27-XS29-01-061818	10.2	9.3	25%	8	M27-XS29-01-061818	1806558-14	12.0		17%
Trip 5	Pink	M28-XS155-01-062018	23.0	22.5	15%	19	M28-XS155-01-062018	1806558-18	13.0		55%
Trip 5	Pink	M28-XS170-01-062018	18.1	18.2	13%	14	M28-XS170-01-062018	1806558-19	6.2		98%
Trip 5	Pink	M28-XS43-01-062018	32.6	32.1	14%	27	M28-XS43-01-062018	1806558-20	22.0		39%
Trip 5	Pink	M30-XS138-01-062218	42.6	41.0	11%	37	M30-XS138-01-062218	1806693-1	21.0		68%
Trip 5	Pink	M30-XS222-01-062218	8.6	8.9	14%	7	M30-XS222-01-062218	1806693-2	3.7		80%
Trip 6	Pink	M10-XS10A-01-071118	47.6	46.5	10%	41.864	M10-XS10A-01-071118	1807369-1	45.0		6%
Trip 6	Pink	M10-XS31-01-071118	5.8	5.8	9%	5.237	M10-XS31-01-071118	1807369-2	3.2		58%
Trip 6	Pink	M10-XS31-02-071118	5.2	5.1	10%	4.458	M10-XS31-02-071118	1807369-3	3.1		50%
Trip 6	Pink	M11-XS7-01-071118	12.5	12.4	8%	11.128	M11-XS7-01-071118	1807369-5	5.3		81%
Trip 6	Red	M12-XS27-01-071518	4.4	4.6	26%	3	M12-XS27-01-071518	1807369-6	4.0		8%
Trip 6	Pink	M24-XS115-01-071418	20.7	20.7	4%	19.919	M24-XS115-01-071418	1807369-7	12.0		53%
Trip 6	Red	M25-XS23-01-071718	8.6	7.7	23%	7	M25-XS23-01-071718	1807452-2	4.3		67%
Trip 6	Red	M25-XS47-01-071718	11.0	7.7	65%	7	M25-XS47-01-071718	1807452-3	3.8		97%
Trip 6	Red	M25-XS88-01-071718	21.7	22.2	12%	18	M25-XS88-01-071718	1807452-4	17.0		24%
Trip 6	Red	M30-XS95-01-071618	28.2	28.7	21%	22	M30-XS95-01-071618	1807369-11	28.0		1%
Trip 6	Red	M31-XS9-01-071018	13.2	10.1	71%	5	M31-XS9-01-071018	1807369-12	6.2		72%
Trip 6	Orange	M32-XS58-01-071018	16.6	15.5	21%	13	M32-XS58-01-071018	1807369-13	12.0		32%
Trip 6	Red	M32-XS89-01-071018	81.7	78.9	14%	72	M32-XS89-01-071018	1807369-14	46.0	J	56%
Trip 6	Orange	M33-XS22-01-071218	21.8	21.6	10%	20	M33-XS22-01-071218	1807369-15	17.0		25%
Trip 6	Orange	M33-XS85-01-071218	28.4	22.2	52%	19	M33-XS85-01-071218	1807369-16	19.0		40%
Trip 6	Red	M33-XS93-01-071218	13.6	13.2	9%	12	M33-XS93-01-071218	1807369-17	6.7		68%
Trip 6	Red	T33-XS43-01-071718	14.5	14.2	13%	12	T33-XS43-01-071718	1807452-5	5.3		93%
Trip 3	Pink	M16-XS191-02-052618	62.0	63.1	18%	44	M16-XS191-02-052618	1806235-5	29.0		72%
Trip 4	Pink	M20-XS278-01-060418	17.2	18.7	17%	12	M20-XS278-01-060418	1806235-15	5.0		110%
Trip 4	Pink	M24-XS128-01-061118	4.4	4.1	15%	4	M24-XS128-01-061118	1806312-4	8.3		61%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Uranium: Average Ex Situ XRF (ppm)	XRF - Uranium: Median Ex Situ XRF (ppm)	XRF - Uranium: Relative Standard Deviation	XRF - Uranium: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	0.9	0.0	156%	0	M2-XS15-01-042418	1805041-1	0.7		14%
Trip 1	Pink	M2-XS15-02-042418	0.8	0.0	158%	0	M2-XS15-02-042418	1805041-2	0.6		20%
Trip 1	Pink	M2-XS59-01-042418	0.4	0.0	245%	0	M2-XS59-01-042418	1805041-4	0.7		44%
Trip 1	Pink	M2-XS73-01-042418	1.0	0.0	160%	0	M2-XS73-01-042418	1805041-5	0.6		47%
Trip 1	Pink	T10-XS20-01-042518	1.2	0.0	156%	0	T10-XS20-01-042518	1805036-2	0.4		92%
Trip 1	Pink	T10-XS33-01-042518	2.4	2.5	53%	0	T10-XS33-01-042518	1805036-3	0.8		101%
Trip 1	Pink	T11-XS20-01-042518	2.0	2.3	89%	0	T11-XS20-01-042518	1805036-7	0.4		135%
Trip 1	Pink	T11-XS60-01-042518	0.6	0.0	155%	0	T11-XS60-01-042518	1805036-8	0.2		88%
Trip 1	Pink	T17-XS208-01-042818	3.3	3.1	61%	0	T17-XS208-01-042818	1805041-7	2.0		50%
Trip 1	Pink	T17-XS304-01-042818	2.5	3.1	54%	0	T17-XS304-01-042818	1805041-9	0.8		103%
Trip 1	Pink	T17-XS603-01-042818	2.9	2.6	66%	0	T17-XS603-01-042818	1805041-16	0.6		130%
Trip 1	Pink	T17-XS659-01-043018	2.3	2.6	53%	0	T17-XS659-01-043018	1805042-6	0.6		121%
Trip 1	Pink	T7-XS11-01-042418	1.4	1.9	30%	0	T7-XS11-01-042418	1805036-9	0.4		114%
Trip 1	Pink	T7-XS5-01-042418	1.4	1.7	83%	0	T7-XS5-01-042418	1805036-10	0.4		113%
Trip 1	Pink	T7-XS58-01-042418	0.7	0.0	155%	0	T7-XS58-01-042418	1805036-11	0.4		54%
Trip 1	Pink	T7-XS7-01-042418	1.1	1.0	110%	0	T7-XS7-01-042418	1805036-12	0.4		96%
Trip 1	Pink	T7-XS9-01-042418	0.4	0.0	245%	0	T7-XS9-01-042418	1805036-13	0.4		2%
Trip 1	Pink	T8-XS15-01-042418	1.7	2.2	82%	0	T8-XS15-01-042418	1805036-14	0.7		84%
Trip 1	Pink	T8-XS23-01-042418	2.7	3.1	52%	0	T8-XS23-01-042418	1805036-15	0.7		116%
Trip 1	Pink	T8-XS6-01-042418	1.4	1.8	82%	0	T8-XS6-01-042418	1805036-16	0.4		108%
Trip 2	Orange	M6-XS41-01-051118	1.5	1.8	81%	0	M6-XS41-01-051118	1805322-13	0.4		114%
Trip 2	Pink	M6-XS44-01-051018	2.0	2.7	80%	0	M6-XS44-01-051018	1805322-14	0.7		95%
Trip 2	Pink	M6-XS81-01-051018	1.2	1.8	96%	0	M6-XS81-01-051018	1805322-15	0.6		60%
Trip 2	Pink	T13-XS12-01-050818	2.5	3.2	55%	0	T13-XS12-01-050818	1805322-21	0.7		109%
Trip 2	Pink	T13-XS24-01-050818	2.2	2.3	57%	0	T13-XS24-01-050818	1805322-22	0.3		155%
Trip 2	Pink	T14-XS27-01-050818	1.5	1.1	113%	0	T14-XS27-01-050818	1805322-24	0.5		106%
Trip 2	Pink	T15-XS45-01-050818	0.5	0.0	245%	0	T15-XS45-01-050818	1805322-26	0.4		10%
Trip 2	Pink	T17-XS178-01-050718	2.1	2.7	81%	0	T17-XS178-01-050718	1805322-29	1.5		32%
Trip 2	Pink	T17-XS619-01-050718	1.4	1.0	130%	0	T17-XS619-01-050718	1805322-30	0.7		75%
Trip 2	Pink	T17-XS619-02-050718	2.3	2.9	51%	0	T17-XS619-02-050718	1805322-31	0.7		111%
Trip 2	Pink	T6-XS2-01-051218	0.7	0.0	159%	0	T6-XS2-01-051218	1805328-21	0.5		28%
Trip 3	Pink	T22-XS64-01-052218	2.7	3.0	51%	0	T22-XS64-01-052218	1805632-11	0.6		127%
Trip 4	Pink	M20-XS185-01-060418	2.2	2.7	55%	0	M20-XS185-01-060418	1806235-13	1.2		61%
Trip 4	Pink	M23-XS123-01-061018	0.5	0.0	245%	0	M23-XS123-01-061018	1806233-2	0.6		26%
Trip 4	Pink	M23-XS20-01-061018	2.5	3.0	83%	0	M23-XS20-01-061018	1806233-3	0.9		94%
Trip 4	Pink	M23-XS48-01-061018	2.0	2.6	81%	0	M23-XS48-01-061018	1806233-4	0.5		124%
Trip 4	Pink	M23-XS64-01-061018	0.7	0.0	161%	0	M23-XS64-01-061018	1806233-5	0.7		11%
Trip 4	Pink	M23-XS70-01-061018	1.5	2.0	82%	0	M23-XS70-01-061018	1806233-6	0.5		101%
Trip 4	Pink	M24-XS100-01-061118	0.0	0.0	0%	0	M24-XS100-01-061118	1806312-3	0.6		200%
Trip 4	Pink	T18-XS14-01-061118	1.2	1.2	110%	0	T18-XS14-01-061118	1806312-5	0.5		82%
Trip 4	Pink	T18-XS27-01-061118	0.0	0.0	0%	0	T18-XS27-01-061118	1806312-6	0.3		200%
Trip 4	Pink	T27-XS19-01-061018	0.0	0.0	0%	0	T27-XS19-01-061018	1806233-10	0.4		200%
Trip 4	Pink	T27-XS6-01-061018	1.5	2.0	78%	0	T27-XS6-01-061018	1806233-11	0.7		69%
Trip 5	Pink	M27-XS239-01-061818	1.6	1.7	96%	0	M27-XS239-01-061818	1806558-11	1.1		38%
Trip 5	Pink	M28-XS8-01-062018	0.6	0.0	158%	0	M28-XS8-01-062018	1806558-21	0.3		79%
Trip 5	Pink	M28-XS105-01-062018	2.2	2.6	86%	0	M28-XS105-01-062018	1806558-16	1.2		60%
Trip 5	Pink	T32-XS5-01-062018	0.8	0.8	110%	0	T32-XS5-01-062018	1806558-22	0.6		41%

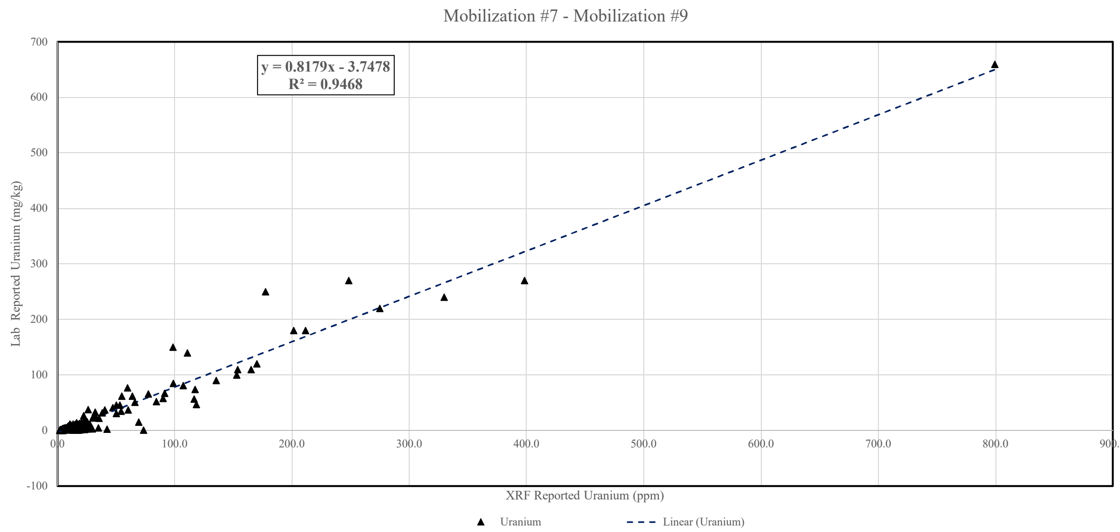
Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Uranium: Average Ex Situ XRF (ppm)	XRF - Uranium: Median Ex Situ XRF (ppm)	XRF - Uranium: Relative Standard Deviation	XRF - Uranium: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 3	Blue	M16-XS166-01-052118	47.4	40.6	35%	36	M16-XS166-01-052118	1805589-9	100.0		71%
Trip 3	Blue	M16-XS45-01-052118	31.3	31.6	11%	27	M16-XS45-01-052118	1805589-13	83.0		90%
Trip 6	Red	M25-XS16-01-071718	10.6	10.7	17%	8	M25-XS16-01-071718	1807452-1	74.0	J	150%
Trip 4	Pink	M22-XS60-01-060418	34.7	35.0	11%	30	M22-XS60-01-060418	1806235-30	67.0		63%
Trip 3	Blue	M15-XS73-01-052118	21.0	20.9	4%	20	M15-XS73-01-052118	1805589-5	49.0		80%
Trip 2	Orange	M1-XS31-01-051218	17.0	16.9	11%	14.6	M1-XS31-01-051218	1805328-1	38.0		76%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence

Removed Data - Above 100 ppm											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M6-XS285-01-04272018	235.1	211.9	34%	173	M6-XS285-01-04272018	1805039-5	210.0		11%
Trip 2	Pink	T1-XS69-01-051318	101.6	99.2	11%	90	T1-XS69-01-051318	1805328-14	80.0		24%
Trip 2	Pink	M4-XS63-02-050718	116.9	114.4	12%	98	M4-XS63-02-050718	1805322-8	110.0	J	6%
Trip 3	Pink	M14-XS36-01-052418	148.2	146.8	5%	137	M14-XS36-01-052418	1805632-1	110.0		30%
Trip 3	Pink	M14-XS40-01-052418	146.4	138.0	19%	121	M14-XS40-01-052418	1805632-2	130.0		12%
Trip 3	Pink	M14-XS67-01-052418	169.5	144.0	38%	129	M14-XS67-01-052418	1805632-4	120.0		34%
Trip 3	Pink	M15-XS22-01-052118	152.6	150.7	8%	138	M15-XS22-01-052118	1805589-1	130.0		16%
Trip 3	Pink	M15-XS93-01-052118	115.0	107.5	29%	83	M15-XS93-01-052118	1805589-7	130.0		12%
Trip 3	Pink	M16-XS128-01-052118	137.5	141.9	34%	68	M16-XS128-01-052118	1805589-8	130.0		6%
Trip 3	Pink	M17-XS55-01-052618	309.1	310.3	6%	286	M17-XS55-01-052618	1806235-6	260.0		17%
Trip 3	Pink	M17-XS83-01-052618	362.7	361.3	3%	353	M17-XS83-01-052618	1806235-7	280.0		26%
Trip 3	Pink	M17-XS83-02-052618	368.8	365.1	7%	335	M17-XS83-02-052618	1806235-8	310.0		17%
Trip 3	Pink	M19-XS22-01-052318	488.7	466.7	15%	421	M19-XS22-01-052318	1805632-7	370.0		28%
Trip 3	Pink	M19-XS22-02-052318	459.6	418.7	17%	399	M19-XS22-02-052318	1805632-8	280.0		49%
Trip 3	Pink	M18-XS161-01-052518	509.1	521.9	35%	285	M18-XS161-01-052518	1805632-6	300.0		52%
Trip 4	Pink	M21-XS403-01-060818	109.6	108.6	29%	62	M21-XS403-01-060818	1806234-16	81.0		30%
Trip 4	Pink	M21-XS477-01-060818	114.0	106.4	21%	89	M21-XS477-01-060818	1806234-19	72.0		45%
Trip 5	Pink	M27-XS38-01-061918	170.3	170.0	7%	155	M27-XS38-01-061918	1806558-15	110.0		43%
Trip 6	Orange	M30-XS127-01-071618	302.2	296.9	5%	287	M30-XS127-01-071618	1807369-9	360.0		17%
Trip 6	Orange	M30-XS170-01-071618	107.6	99.3	33%	81	M30-XS170-01-071618	1807369-10	170.0		45%
Trip 6	Pink	M11-XS11-01-071118	192.6	152.1	62%	106.384	M11-XS11-01-071118	1807369-4	230.0		18%
Trip 1	Pink	M6-XS269-01-04262018	20.0	19.7	10%	18	M6-XS269-01-04262018	1805039-3	240.0	J	169%
Trip 2	Pink	M4-XS63-01-050718	126.9	126.4	18%	96	M4-XS63-01-050718	1805322-7	320.0	J	86%
Trip 2	Pink	M8-XS110-01-050918	55.2	51.4	20%	43	M8-XS110-01-050918	1805328-6	110.0		66%
Trip 4	Pink	M21-XS302-02-060918	47.8	47.7	16%	40	M21-XS302-02-060918	1806234-12	350.0	J	152%
Trip 4	Pink	M21-XS46-01-060818	202.0	191.1	21%	163	M21-XS46-01-060818	1806234-18	82.0		85%
Trip 5	Pink	M28-XS148-01-062018	476.8	335.7	70%	305	M28-XS148-01-062018	1806558-17	240.0		66%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
XRF = X-ray fluorescence



Data Included											
Trip	XRF Color	XRF ID	XRF - Uranium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 7	Red	M10-XS22-01-082118	11.7	11.7	20%	9	M10-XS22-01-082118	1808494-1	10		16%
Trip 7	Red	M10-XS39-01-082118	9.1	8.8	16%	8	M10-XS39-01-082118	1808494-2	5.4		51%
Trip 7	Red	M10-XS43-01-082118	99.0	99.9	13%	76	M10-XS43-01-082118	1808494-3	85.0		15%
Trip 7	Red	M1-XSG2-01-081918	8.2	8.0	12%	7	M1-XSG2-01-081918	1808483-1	3.7		76%
Trip 7	Red	M34-XS110-01-081218	170.3	164.7	9%	156	M34-XS110-01-081218	1808303-1	120.0		35%
Trip 7	Pink	M34-XS22-01-081218	11.8	12.0	30%	6	M34-XS22-01-081218	1808303-2	4.0		99%
Trip 7	Pink	M34-XS43-01-081218	91.5	82.6	22%	77	M34-XS43-01-081218	1808303-3	67.0		31%
Trip 7	Pink	M34-XS50-01-081218	19.6	20.0	8%	18	M34-XS50-01-081218	1808303-4	11.0		56%
Trip 7	Pink	M34-XS68-01-081218	69.4	65.2	23%	49	M34-XS68-01-081218	1808303-5	15.0		129%
Trip 7	Pink	M35-XS11-01-081218	90.2	88.0	20%	67	M35-XS11-01-081218	1808303-6	58.0		43%
Trip 7	Pink	M35-XS20-01-081318	118.6	114.2	13%	101	M35-XS20-01-081318	1808303-7	47.0		86%
Trip 7	Pink	M35-XS31-01-081218	30.0	30.9	10%	25	M35-XS31-01-081218	1808303-8	3.1		162%
Trip 7	Pink	M35-XS63-01-081218	6.2	5.9	11%	6	M35-XS63-01-081218	1808303-9	3.3		62%
Trip 7	Pink	M35-XS74-01-081318	135.6	135.8	6%	125	M35-XS74-01-081318	1808303-10	90.0		40%
Trip 7	Pink	M35-XS74-02-081318	117.5	121.8	7%	107	M35-XS74-02-081318	1808303-11	74.0		45%
Trip 7	Pink	M36-XS20-01-081218	26.3	26.5	6%	24	M36-XS20-01-081218	1808303-12	5.2		134%
Trip 7	Pink	M36-XS2-01-081218	12.8	12.1	21%	10	M36-XS2-01-081218	1808303-13	5.2	J	84%
Trip 7	Pink	M36-XS3-01-081218	5.7	5.0	27%	4	M36-XS3-01-081218	1808303-14	2.6		74%
Trip 7	Pink	M36-XS31-01-081218	165.4	153.4	27%	127	M36-XS31-01-081218	1808303-15	110.0		40%
Trip 7	Pink	M37-XS124A-01-081318	330.0	281.0	39%	229	M37-XS124A-01-081318	1808303-16	240.0		32%
Trip 7	Pink	M37-XS144-01-081318	116.6	111.4	10%	109	M37-XS144-01-081318	1808303-17	57.0		69%
Trip 7	Pink	M37-XS2-01-081318	42.4	42.0	9%	38	M37-XS2-01-081318	1808303-18	2.8		175%
Trip 7	Pink	M37-XS23-01-081318	25.0	24.3	9%	23	M37-XS23-01-081318	1808303-19	2.9		158%
Trip 7	Pink	M37-XS31-01-081318	153.7	148.1	17%	129	M37-XS31-01-081318	1808303-20	110.0		33%
Trip 7	Pink	M37-XS38-01-081318	22.2	21.2	12%	21	M37-XS38-01-081318	1808356-1	2.8	J	155%
Trip 7	Pink	M37-XS44-01-081318	153.1	151.9	8%	138	M37-XS44-01-081318	1808356-2	100.0		42%
Trip 7	Pink	M37-XS50-01-081318	35.1	35.6	7%	32	M37-XS50-01-081318	1808356-3	4.8		152%
Trip 7	Pink	M37-XS7-01-081318	25.2	19.3	60%	11	M37-XS7-01-081318	1808356-4	5.8		125%
Trip 7	Pink	M38-XS20-01-081818	16.7	16.6	8%	15	M38-XS20-01-081818	1808483-2	10.0		50%
Trip 7	Red	M3-XS19-01-081718	4.4	4.4	12%	4	M3-XS19-01-081718	1808476-1	2.6		51%
Trip 7	Red	M3-XS41-01-081718	9.4	9.1	9%	9	M3-XS41-01-081718	1808476-2	5.9		46%
Trip 7	Red	M4-XSG2-01-081818	3.1	3.4	36%	2	M4-XSG2-01-081818	1808483-5	1.1		96%
Trip 7	Red	M5-XS131-01-082018	64.1	59.8	19%	54	M5-XS131-01-082018	1808487-1	62.0		3%
Trip 7	Red	M5-XS15-01-081818	4.3	4.6	31%	3	M5-XS15-01-081818	1808483-6	3.5		22%
Trip 7	Red	M5-XS192-01-081818	8.1	8.5	16%	6	M5-XS192-01-081818	1808483-7	4.1		65%
Trip 7	Red	M5-XS199-01-082018	22.5	22.6	8%	21	M5-XS199-01-082018	1808487-2	27.0		18%
Trip 7	Red	M5-XS207A-01-082018	59.8	54.1	31%	42	M5-XS207A-01-082018	1808487-3	77.0		25%
Trip 7	Red	M5-XS261-01-082018	53.4	53.9	9%	48	M5-XS261-01-082018	1808487-4	46.0		15%
Trip 7	Red	M5-XS305-01-082018	40.4	40.5	11%	34	M5-XS305-01-082018	1808487-6	37.0		9%
Trip 7	Red	M6-XS108-01-081618	10.9	10.2	13%	10	M6-XS108-01-081618	1808476-3	12.0	J	10%
Trip 7	Red	M6-XS108-02-081618	9.3	8.7	28%	6	M6-XS108-02-081618	1808476-4	8.3	J	11%
Trip 7	Red	M6-XS198-01-081618	9.6	9.6	10%	9	M6-XS198-01-081618	1808476-5	6.5		39%
Trip 7	Red	M6-XS249-01-081618	3.2	3.3	30%	2	M6-XS249-01-081618	1808476-6	1.6		65%
Trip 7	Red	M6-XS289-01-081618	5.4	5.4	10%	5	M6-XS289-01-081618	1808476-7	4.4		21%

Data Included											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M6-XS60-01-081618	6.1	5.3	47%	3	M6-XS60-01-081618	1808476-9	3.5		54%
Trip 7	Red	M6-XS72-01-081618	19.8	19.3	15%	17	M6-XS72-01-081618	1808476-10	5.3		116%
Trip 7	Red	M7-XS162A-01-081518	398.4	365.0	26%	311	M7-XS162A-01-081518	1808356-5	270.0		38%
Trip 7	Pink	M7-XS203-01-081418	50.2	44.4	30%	38	M7-XS203-01-081418	1808356-6	31.0		47%
Trip 7	Pink	M7-XS213-01-081518	16.4	14.8	37%	10	M7-XS213-01-081518	1808356-7	14.0		16%
Trip 7	Pink	M7-XS214-01-081518	47.4	45.3	14%	40	M7-XS214-01-081518	1808356-8	41.0		14%
Trip 7	Pink	M7-XS235A-01-081418	110.9	111.0	24%	83	M7-XS235A-01-081418	1808356-9	140.0		23%
Trip 7	Pink	M7-XS244-01-081518	13.6	12.5	26%	10	M7-XS244-01-081518	1808356-10	12.0		12%
Trip 7	Pink	M8-XS55-01-081418	54.4	48.5	20%	46	M8-XS55-01-081418	1808356-20	35.0		43%
Trip 7	Pink	M8-XS83-01-081418	211.8	220.7	17%	163	M8-XS83-01-081418	1808476-12	180.0		16%
Trip 7	Red	M8-XSG16-01-081518	32.2	29.8	28%	24	M8-XSG16-01-081518	1808356-11	33.0		2%
Trip 7	Pink	M8-XSG28-01-081418	4.2	4.2	21%	3	M8-XSG28-01-081418	1808356-12	2.6		46%
Trip 7	Pink	M8-XSG31-01-081518	28.1	28.3	7%	25	M8-XSG31-01-081518	1808356-13	8.3		109%
Trip 7	Pink	M8-XSG37-01-081418	6.4	6.2	10%	6	M8-XSG37-01-081418	1808356-14	3.8		51%
Trip 7	Pink	M8-XSG40-01-081418	19.1	18.6	11%	17	M8-XSG40-01-081418	1808356-15	6.8		95%
Trip 7	Pink	M8-XSG4-01-081518	23.3	23.0	7%	22	M8-XSG4-01-081518	1808356-16	2.2		166%
Trip 7	Pink	M8-XSG44-01-081418	19.7	14.5	63%	12	M8-XSG44-01-081418	1808356-17	1.6		170%
Trip 7	Pink	M8-XSG47-01-081418	19.8	19.9	9%	17	M8-XSG47-01-081418	1808356-19	1.9		165%
Trip 7	Red	M9-XS19A-01-081718	17.7	17.5	5%	17	M9-XS19A-01-081718	1808483-8	1.5		169%
Trip 7	Red	M9-XS28A-01-081718	98.8	96.8	16%	74	M9-XS28A-01-081718	1808483-9	150.0		41%
Trip 7	Red	T10-XSG1-01-081818	5.1	5.1	7%	5	T10-XSG1-01-081818	1808483-10	2.6		66%
Trip 7	Red	T13-XSG16-01-081618	17.0	16.2	17%	14	T13-XSG16-01-081618	1808476-13	1.0		178%
Trip 7	Red	T13-XSG26-01-081618	3.3	3.4	23%	2	T13-XSG26-01-081618	1808476-14	1.0		108%
Trip 7	Red	T13-XSG7-01-081618	3.3	3.2	26%	2	T13-XSG7-01-081618	1808476-15	0.6		140%
Trip 7	Red	T15-XS20-01-081718	2.2	1.9	31%	2	T15-XS20-01-081718	1808483-11	0.3		154%
Trip 7	Red	T15-XSG5-01-081718	4.0	4.0	26%	3	T15-XSG5-01-081718	1808483-12	0.7		137%
Trip 7	Red	T17-XSG17-01-081618	16.6	15.8	11%	15	T17-XSG17-01-081618	1808476-16	4.2		119%
Trip 7	Red	T17-XSG27-01-081618	17.9	17.5	16%	14	T17-XSG27-01-081618	1808476-17	1.1		177%
Trip 7	Red	T17-XSG31-01-081518	17.3	16.7	12%	15	T17-XSG31-01-081518	1808476-18	0.9	J	180%
Trip 7	Red	T17-XSG7-01-081618	16.6	16.4	13%	14	T17-XSG7-01-081618	1808476-19	1.2	J	173%
Trip 7	Red	T17-XSG7-02-081618	4.1	4.0	12%	4	T17-XSG7-02-081618	1808476-20	1.8	J	78%
Trip 7	Red	T1-XSG49A-01-081918	12.4	11.5	18%	11	T1-XSG49A-01-081918	1808483-14	6.0		70%
Trip 7	Red	T1-XSG5A-01-081918	73.5	2.4	256%	2	T1-XSG5A-01-081918	1808483-15	0.7		196%
Trip 7	Red	T4-XS15A-01-081918	84.6	83.2	12%	72	T4-XS15A-01-081918	1808487-9	52.0		48%
Trip 7	Red	T4-XSG10-01-081918	7.2	7.2	12%	6	T4-XSG10-01-081918	1808483-16	5.3		31%
Trip 7	Red	T4-XSG39-01-081918	4.7	4.5	23%	3	T4-XSG39-01-081918	1808483-17	2.5		60%
Trip 7	Red	T4-XSG50A-01-081918	32.7	28.2	35%	24	T4-XSG50A-01-081918	1808483-18	25.0		27%
Trip 7	Red	T5-XSG10-01-081918	66.2	63.6	13%	59	T5-XSG10-01-081918	1808483-19	51.0		26%
Trip 7	Red	T9-XSG12-01-081818	3.4	3.4	13%	3	T9-XSG12-01-081818	1808483-20	0.7		132%
Trip 8	Red	M13-XS112-01-091518	7.0	7.0	23%	5	M13-XS112-01-091518	1809475-1	2.8		85%
Trip 8	Red	M14-XS62-01-091818	5.2	5.2	17%	4	M14-XS62-01-091818	1809475-21	1.9		92%
Trip 8	Red	M14-XSG14A-01-091818	38.4	38.7	17%	30	M14-XSG14A-01-091818	1809475-22	32.0		18%
Trip 8	Red	M14-XSG27A-01-091818	11.7	10.5	27%	9	M14-XSG27A-01-091818	1809475-23	8.7		29%
Trip 8	Red	M14-XSG41-01-091818	4.6	4.6	24%	3	M14-XSG41-01-091818	1809475-24	1.6		97%
Trip 8	Red	M14-XSG49-01-091818	3.6	3.6	22%	2	M14-XSG49-01-091818	1809475-25	0.7		132%
Trip 8	Red	M14-XSG58-01-091818	8.0	6.7	52%	5	M14-XSG58-01-091818	1809475-26	1.5		137%
Trip 8	Red	M14-XSG6-01-091818	12.4	11.8	19%	11	M14-XSG6-01-091818	1809475-27	8.1		42%
Trip 8	Red	M15-XSG20-01-091118	16.6	17.6	16%	11	M15-XSG20-01-091118	1809473-20	2.3		151%
Trip 8	Red	M15-XSG2-01-091118	3.5	3.5	23%	2	M15-XSG2-01-091118	1809473-21	0.8		127%
Trip 8	Red	M16-XSG13-01-091118	11.9	12.0	9%	10	M16-XSG13-01-091118	1809473-22	4.3		94%
Trip 8	Red	M16-XSG24-01-091118	16.4	16.1	14%	14	M16-XSG24-01-091118	1809473-23	12.0		31%
Trip 8	Red	M16-XSG30-01-091518	8.7	8.8	14%	7	M16-XSG30-01-091518	1809475-3	7.3		18%
Trip 8	Red	M17-XS79-01-091318	107.3	99.7	16%	90	M17-XS79-01-091318	1809473-1	81.0		28%
Trip 8	Red	M17-XSG1-01-091318	5.6	5.7	12%	5	M17-XSG1-01-091318	1809473-2	1.7		107%
Trip 8	Red	M17-XSG27-01-091318	3.5	3.3	17%	3	M17-XSG27-01-091318	1809473-3	1.0		113%
Trip 8	Red	M17-XSG36-01-091318	10.7	10.4	10%	10	M17-XSG36-01-091318	1809473-4	8.1		28%
Trip 8	Red	M17-XSG36-02-091318	11.1	11.0	16%	9	M17-XSG36-02-091318	1809473-5	7.9		33%
Trip 8	Red	M18-XSG16-01-091318	3.7	3.6	38%	2	M18-XSG16-01-091318	1809473-6	0.9		123%
Trip 8	Red	M18-XSG30-01-091318	12.2	12.5	14%	9	M18-XSG30-01-091318	1809473-7	8.5		36%
Trip 8	Red	M18-XSG32-01-091318	3.4	3.3	32%	2	M18-XSG32-01-091318	1809473-8	1.2		97%
Trip 8	Red	M19-XSG11-01-091318	6.3	6.5	15%	5	M19-XSG11-01-091318	1809473-9	3.0		71%
Trip 8	Red	M19-XSG19-01-091318	54.9	56.5	20%	41	M19-XSG19-01-091318	1809473-10	62.0		12%
Trip 8	Red	M19-XSG25-01-091318	18.1	17.8	16%	15	M19-XSG25-01-091318	1809473-11	11.0		49%
Trip 8	Red	M19-XSG29-01-091318	6.8	6.4	25%	5	M19-XSG29-01-091318	1809473-12	3.9		55%
Trip 8	Red	M19-XSG39-01-091318	11.6	11.6	6%	11	M19-XSG39-01-091318	1809473-13	6.9		51%
Trip 8	Red	M19-XSG43-01-091318	17.8	15.1	43%	13	M19-XSG43-01-091318	1809473-14	8.8		67%
Trip 8	Red	M20-XS146-01-091718	248.5	231.5	33%	158	M20-XS146-01-091718	1809475-28	270.0		8%
Trip 8	Red	M20-XS243-01-091718	177.7	170.9	16%	152	M20-XS243-01-091718	1809475-29	250.0		34%

Data Included												
Trip	XRF Color	XRF ID	XRF - Uranium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 8	Red	M20-XS247-01-091718	5.3	4.3	48%	3	M20-XS247-01-091718	1809475-30	2.6		68%
Trip 8	Red	M20-XS267-01-091718	201.5	201.0	27%	135	M20-XS267-01-091718	1809475-31	180.0		11%
Trip 8	Red	M20-XS271-01-091718	4.7	4.9	29%	3	M20-XS271-01-091718	1809475-32	2.8		52%
Trip 8	Red	M20-XS30-01-091718	14.0	14.4	12%	11	M20-XS30-01-091718	1809475-33	9.8		35%
Trip 8	Red	M20-XS335-01-091418	7.5	6.9	28%	5	M20-XS335-01-091418	1809475-5	4.3		55%
Trip 8	Red	M20-XS422-01-091418	5.1	4.7	30%	4	M20-XS422-01-091418	1809475-6	3.9		26%
Trip 8	Red	M20-XS58-01-091718	50.3	51.8	14%	39	M20-XS58-01-091718	1809475-34	46.0		9%
Trip 8	Red	M20-XS60-01-091718	24.0	23.6	15%	20	M20-XS60-01-091718	1809475-35	19.0		23%
Trip 8	Red	M20-XSG15-01-091418	4.4	4.3	27%	3	M20-XSG15-01-091418	1809475-7	1.2		114%
Trip 8	Red	M20-XSG28-01-091418	35.5	26.2	68%	23	M20-XSG28-01-091418	1809475-8	22.0		47%
Trip 8	Red	M21-XS1-01-091218	16.1	16.6	8%	14	M21-XS1-01-091218	1809473-24	1.7		162%
Trip 8	Red	M21-XS317-01-091218	13.5	12.1	25%	12	M21-XS317-01-091218	1809473-25	9.7		33%
Trip 8	Red	M21-XS323-01-091218	26.3	24.7	20%	21	M21-XS323-01-091218	1809473-26	38.0		36%
Trip 8	Red	M21-XS366-01-091418	17.0	15.9	41%	10	M21-XS366-01-091418	1809475-10	12.0		35%
Trip 8	Red	M21-XS366-02-091418	18.8	18.0	14%	16	M21-XS366-02-091418	1809475-11	13.0		37%
Trip 8	Red	M21-XS465-01-091218	16.2	16.3	6%	15	M21-XS465-01-091218	1809473-27	11.0		38%
Trip 8	Red	M21-XS503-01-091218	77.6	75.1	28%	54	M21-XS503-01-091218	1809473-28	66.0		16%
Trip 8	Red	M21-XS511-01-091218	5.6	5.8	11%	5	M21-XS511-01-091218	1809473-29	1.9		98%
Trip 8	Red	M21-XS536-01-091218	14.5	14.7	12%	12	M21-XS536-01-091218	1809473-30	6.7		74%
Trip 8	Red	M21-XSG16-01-091218	26.6	27.1	13%	22	M21-XSG16-01-091218	1809473-31	2.9		161%
Trip 8	Red	M21-XSG38-01-091418	17.0	16.7	8%	16	M21-XSG38-01-091418	1809475-12	8.5		67%
Trip 8	Red	M21-XSG43-01-091418	9.3	8.7	18%	8	M21-XSG43-01-091418	1809475-13	6.3		39%
Trip 8	Red	M21-XSG7-01-091218	16.4	16.4	20%	13	M21-XSG7-01-091218	1809473-32	2.1		155%
Trip 8	Red	M22-XS112-01-091418	22.7	23.6	16%	16	M22-XS112-01-091418	1809475-14	17.0		29%
Trip 8	Red	M22-XS115-01-091418	5.0	5.1	19%	4	M22-XS115-01-091418	1809475-15	1.7		99%
Trip 8	Red	M22-XS121-01-091418	3.3	3.0	29%	2	M22-XS121-01-091418	1809475-16	1.2		94%
Trip 8	Red	M22-XS94-01-091418	8.0	5.8	101%	2	M22-XS94-01-091418	1809475-17	2.4		107%
Trip 8	Red	M23-XSG1-01-091418	14.6	15.2	14%	12	M23-XSG1-01-091418	1809475-18	6.3		79%
Trip 8	Red	M6-XS164-01-091118	15.6	15.1	10%	14	M6-XS164-01-091118	1809473-33	0.8		181%
Trip 8	Red	M6-XS224-01-091118	16.9	16.7	8%	15	M6-XS224-01-091118	1809473-34	2.6		147%
Trip 8	Red	M6-XS353A-01-091618	11.7	11.8	12%	10	M6-XS353A-01-091618	1809475-36	5.2		77%
Trip 8	Red	M6-XS52-01-091118	3.5	3.7	28%	2	M6-XS52-01-091118	1809473-35	0.6		139%
Trip 8	Red	M6-XSG13A-01-091618	60.5	42.8	80%	35	M6-XSG13A-01-091618	1809475-38	37.0		48%
Trip 8	Red	M7-XSG34-01-091618	6.1	6.0	30%	4	M7-XSG34-01-091618	1809475-40	2.1		98%
Trip 8	Red	M7-XSG41-01-091618	2.6	2.5	22%	2	M7-XSG41-01-091618	1809475-41	1.2		74%
Trip 8	Red	T19-XS9-01-091118	16.1	16.7	12%	14	T19-XS9-01-091118	1809473-36	1.4		168%
Trip 8	Red	T20-XSG3-01-091118	12.9	13.2	44%	2	T20-XSG3-01-091118	1809473-37	0.8		176%
Trip 8	Red	T21-XSG13-01-091118	7.9	7.6	35%	5	T21-XSG13-01-091118	1809473-38	4.7		51%
Trip 8	Red	T21-XSG26-01-091118	3.9	3.6	32%	3	T21-XSG26-01-091118	1809473-39	1.7		79%
Trip 8	Red	T22-XS20-01-091118	14.2	14.7	10%	12	T22-XS20-01-091118	1809473-15	0.7		180%
Trip 8	Red	T23-XSG26-01-091118	5.7	5.5	35%	4	T23-XSG26-01-091118	1809473-16	3.7	J	43%
Trip 8	Red	T23-XSG7-01-091118	20.5	21.3	13%	16	T23-XSG7-01-091118	1809473-17	15.0		31%
Trip 8	Red	T24-XSG2-01-091118	3.5	3.2	35%	2	T24-XSG2-01-091118	1809473-18	0.6		144%
Trip 8	Red	T24-XSG26-01-091118	17.1	17.9	12%	15	T24-XSG26-01-091118	1809473-19	1.3		172%
Trip 8	Red	T26-XSG2-01-091518	9.3	9.5	18%	7	T26-XSG2-01-091518	1809475-43	5.6		50%
Trip 9	Red	M10-XSG2-01-092818	4.8	5.0	12%	4	M10-XSG2-01-092818	1810122-1	2.5		63%
Trip 9	Blue	M10-XSG4-01-092818	4.5	4.7	25%	3	M10-XSG4-01-092818	1810122-2	1.5		100%
Trip 9	Blue	M11-XSG25-01-092818	24.5	19.4	66%	9	M11-XSG25-01-092818	1810122-5	13.0		61%
Trip 9	Blue	M11-XSG28-01-092818	7.1	7.0	18%	5	M11-XSG28-01-092818	1810122-6	1.5		130%
Trip 9	Red	M12-XSG26-01-092818	2.0	2.0	17%	2	M12-XSG26-01-092818	1810122-8	0.8		91%
Trip 9	Blue	M14-XSR1-01-093018	6.4	3.4	125%	2	M14-XSR1-01-093018	1810072-21	1.3		133%
Trip 9	White	M16-XSR1-01-093018	3.2	3.0	27%	2	M16-XSR1-01-093018	1810072-23	1.2		91%
Trip 9	White	M16-XSR6-01-093018	3.5	3.6	21%	3	M16-XSR6-01-093018	1810072-24	0.7		134%
Trip 9	Blue	M19-XSR2-02-093018	4.9	4.7	22%	4	M19-XSR2-02-093018	1810072-27	0.5		164%
Trip 9	Red	M1-XSG4-01-092818	11.0	11.5	16%	8	M1-XSG4-01-092818	1810072-1	6.8		48%
Trip 9	White	M23-XSR4-01-093018	6.4	6.1	17%	5	M23-XSR4-01-093018	1810072-29	1.9		108%
Trip 9	Red	M24-XS112-01-092518	3.5	3.4	23%	2	M24-XS112-01-092518	1810032-1	1.1		104%
Trip 9	Red	M24-XS114-01-092518	3.5	3.5	32%	2	M24-XS114-01-092518	1810032-2	1.0		111%
Trip 9	Red	M24-XSG15-01-092518	9.7	9.8	9%	9	M24-XSG15-01-092518	1810032-3	4.8		67%
Trip 9	Red	M24-XSG3-01-092518	6.7	6.4	25%	5	M24-XSG3-01-092518	1810032-4	3.6		61%
Trip 9	Red	M24-XSG32-01-092518	2.7	2.5	21%	2	M24-XSG32-01-092518	1810032-5	1.1		83%
Trip 9	Red	M24-XSR1-01-093018	6.0	5.8	17%	5	M24-XSR1-01-093018	1810072-30	2.8		73%
Trip 9	Blue	M25-XSG19-01-092818	4.3	4.0	31%	3	M25-XSG19-01-092818	1810122-11	1.7		86%
Trip 9	Blue	M25-XSG19-02-092818	4.2	4.3	36%	2	M25-XSG19-02-092818	1810122-12	1.9		75%
Trip 9	Red	M27-XS116-01-092618	6.2	6.0	19%	5	M27-XS116-01-092618	1810072-2	2.9		73%
Trip 9	Red	M27-XS149-01-092618	3.0	2.7	36%	2	M27-XS149-01-092618	1810072-3	1.7		56%
Trip 9	Red	M27-XS150-01-092618	2.6	2.8	21%	2	M27-XS150-01-092618	1810072-4	1.3		68%
Trip 9	Red	M27-XS163-01-092618	11.7	11.5	26%	9	M27-XS163-01-092618	1810072-5	6.1		63%

Data Included											
			XRF - Uranium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	Red	M27-XSG28-01-092618	30.6	31.0	9%	25	M27-XSG28-01-092618	1810072-6	25.0		20%
Trip 9	Red	M27-XSG28-02-092618	31.0	29.9	12%	27	M27-XSG28-02-092618	1810072-7	23.0		30%
Trip 9	Red	M27-XSG48-01-092618	7.6	7.4	17%	6	M27-XSG48-01-092618	1810072-8	1.9		120%
Trip 9	Red	M27-XSG6-01-092618	6.4	6.4	19%	4	M27-XSG6-01-092618	1810072-9	5.0		24%
Trip 9	Red, Blue	M28-XS162-01-092818	27.6	27.5	30%	15	M28-XS162-01-092818	1810122-14	12.0		79%
Trip 9	White	M28-XS19-01-092918	6.6	6.3	19%	5	M28-XS19-01-092918	1810122-15	1.3		135%
Trip 9	Red	M28-XS29-01-092618	274.9	241.3	37%	205	M28-XS29-01-092618	1810032-6	220.0		22%
Trip 9	Red	M28-XSG49-01-092618	9.6	10.3	24%	5	M28-XSG49-01-092618	1810032-7	5.0		63%
Trip 9	Red, White	M28-XSG54-01-092918	9.9	10.0	15%	8	M28-XSG54-01-092918	1810122-17	3.7		91%
Trip 9	Red	M28-XSG7-01-092618	799.4	725.8	35%	558	M28-XSG7-01-092618	1810032-8	660.0		19%
Trip 9	White	M28-XSG76-01-092918	7.7	7.6	17%	6	M28-XSG76-01-092918	1810122-18	2.3		108%
Trip 9	Red	M29-XS19-01-092518	15.0	14.1	21%	12	M29-XS19-01-092518	1810032-9	11.0		31%
Trip 9	Red	M29-XS59-01-092518	22.5	21.9	18%	17	M29-XS59-01-092518	1810032-11	15.0		40%
Trip 9	Red	M29-XS64-01-092518	6.5	6.1	37%	4	M29-XS64-01-092518	1810032-12	3.1		71%
Trip 9	Red	M29-XSG25-01-092518	2.3	2.4	16%	2	M29-XSG25-01-092518	1810032-14	1.0		83%
Trip 9	Red	M29-XSG35-01-092518	3.6	3.9	21%	2	M29-XSG35-01-092518	1810032-15	0.5		151%
Trip 9	Blue	M29-XSR4-01-093018	5.4	5.4	24%	4	M29-XSR4-01-093018	1810072-33	1.3		123%
Trip 9	Red	M29-XSR7-01-093018	4.5	4.7	18%	3	M29-XSR7-01-093018	1810072-34	1.5		100%
Trip 9	White	M30-XS144-01-092918	10.1	9.8	16%	8	M30-XS144-01-092918	1810122-19	4.6		75%
Trip 9	White	M30-XS185-01-092918	7.8	7.4	18%	7	M30-XS185-01-092918	1810122-20	2.0		119%
Trip 9	White	M30-XS62-01-092918	12.7	12.6	18%	9	M30-XS62-01-092918	1810122-21	9.0		34%
Trip 9	White	M30-XSG18-01-092918	6.7	6.9	15%	5	M30-XSG18-01-092918	1810122-22	1.9		112%
Trip 9	White	M30-XSG29-01-092918	6.5	6.9	21%	4	M30-XSG29-01-092918	1810122-23	1.9		109%
Trip 9	White	M30-XSG43-01-092918	5.4	5.4	14%	5	M30-XSG43-01-092918	1810122-24	2.2		84%
Trip 9	Red, White	M30-XSG6-01-092918	25.4	16.1	99%	11	M30-XSG6-01-092918	1810122-26	16.0		46%
Trip 9	White	M30-XSR5-01-093018	3.7	3.9	22%	3	M30-XSR5-01-093018	1810072-36	0.8		127%
Trip 9	Red	M31-XS1-01-092918	10.1	9.8	16%	8	M31-XS1-01-092918	1810122-28	6.3		46%
Trip 9	Blue	M31-XS39-01-092918	12.3	12.1	6%	12	M31-XS39-01-092918	1810122-29	6.6		61%
Trip 9	White	M31-XS8-01-092918	13.8	13.2	27%	10	M31-XS8-01-092918	1810122-30	6.7		69%
Trip 9	White	M31-XSG1-01-092918	4.3	4.2	15%	3	M31-XSG1-01-092918	1810122-31	1.9		77%
Trip 9	White	M31-XSG12-01-092918	9.8	10.0	8%	9	M31-XSG12-01-092918	1810122-32	2.2		127%
Trip 9	White	M31-XSG17-01-092918	7.5	7.4	19%	6	M31-XSG17-01-092918	1810122-33	3.2		80%
Trip 9	Red	M31-XSG9-01-092918	4.0	3.9	43%	2	M31-XSG9-01-092918	1810122-34	1.8		76%
Trip 9	Red	M32-XSG23-01-092918	4.5	4.4	23%	3	M32-XSG23-01-092918	1810072-10	1.3		111%
Trip 9	Red	M32-XSG26-01-092918	5.9	6.0	16%	5	M32-XSG26-01-092918	1810072-11	3.5		51%
Trip 9	Red	M32-XSG46-01-092918	2.4	2.3	21%	2	M32-XSG46-01-092918	1810072-13	1.3		58%
Trip 9	Red	M32-XSG9-01-092918	3.8	3.6	19%	3	M32-XSG9-01-092918	1810072-14	1.6		83%
Trip 9	Red	M35-XSG20-01-092718	8.0	8.3	23%	6	M35-XSG20-01-092718	1810072-16	3.5		78%
Trip 9	Red	M35-XSG4-01-092718	3.6	3.5	27%	2	M35-XSG4-01-092718	1810072-17	1.1		107%
Trip 9	Red	M36-XSG1-01-092718	10.3	10.0	19%	8	M36-XSG1-01-092718	1810072-18	6.5		46%
Trip 9	White	M7-XSR1-01-093018	8.2	8.6	16%	7	M7-XSR1-01-093018	1810072-38	3.5		81%
Trip 9	White	M7-XSR1-02-093018	8.4	8.3	9%	8	M7-XSR1-02-093018	1810072-39	3.8		75%
Trip 9	Blue	M8-XSR1-01-093018	6.1	6.1	42%	2	M8-XSR1-01-093018	1810072-40	1.9		105%
Trip 9	White	T17-XSR1-01-093018	6.0	5.8	23%	4	T17-XSR1-01-093018	1810072-41	3.0		67%
Trip 9	Red	T5-XSG3-01-092818	3.9	3.9	22%	3	T5-XSG3-01-092818	1810072-19	1.8		75%
Trip 9	Red	T5-XSG3-02-092818	4.5	4.3	18%	4	T5-XSG3-02-092818	1810072-20	1.8		85%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Uranium: Average Ex Situ XRF (ppm)	XRF - Uranium: Median Ex Situ XRF (ppm)	XRF - Uranium: Relative Standard Deviation	XRF - Uranium: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 7	Red	M4-XS210-01-081818	1.1	1.5	79%	0	M4-XS210-01-081818	1808483-3	1.3		19%
Trip 7	Red	M4-XSG11-01-081818	0.8	0.0	167%	0	M4-XSG11-01-081818	1808483-4	1.1		34%
Trip 7	Red	M5-XS476-01-082018	1.3	0.8	117%	0	M5-XS476-01-082018	1808487-7	0.6		69%
Trip 7	Red	M5-XS488-01-082018	1.5	1.9	84%	0	M5-XS488-01-082018	1808487-8	0.5		107%
Trip 7	Red	M6-XS324-01-081618	2.7	3.1	57%	0	M6-XS324-01-081618	1808476-8	1.2		78%
Trip 7	Pink	M8-XSG44-02-081418	1.1	0.8	113%	0	M8-XSG44-02-081418	1808356-18	1.6		37%
Trip 7	Pink	M8-XSG6-01-081518	1.6	2.1	79%	0	M8-XSG6-01-081518	1808476-11	0.6		89%
Trip 7	Red	T1-XSG38-01-081918	2.5	2.9	53%	0	T1-XSG38-01-081918	1808483-13	0.6		126%
Trip 7	Red	T6-XSG6-01-081918	1.4	1.8	79%	0	T6-XSG6-01-081918	1808487-10	0.6		72%
Trip 7	Red	T6-XSG6-02-081918	0.7	0.0	159%	0	T6-XSG6-02-081918	1808487-11	0.5		20%
Trip 8	Red	M13-XS258-01-091518	1.0	0.9	112%	0	M13-XS258-01-091518	1809475-2	0.5		72%
Trip 8	Red	M16-XSG38-01-091518	0.0	0.0	#DIV/0!	0	M16-XSG38-01-091518	1809475-4	0.3		200%
Trip 8	Red	M20-XSG7-01-091418	0.6	0.0	156%	0	M20-XSG7-01-091418	1809475-9	0.6		2%
Trip 8	Red	M23-XSG20-01-091418	1.8	1.7	110%	0	M23-XSG20-01-091418	1809475-19	0.9		66%
Trip 8	Red	M23-XSG5-01-091418	1.2	1.1	110%	0	M23-XSG5-01-091418	1809475-20	0.8		44%
Trip 8	Red	M6-XS369-01-091618	0.7	0.0	155%	0	M6-XS369-01-091618	1809475-37	0.6		27%
Trip 8	Red	M6-XSG22-01-091618	2.3	2.5	57%	0	M6-XSG22-01-091618	1809475-39	1.0		83%
Trip 8	Red	T18-XSG7-01-091518	1.2	0.9	113%	0	T18-XSG7-01-091518	1809475-42	0.3		111%
Trip 8	Red	T26-XSG9-01-091518	2.1	2.7	81%	0	T26-XSG9-01-091518	1809475-44	1.1		63%
Trip 9	Blue	M11-XSG2-01-092818	1.3	1.2	110%	0	M11-XSG2-01-092818	1810122-4	0.8		47%
Trip 9	Red	M11-XSG33-01-092818	2.4	3.1	82%	0	M11-XSG33-01-092818	1810122-7	1.5		47%
Trip 9	White	M15-XSR1-01-093018	2.6	2.9	53%	0	M15-XSR1-01-093018	1810072-22	0.5		140%
Trip 9	Blue	M17-XSR1-01-093018	2.0	1.7	112%	0	M17-XSR1-01-093018	1810072-25	0.4		138%
Trip 9	Red	M19-XSR2-01-093018	1.4	2.0	78%	0	M19-XSR2-01-093018	1810072-26	0.5		100%
Trip 9	Blue	M20-XSR2-01-093018	6.1	3.2	141%	0	M20-XSR2-01-093018	1810072-28	0.4		177%
Trip 9	Blue	M25-XSG12-01-092818	0.8	0.0	155%	0	M25-XSG12-01-092818	1810122-10	0.3		92%
Trip 9	Blue	M25-XSG5-01-092818	0.8	0.0	161%	0	M25-XSG5-01-092818	1810122-13	0.5		57%
Trip 9	Blue	M28-XSG18-01-092918	2.7	2.5	61%	0	M28-XSG18-01-092918	1810122-16	1.0		91%
Trip 9	Blue	M28-XSR1-01-093018	0.7	0.0	155%	0	M28-XSR1-01-093018	1810072-31	0.3		81%
Trip 9	Red	M28-XSR1-02-093018	0.4	0.0	245%	0	M28-XSR1-02-093018	1810072-32	0.3		34%
Trip 9	Red	M29-XS42-01-092518	1.8	2.2	82%	0	M29-XS42-01-092518	1810032-10	0.8		75%
Trip 9	Red	M29-XSG1-01-092518	1.5	1.2	111%	0	M29-XSG1-01-092518	1810032-13	1.1		31%
Trip 9	White	M2-XSR3-01-093018	2.5	2.8	54%	0	M2-XSR3-01-093018	1810072-35	0.7		115%
Trip 9	White	M30-XSG45-01-092918	3.2	3.9	51%	0	M30-XSG45-01-092918	1810122-25	0.7		132%
Trip 9	Blue	M30-XSG61-01-092918	0.8	0.0	158%	0	M30-XSG61-01-092918	1810122-27	0.3		102%
Trip 9	Red	M32-XSG34-01-092918	2.4	2.8	50%	0	M32-XSG34-01-092918	1810072-12	0.8		103%
Trip 9	White	M6-XSR1-01-093018	1.8	2.0	51%	0	M6-XSR1-01-093018	1810072-37	0.3		139%
Trip 9	Red	T30-XS20-01-092518	2.3	2.6	51%	0	T30-XS20-01-092518	1810032-16	0.7		111%
Trip 9	Red	T30-XS28-01-092518	2.6	3.0	56%	0	T30-XS28-01-092518	1810032-17	0.6		124%
Trip 9	Red	T30-XS8-01-092518	2.1	2.4	57%	0	T30-XS8-01-092518	1810032-18	0.4		141%
Trip 9	Red	T31-XSG7-01-092518	2.3	3.3	78%	0	T31-XSG7-01-092518	1810032-19	0.4		144%
Trip 9	Red	T31-XSG9-01-092518	2.0	2.2	86%	0	T31-XSG9-01-092518	1810032-20	0.5		122%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Uranium: Average Ex Situ XRF (ppm)	XRF - Uranium: Median Ex Situ XRF (ppm)	XRF - Uranium: Relative Standard Deviation	XRF - Uranium: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 7	Red	M5-XS263-01-082018	280.6	93.7	163%	67	M5-XS263-01-082018	1808487-5	83.0		109%
Trip 9	Red	M11-XS47-01-092818	18.7	18.4	18%	15	M11-XS47-01-092818	1810122-3	26.0		33%
Trip 9	Red	M12-XSG3-01-092818	56.4	2.8	236%	0	M12-XSG3-01-092818	1810122-9	0.9		194%
Trip 9	Red	M34-XSG15-01-092718	7.8	7.6	10%	7	M34-XSG15-01-092718	1810072-15	20.0		88%

Notes:

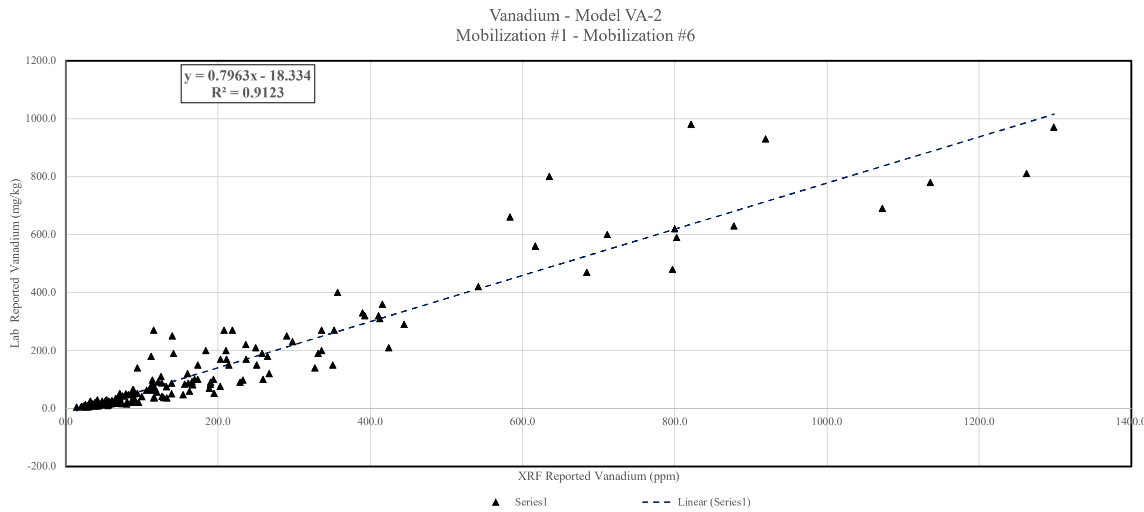
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model VA-2												
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-01-042418	26.2	26.8	19%	21	M2-XS15-01-042418	1805041-1	13.0		67%
Trip 1	Pink	M2-XS15-02-042418	25.4	23.8	23%	20	M2-XS15-02-042418	1805041-2	11.0		79%
Trip 1	Pink	M2-XS32-01-042418	70.8	68.7	11%	62	M2-XS32-01-042418	1805041-3	52.0		31%
Trip 1	Pink	M2-XS59-01-042418	25.4	24.1	27%	20	M2-XS59-01-042418	1805041-4	7.0		114%
Trip 1	Pink	M2-XS73-01-042418	21.4	21.6	15%	17	M2-XS73-01-042418	1805041-5	7.5		96%
Trip 1	Pink	M3-XS34-01-043018	167.0	167.3	4%	156	M3-XS34-01-043018	1805042-1	82.0		68%
Trip 1	Pink	M3-XS36-01-043018	121.3	120.3	7%	114	M3-XS36-01-043018	1805042-2	91.0		29%
Trip 1	Pink	M6-XS140-01-042818	139.1	135.2	20%	105	M6-XS140-01-042818	1805041-6	87.0		46%
Trip 1	Orange	M6-XS159-01-04262018	331.6	343.2	12%	269	M6-XS159-01-04262018	1805039-1	190.0		54%
Trip 1	Pink	M6-XS251-01-04272018	82.2	81.2	6%	76	M6-XS251-01-04272018	1805039-2	47.0		54%
Trip 1	Pink	M6-XS269-02-04262018	110.6	110.1	2%	108	M6-XS269-02-04262018	1805039-4	66.0	J	50%
Trip 1	Pink	T10-XS1-01-042518	44.7	40.6	10%	36	T10-XS1-01-042518	1805036-1	12.0		115%
Trip 1	Pink	T10-XS20-01-042518	31.0	31.5	17%	24	T10-XS20-01-042518	1805036-2	8.0		118%
Trip 1	Pink	T10-XS33-01-042518	35.3	36.9	17%	25	T10-XS33-01-042518	1805036-3	9.2		117%
Trip 1	Pink	T10-XS56-01-042518	44.2	41.8	15%	38	T10-XS56-01-042518	1805036-4	12.0		115%
Trip 1	Pink	T10-XS78-01-042518	44.8	42.4	15%	39	T10-XS78-01-042518	1805036-5	13.0		110%
Trip 1	Pink	T11-XS1-01-042518	44.7	42.1	12%	40	T11-XS1-01-042518	1805036-6	11.0		121%
Trip 1	Pink	T11-XS20-01-042518	40.1	40.7	8%	36	T11-XS20-01-042518	1805036-7	10.0		120%
Trip 1	Pink	T11-XS60-01-042518	29.8	32.0	17%	20	T11-XS60-01-042518	1805036-8	7.2		122%
Trip 1	Pink	T17-XS1-01-04262018	32.6	31.0	14%	27	T17-XS1-01-04262018	1805039-6	12.0		92%
Trip 1	Pink	T17-XS1-02-04262018	31.2	31.7	8%	28	T17-XS1-02-04262018	1805039-7	11.0		96%
Trip 1	Pink	T17-XS143-01-04262018	190.0	117.5	94%	113	T17-XS143-01-04262018	1805039-8	83.0		78%
Trip 1	Orange	T17-XS144-01-04262018	125.2	124.3	8%	116	T17-XS144-01-04262018	1805039-9	110.0		13%
Trip 1	Pink	T17-XS194-01-04272018	41.4	40.6	13%	35	T17-XS194-01-04272018	1805039-10	13.0		104%
Trip 1	Pink	T17-XS194-02-04272018	40.2	42.7	14%	32	T17-XS194-02-04272018	1805039-11	13.0		102%
Trip 1	Pink	T17-XS20-01-04262018	48.3	47.5	9%	43	T17-XS20-01-04262018	1805039-12	16.0		101%
Trip 1	Pink	T17-XS208-01-042818	38.0	38.3	7%	35	T17-XS208-01-042818	1805041-7	12.0		104%
Trip 1	Pink	T17-XS251-01-04272018	90.1	86.3	12%	79	T17-XS251-01-04272018	1805039-13	51.0		55%
Trip 1	Pink	T17-XS257-01-04272018	69.1	66.1	11%	62	T17-XS257-01-04272018	1805039-14	32.0		73%
Trip 1	Pink	T17-XS273-01-042818	35.9	36.2	6%	33	T17-XS273-01-042818	1805041-8	13.0	J	94%
Trip 1	Pink	T17-XS287-01-04272018	55.8	57.8	11%	48	T17-XS287-01-04272018	1805039-15	21.0		91%
Trip 1	Pink	T17-XS304-01-042818	32.4	33.0	21%	21	T17-XS304-01-042818	1805041-9	8.9		114%
Trip 1	Pink	T17-XS317-01-04272018	79.0	78.2	8%	73	T17-XS317-01-04272018	1805039-16	51.0		43%
Trip 1	Pink	T17-XS328-01-04272018	53.7	53.6	9%	47	T17-XS328-01-04272018	1805039-17	18.0		100%
Trip 1	Pink	T17-XS369-01-043018	42.9	43.6	8%	39	T17-XS369-01-043018	1805042-4	11.0		118%
Trip 1	Pink	T17-XS377-01-042818	117.7	113.6	8%	110	T17-XS377-01-042818	1805041-10	68.0		54%
Trip 1	Pink	T17-XS393-01-043018	36.9	35.2	14%	32	T17-XS393-01-043018	1805042-5	11.0		108%
Trip 1	Pink	T17-XS417-01-04272018	51.2	50.4	8%	48	T17-XS417-01-04272018	1805039-18	16.0		105%
Trip 1	Pink	T17-XS438-01-042818	31.3	31.0	12%	27	T17-XS438-01-042818	1805041-11	9.7		105%
Trip 1	Pink	T17-XS44-01-04262018	48.1	49.3	9%	43	T17-XS44-01-04262018	1805039-19	17.0		96%
Trip 1	Pink	T17-XS442-01-04272018	69.7	68.1	7%	64	T17-XS442-01-04272018	1805039-20	37.0		61%
Trip 1	Pink	T17-XS46-01-042618	46.8	48.0	8%	41	T17-XS46-01-042618	1805041-12	17.0		93%
Trip 1	Pink	T17-XS473-01-042818	74.9	73.1	7%	70	T17-XS473-01-042818	1805041-13	43.0		54%
Trip 1	Pink	T17-XS479-01-042818	47.8	47.7	4%	46	T17-XS479-01-042818	1805041-14	21.0		78%
Trip 1	Pink	T17-XS479-02-042818	48.7	48.9	9%	43	T17-XS479-02-042818	1805041-15	20.0		83%
Trip 1	Pink	T17-XS603-01-042818	41.6	41.8	7%	37	T17-XS603-01-042818	1805041-16	9.1		128%
Trip 1	Pink	T17-XS659-01-043018	36.4	34.8	14%	31	T17-XS659-01-043018	1805042-6	8.3		126%

Data Included in Model VA-2

Trip	XRF Color	XRF ID	XRF - Vanadium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 1	Pink	T17-XS679-01-043018	42.8	40.6	14%	39	T17-XS679-01-043018	1805042-7	15.0		96%
Trip 1	Pink	T17-XS704-01-043018	38.8	38.2	14%	31	T17-XS704-01-043018	1805042-8	7.5		135%
Trip 1	Pink	T7-XS11-01-042418	26.5	26.1	2%	22	T7-XS11-01-042418	1805036-9	5.9		127%
Trip 1	Pink	T7-XS5-01-042418	23.8	24.1	19%	18	T7-XS5-01-042418	1805036-10	5.7		123%
Trip 1	Pink	T7-XS58-01-042418	24.3	23.9	17%	20	T7-XS58-01-042418	1805036-11	5.5		126%
Trip 1	Pink	T7-XS7-01-042418	20.7	20.8	13%	18	T7-XS7-01-042418	1805036-12	5.0		122%
Trip 1	Pink	T7-XS9-01-042418	23.4	24.5	19%	17	T7-XS9-01-042418	1805036-13	5.9		119%
Trip 1	Pink	T8-XS15-01-042418	25.7	25.0	12%	23	T8-XS15-01-042418	1805036-14	7.3		112%
Trip 1	Pink	T8-XS23-01-042418	31.4	30.3	10%	29	T8-XS23-01-042418	1805036-15	7.9		120%
Trip 1	Pink	T8-XS6-01-042418	28.8	27.4	13%	25	T8-XS6-01-042418	1805036-16	6.6		125%
Trip 1	Pink	T9-XS217-01-042518	41.2	39.3	13%	36	T9-XS217-01-042518	1805036-17	12.0		110%
Trip 1	Pink	T9-XS61-01-042518	47.6	48.5	10%	41	T9-XS61-01-042518	1805036-18	13.0		114%
Trip 1	Orange	T9-XS61-02-042518	47.8	47.6	9%	43	T9-XS61-02-042518	1805041-17	13.0		114%
Trip 1	Pink	T9-XS86-01-042518	44.8	46.1	15%	34	T9-XS86-01-042518	1805036-19	12.0		116%
Trip 1	Pink	T9-XS93-01-042518	57.4	56.9	8%	52	T9-XS93-01-042518	1805036-20	23.0		86%
Trip 2	Orange	M1-XS31-01-051218	211.4	212.3	5%	191	M1-XS31-01-051218	1805328-1	170.0		22%
Trip 2	Pink	M1-XS32-01-051218	250.9	241.2	17%	204	M1-XS32-01-051218	1805328-2	150.0		50%
Trip 2	Pink	M4-XS136-01-050918	390.2	380.3	7%	368	M4-XS136-01-050918	1805322-1	330.0		17%
Trip 2	Pink	M4-XS18-01-050718	190.5	186.4	7%	178	M4-XS18-01-050718	1805322-2	90.0		72%
Trip 2	Orange	M4-XS219-01-051018	115.1	114.0	6%	105	M4-XS219-01-051018	1805322-3	63.0		59%
Trip 2	Pink	M4-XS238-01-051018	336.2	322.6	18%	271	M4-XS238-01-051018	1805322-4	270.0		22%
Trip 2	Pink	M4-XS4-01-050718	89.2	89.4	7%	79	M4-XS4-01-050718	1805322-5	40.0		76%
Trip 2	Pink	M4-XS45-01-050718	214.4	212.7	6%	188	M4-XS45-01-050718	1805322-6	150.0		35%
Trip 2	Pink	M4-XS78-01-051018	616.9	515.4	33%	477	M4-XS78-01-051018	1805322-9	560.0		10%
Trip 2	Orange	M5-XS115-01-051118	160.2	160.3	7%	147	M5-XS115-01-051118	1805322-10	120.0		29%
Trip 2	Pink	M5-XS385-01-051118	56.1	55.6	11%	48	M5-XS385-01-051118	1805322-11	20.0		95%
Trip 2	Pink	M5-XS69-01-051118	52.2	52.6	6%	48	M5-XS69-01-051118	1805322-12	27.0		64%
Trip 2	Orange	M6-XS41-01-051118	20.1	19.1	13%	18	M6-XS41-01-051118	1805322-13	5.9		109%
Trip 2	Pink	M6-XS44-01-051018	41.5	41.2	8%	37	M6-XS44-01-051018	1805322-14	15.0		94%
Trip 2	Pink	M6-XS81-01-051018	51.6	50.4	11%	43	M6-XS81-01-051018	1805322-15	17.0		101%
Trip 2	Pink	M7-XS181-01-051018	165.8	167.4	7%	140	M7-XS181-01-051018	1805322-16	93.0		56%
Trip 2	Orange	M7-XS181-02-051018	169.5	170.3	5%	158	M7-XS181-02-051018	1805322-17	100.0		52%
Trip 2	Orange	M7-XS39-01-051018	49.1	49.1	8%	45	M7-XS39-01-051018	1805322-18	17.0		97%
Trip 2	Orange	M7-XS74-01-051018	94.2	96.4	17%	76	M7-XS74-01-051018	1805322-19	52.0		58%
Trip 2	Orange	M7-XS77-01-051018	69.8	69.9	7%	60	M7-XS77-01-051018	1805322-20	31.0		77%
Trip 2	Pink	M8-XS100-01-050918	34.6	34.8	13%	28	M8-XS100-01-050918	1805328-3	13.0		91%
Trip 2	Pink	M8-XS102-01-050918	115.5	116.3	10%	101	M8-XS102-01-050918	1805328-4	36.0		105%
Trip 2	Pink	M8-XS102-02-050918	128.7	130.2	10%	111	M8-XS102-02-050918	1805328-5	37.0		111%
Trip 2	Pink	M8-XS110-01-050918	424.4	425.9	3%	400	M8-XS110-01-050918	1805328-6	210.0		68%
Trip 2	Orange	M8-XS19-01-051018	57.8	57.7	10%	52	M8-XS19-01-051018	1805328-7	21.0		93%
Trip 2	Orange	M8-XS32-01-051018	58.6	59.4	12%	47	M8-XS32-01-051018	1805328-8	19.0		102%
Trip 2	Pink	M8-XS94-01-050918	684.8	607.4	30%	561	M8-XS94-01-050918	1805328-9	470.0		37%
Trip 2	Pink	T13-XS12-01-050818	42.4	42.5	8%	37	T13-XS12-01-050818	1805322-21	13.0		106%
Trip 2	Pink	T13-XS24-01-050818	24.3	23.5	16%	19	T13-XS24-01-050818	1805322-22	6.7		113%
Trip 2	Pink	T14-XS12-01-050818	39.9	38.8	9%	37	T14-XS12-01-050818	1805322-23	11.0		114%
Trip 2	Pink	T14-XS27-01-050818	33.8	31.9	11%	31	T14-XS27-01-050818	1805322-24	9.4		113%
Trip 2	Pink	T15-XS2-01-050818	40.1	40.5	11%	35	T15-XS2-01-050818	1805322-25	11.0		114%
Trip 2	Pink	T15-XS45-01-050818	33.6	31.8	20%	26	T15-XS45-01-050818	1805322-26	11.0		101%
Trip 2	Pink	T17-XS122-01-050718	38.3	37.4	11%	35	T17-XS122-01-050718	1805322-27	15.0		87%
Trip 2	Pink	T17-XS176-01-050718	41.7	39.6	12%	38	T17-XS176-01-050718	1805322-28	16.0		89%
Trip 2	Pink	T17-XS178-01-050718	30.7	32.4	12%	26	T17-XS178-01-050718	1805322-29	11.0		95%
Trip 2	Pink	T17-XS619-01-050718	35.8	35.7	10%	30	T17-XS619-01-050718	1805322-30	10.0		113%
Trip 2	Pink	T17-XS619-02-050718	35.1	36.5	8%	31	T17-XS619-02-050718	1805322-31	11.0		104%
Trip 2	Pink	T17-XS645-01-050718	39.8	40.3	13%	30	T17-XS645-01-050718	1805322-32	12.0		107%
Trip 2	Pink	T17-XS669-01-050718	31.9	33.3	14%	23	T17-XS669-01-050718	1805322-33	12.0		91%
Trip 2	Pink	T1-XS104-01-051318	54.2	53.1	12%	45	T1-XS104-01-051318	1805328-10	15.0		113%
Trip 2	Pink	T1-XS20-01-051318	38.7	41.1	13%	29	T1-XS20-01-051318	1805328-11	9.7		120%
Trip 2	Pink	T1-XS54-01-051318	39.3	39.4	14%	33	T1-XS54-01-051318	1805328-12	10.0		119%
Trip 2	Pink	T1-XS54-02-051318	42.5	41.8	5%	40	T1-XS54-02-051318	1805328-13	10.0		124%
Trip 2	Pink	T1-XS69-01-051318	56.1	51.7	21%	46	T1-XS69-01-051318	1805328-14	25.0		77%
Trip 2	Orange	T3-XS10-01-051218	42.4	41.2	6%	40	T3-XS10-01-051218	1805328-15	10.0		124%
Trip 2	Orange	T3-XS5-01-051218	30.1	29.7	6%	28	T3-XS5-01-051218	1805328-16	6.6		128%
Trip 2	Pink	T4-XS23-01-051218	24.3	23.9	16%	20	T4-XS23-01-051218	1805328-17	6.3		118%
Trip 2	Orange	T4-XS32-01-051218	89.3	89.1	8%	81	T4-XS32-01-051218	1805328-18	29.0		102%
Trip 2	Pink	T4-XS43-01-051218	39.0	38.6	13%	32	T4-XS43-01-051218	1805328-19	14.0		94%
Trip 2	Pink	T5-XS18-01-051418	31.0	29.7	13%	27	T5-XS18-01-051418	1805328-20	7.1		125%
Trip 2	Pink	T6-XS2-01-051218	26.2	25.7	11%	22	T6-XS2-01-051218	1805328-21	4.7		139%
Trip 2	Orange	T6-XS25-01-051218	27.8	29.3	10%	23	T6-XS25-01-051218	1805328-22	5.8		131%
Trip 3	Pink	M14-XS36-01-052418	1262.5	1251.8	5%	1203	M14-XS36-01-052418	1805632-1	810		44%
Trip 3	Pink	M14-XS40-01-052418	1072.8	1055.1	7%	989	M14-XS40-01-052418	1805632-2	690		43%
Trip 3	Pink	M14-XS64-01-052418	412.6	418.1	7%	373	M14-XS64-01-052418	1805632-3	310		28%

Data Included in Model VA-2

Trip	XRF Color	XRF ID	XRF - Vanadium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 3	Pink	M14-XS67-01-052418	1136.1	1147.8	6%	1018	M14-XS67-01-052418	1805632-4	780		37%
Trip 3	Pink	M15-XS3-01-052118	173.5	176.5	6%	156	M15-XS3-01-052118	1805589-2	150		15%
Trip 3	Pink	M15-XS22-01-052118	416.0	418.4	6%	387	M15-XS22-01-052118	1805589-1	360		14%
Trip 3	Pink	M15-XS46-01-052118	71.0	69.7	10%	64	M15-XS46-01-052118	1805589-3	38		61%
Trip 3	Pink	M15-XS46-02-052118	66.7	65.5	11%	57	M15-XS46-02-052118	1805589-4	33		68%
Trip 3	Pink	M15-XS82-01-052118	80.6	81.3	9%	70	M15-XS82-01-052118	1805589-6	23		111%
Trip 3	Pink	M15-XS93-01-052118	797.2	806.0	7%	724	M15-XS93-01-052118	1805589-7	480		50%
Trip 3	Pink	M16-XS4-01-052118	115.7	117.4	7%	102	M16-XS4-01-052118	1805589-12	77		40%
Trip 3	Pink	M16-XS30-01-052118	265.3	278.5	11%	216	M16-XS30-01-052118	1805589-10	180		38%
Trip 3	Pink	M16-XS31-01-052118	106.4	104.3	9%	94	M16-XS31-01-052118	1805589-11	63		51%
Trip 3	Pink	M16-XS128-01-052118	877.7	868.9	16%	676	M16-XS128-01-052118	1805589-8	630		33%
Trip 3	Pink	M16-XS154-01-052618	392.8	390.8	4%	368	M16-XS154-01-052618	1806235-2	320		20%
Trip 3	Pink	M16-XS177-01-052618	290.4	282.8	11%	251	M16-XS177-01-052618	1806235-3	250		15%
Trip 3	Pink	M16-XS191-01-052618	249.8	241.9	11%	223	M16-XS191-01-052618	1806235-4	210		17%
Trip 3	Pink	M16-XS191-02-052618	298.1	273.7	22%	232	M16-XS191-02-052618	1806235-5	230		26%
Trip 3	Pink	M17-XS55-01-052618	711.5	712.1	5%	655	M17-XS55-01-052618	1806235-6	600		17%
Trip 3	Pink	M17-XS83-01-052618	800.2	789.0	6%	749	M17-XS83-01-052618	1806235-7	620		25%
Trip 3	Pink	M17-XS83-02-052618	802.8	789.1	9%	730	M17-XS83-02-052618	1806235-8	590		31%
Trip 3	Pink	M18-XS155-01-052518	55.3	54.3	12%	45	M18-XS155-01-052518	1805632-5	17		106%
Trip 3	Pink	M18-XS161-01-052518	1298.2	1284.1	23%	1000	M18-XS161-01-052518	1805632-6	970		29%
Trip 3	Pink	M19-XS22-02-052318	821.8	804.5	13%	716	M19-XS22-02-052318	1805632-8	980		18%
Trip 3	Pink	M19-XS22-01-052318	919.5	932.5	7%	843	M19-XS22-01-052318	1805632-7	930		1%
Trip 3	Pink	M19-XS43-01-052318	208.1	202.8	11%	189	M19-XS43-01-052318	1805632-9	270		26%
Trip 3	Pink	T21-XS55-02-052118	65.5	66.0	8%	59	T21-XS55-02-052118	1805589-16	34	J	63%
Trip 3	Pink	T22-XS64-01-052218	40.5	40.4	14%	33	T22-XS64-01-052218	1805632-11	13		103%
Trip 3	Pink	T23-XS23-01-052118	89.1	87.9	5%	85	T23-XS23-01-052118	1805589-19	64		33%
Trip 3	Pink	T23-XS40-01-052118	88.2	87.8	6%	81	T23-XS40-01-052118	1805589-20	65		30%
Trip 3	Pink	T24-XS48-01-052418	56.8	56.4	15%	48	T24-XS48-01-052418	1805632-12	14		121%
Trip 4	Pink	M13-XS72-01-060618	55.4	55.1	7%	51	M13-XS72-01-060618	1806235-1	10		139%
Trip 4	Pink	M20-XS5-01-060518	88.6	89.2	5%	82	M20-XS5-01-060518	1806235-20	34		89%
Trip 4	Pink	M20-XS11-01-060618	139.3	138.7	3%	134	M20-XS11-01-060618	1806235-9	51		93%
Trip 4	Pink	M20-XS18-01-060618	267.3	265.8	9%	235	M20-XS18-01-060618	1806235-12	120		76%
Trip 4	Pink	M20-XS86-01-060618	327.5	323.0	3%	317	M20-XS86-01-060618	1806235-21	140		80%
Trip 4	Pink	M20-XS130-01-060418	37.2	37.0	7%	34	M20-XS130-01-060418	1806235-10	12		102%
Trip 4	Pink	M20-XS166-01-060518	132.7	132.7	3%	128	M20-XS166-01-060518	1806235-11	36		115%
Trip 4	Pink	M20-XS185-01-060418	36.9	36.1	10%	34	M20-XS185-01-060418	1806235-13	10		115%
Trip 4	Pink	M20-XS231-01-060418	43.4	42.3	11%	38	M20-XS231-01-060418	1806235-14	12		113%
Trip 4	Pink	M20-XS278-01-060418	95.9	96.5	12%	82	M20-XS278-01-060418	1806235-15	21		128%
Trip 4	Pink	M20-XS306-01-060518	54.9	53.6	11%	48	M20-XS306-01-060518	1806235-16	14		119%
Trip 4	Pink	M20-XS312-01-060518	232.7	232.7	8%	210	M20-XS312-01-060518	1806235-17	98		81%
Trip 4	Pink	M20-XS365-01-060618	336.4	352.4	13%	277	M20-XS365-01-060618	1806235-18	200		51%
Trip 4	Pink	M20-XS365-02-060618	351.0	351.7	10%	292	M20-XS365-02-060618	1806235-19	150		80%
Trip 4	Pink	M21-XS14-01-060818	73.8	74.8	9%	63	M21-XS14-01-060818	1806234-3	17		125%
Trip 4	Pink	M21-XS27-01-060818	45.5	47.7	10%	36	M21-XS27-01-060818	1806234-7	14		106%
Trip 4	Pink	M21-XS27-02-060818	48.8	48.6	11%	42	M21-XS27-02-060818	1806234-8	15		106%
Trip 4	Pink	M21-XS40-01-060818	154.2	153.3	3%	148	M21-XS40-01-060818	1806234-15	47		107%
Trip 4	Pink	M21-XS122-01-060818	55.1	52.8	14%	47	M21-XS122-01-060818	1806234-1	16		110%
Trip 4	Pink	M21-XS126-01-060818	79.7	75.7	13%	69	M21-XS126-01-060818	1806234-2	16		133%
Trip 4	Pink	M21-XS175-01-060818	64.4	64.5	4%	61	M21-XS175-01-060818	1806234-4	21		102%
Trip 4	Pink	M21-XS225-01-060518	87.5	89.7	17%	67	M21-XS225-01-060518	1806235-22	21		123%
Trip 4	Pink	M21-XS260-01-060918	119.6	120.0	4%	114	M21-XS260-01-060918	1806234-6	56		72%
Trip 4	Pink	M21-XS282-01-060918	259.2	260.5	4%	242	M21-XS282-01-060918	1806234-9	100		89%
Trip 4	Pink	M21-XS290-01-060918	73.0	72.7	8%	66	M21-XS290-01-060918	1806234-10	19		117%
Trip 4	Pink	M21-XS292-01-060518	80.4	79.9	6%	74	M21-XS292-01-060518	1806235-23	20		120%
Trip 4	Pink	M21-XS302-01-060918	203.5	189.3	21%	173	M21-XS302-01-060918	1806234-11	170	J	18%
Trip 4	Pink	M21-XS334-01-060918	89.0	89.3	8%	80	M21-XS334-01-060918	1806234-13	37		83%
Trip 4	Pink	M21-XS377-01-060918	116.4	112.0	7%	110	M21-XS377-01-060918	1806234-14	38		102%
Trip 4	Pink	M21-XS403-01-060818	444.8	393.1	34%	321	M21-XS403-01-060818	1806234-16	290		42%
Trip 4	Pink	M21-XS419-01-060818	54.9	53.8	6%	51	M21-XS419-01-060818	1806234-17	22		86%
Trip 4	Pink	M21-XS477-01-060818	352.7	357.1	6%	315	M21-XS477-01-060818	1806234-19	270		27%
Trip 4	Pink	M21-XS541-01-060818	126.5	127.7	7%	110	M21-XS541-01-060818	1806234-20	42		100%
Trip 4	Pink	M21-XS596-01-060518	194.1	193.3	3%	188	M21-XS596-01-060518	1806235-24	100		64%
Trip 4	Pink	M21-XS615-01-060518	188.6	189.8	2%	182	M21-XS615-01-060518	1806235-25	69		93%
Trip 4	Pink	M21-XS619-01-060618	195.0	159.6	46%	150	M21-XS619-01-060618	1806235-26	52		116%
Trip 4	Pink	M22-XS14-01-060418	162.6	162.3	7%	144	M22-XS14-01-060418	1806235-27	60		92%
Trip 4	Pink	M22-XS30-01-060418	229.0	230.2	10%	197	M22-XS30-01-060418	1806235-28	90		87%
Trip 4	Pink	M22-XS40-01-060518	100.0	102.2	7%	88	M22-XS40-01-060518	1806235-29	41		84%
Trip 4	Pink	M22-XS60-01-060418	236.9	225.3	15%	210	M22-XS60-01-060418	1806235-30	170		33%
Trip 4	Pink	M22-XS87-01-060418	203.0	201.0	20%	147	M22-XS87-01-060418	1806235-31	76		91%
Trip 4	Pink	M23-XS20-01-061018	32.2	31.2	14%	27	M23-XS20-01-061018	1806233-3	11		98%
Trip 4	Pink	M23-XS48-01-061018	26.4	25.8	18%	19	M23-XS48-01-061018	1806233-4	8.2		105%

Data Included in Model VA-2											
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M23-XS54-01-061118	542.3	499.6	21%	479	M23-XS54-01-061118	1806312-1	420	J	25%
Trip 4	Pink	M23-XS64-01-061018	25.6	25.1	18%	20	M23-XS64-01-061018	1806233-5	9.3		93%
Trip 4	Pink	M23-XS70-01-061018	31.8	31.5	9%	27	M23-XS70-01-061018	1806233-6	8.4		116%
Trip 4	Pink	M23-XS79-01-061018	53.2	53.0	4%	50	M23-XS79-01-061018	1806233-7	22		83%
Trip 4	Pink	M23-XS102-01-061018	44.8	45.9	13%	34	M23-XS102-01-061018	1806233-1	13		110%
Trip 4	Pink	M23-XS123-01-061018	28.4	28.6	10%	24	M23-XS123-01-061018	1806233-2	9		104%
Trip 4	Pink	M24-XS100-01-061118	31.8	32.2	23%	21	M24-XS100-01-061118	1806312-3	11		97%
Trip 4	Pink	M24-XS128-01-061118	34.3	34.8	14%	27	M24-XS128-01-061118	1806312-4	18		62%
Trip 4	Pink	T18-XS14-01-061118	25.5	26.3	21%	17	T18-XS14-01-061118	1806312-5	7.8		106%
Trip 4	Pink	T18-XS27-01-061118	14.3	13.9	17%	12	T18-XS27-01-061118	1806312-6	4.6		103%
Trip 4	Pink	T25-XS2-01-060618	40.3	39.3	8%	37	T25-XS2-01-060618	1806235-32	11		114%
Trip 4	Pink	T26-XS1-01-061018	67.0	63.4	15%	58	T26-XS1-01-061018	1806233-8	18		115%
Trip 4	Pink	T26-XS8-01-061018	60.1	61.5	8%	54	T26-XS8-01-061018	1806233-9	17		112%
Trip 4	Pink	T27-XS6-01-061018	28.8	30.0	10%	24	T27-XS6-01-061018	1806233-11	8.7		107%
Trip 4	Pink	T27-XS19-01-061018	26.1	25.9	13%	22	T27-XS19-01-061018	1806233-10	7.7		109%
Trip 5	Pink	M26-XS13-01-061818	38.9	34.7	37%	27	M26-XS13-01-061818	1806558-1	21.0		60%
Trip 5	Pink	M26-XS25-01-061818	236.4	237.2	6%	221	M26-XS25-01-061818	1806558-2	220.0		7%
Trip 5	Pink	M27-XS21-01-061918	87.2	87.5	11%	75	M27-XS21-01-061918	1806558-10	56.0		44%
Trip 5	Pink	M27-XS29-01-061818	53.9	53.4	8%	50	M27-XS29-01-061818	1806558-14	30.0		57%
Trip 5	Pink	M27-XS38-01-061918	410.9	397.1	12%	376	M27-XS38-01-061918	1806558-15	320.0		25%
Trip 5	Pink	M27-XS108-01-061918	48.0	47.4	8%	43	M27-XS108-01-061918	1806558-3	25.0		63%
Trip 5	Pink	M27-XS109-01-061918	66.9	64.3	20%	52	M27-XS109-01-061918	1806558-4	29.0	J	79%
Trip 5	Pink	M27-XS123-01-061818	32.4	30.1	21%	27	M27-XS123-01-061818	1806558-5	25.0		26%
Trip 5	Pink	M27-XS188-01-061918	61.1	60.8	8%	55	M27-XS188-01-061918	1806558-6	26.0		81%
Trip 5	Pink	M27-XS197-01-061918	54.4	52.3	12%	48	M27-XS197-01-061918	1806558-7	24.0		78%
Trip 5	Pink	M27-XS210-02-061818	24.6	22.8	18%	21	M27-XS210-02-061818	1806558-9	9.2		91%
Trip 5	Pink	M27-XS210-01-061818	33.2	33.5	9%	29	M27-XS210-01-061818	1806558-8	9.9		108%
Trip 5	Pink	M27-XS239-01-061818	25.3	26.3	16%	18	M27-XS239-01-061818	1806558-11	7.9		105%
Trip 5	Pink	M27-XS275-01-061918	141.6	136.9	13%	125	M27-XS275-01-061918	1806558-12	190.0		29%
Trip 5	Pink	M27-XS283-01-061818	210.7	208.4	6%	195	M27-XS283-01-061818	1806558-13	200.0		5%
Trip 5	Pink	M28-XS8-01-062018	28.4	27.2	22%	22	M28-XS8-01-062018	1806558-21	5.1		139%
Trip 5	Pink	M28-XS43-01-062018	41.4	40.6	12%	35	M28-XS43-01-062018	1806558-20	30.0		32%
Trip 5	Pink	M28-XS105-01-062018	31.7	31.7	11%	26	M28-XS105-01-062018	1806558-16	11.0		97%
Trip 5	Pink	M28-XS148-01-062018	132.3	128.9	19%	106	M28-XS148-01-062018	1806558-17	75.0		55%
Trip 5	Pink	M28-XS155-01-062018	52.0	51.4	17%	40	M28-XS155-01-062018	1806558-18	27.0		63%
Trip 5	Pink	M28-XS170-01-062018	61.3	59.9	9%	56	M28-XS170-01-062018	1806558-19	19.0		105%
Trip 5	Pink	M30-XS138-01-062218	156.4	132.0	40%	105	M30-XS138-01-062218	1806693-1	84.0		60%
Trip 5	Pink	M30-XS222-01-062218	51.6	49.5	17%	42	M30-XS222-01-062218	1806693-2	15.0		110%
Trip 5	Pink	T32-XS5-01-062018	28.1	25.8	18%	24	T32-XS5-01-062018	1806558-22	8.5		107%
Trip 6	Orange	M10-XS31-01-071118	38.1	38.2	19%	28	M10-XS31-01-071118	1807369-2	15.0		87%
Trip 6	Orange	M10-XS31-02-071118	35.9	35.9	10%	32	M10-XS31-02-071118	1807369-3	15.0		82%
Trip 6	Red	M11-XS7-01-071118	635.3	632.3	9%	575	M11-XS7-01-071118	1807369-5	800.0		23%
Trip 6	Red	M12-XS27-01-071518	86.7	86.6	6%	79	M12-XS27-01-071518	1807369-6	25.0		110%
Trip 6	Orange	M24-XS115-01-071418	65.7	64.5	9%	60	M24-XS115-01-071418	1807369-7	19.0		110%
Trip 6	Red	M25-XS16-01-071718	93.9	71.9	43%	69	M25-XS16-01-071718	1807452-1	140.0	J	39%
Trip 6	Red	M25-XS23-01-071718	60.7	57.8	14%	55	M25-XS23-01-071718	1807452-2	26.0		80%
Trip 6	Red	M25-XS47-01-071718	24.2	23.9	20%	18	M25-XS47-01-071718	1807452-3	9.9		84%
Trip 6	Red	M25-XS88-01-071718	112.1	110.5	4%	108	M25-XS88-01-071718	1807452-4	78.0		36%
Trip 6	Orange	M30-XS127-01-071618	583.9	583.7	4%	552	M30-XS127-01-071618	1807369-9	660.0		12%
Trip 6	Orange	M30-XS170-01-071618	184.1	187.6	9%	160	M30-XS170-01-071618	1807369-10	200.0		8%
Trip 6	Red	M30-XS95-01-071618	113.7	114.0	16%	89	M30-XS95-01-071618	1807369-11	98.0		15%
Trip 6	Red	M31-XS9-01-071018	160.8	158.3	8%	143	M31-XS9-01-071018	1807369-12	87.0		60%
Trip 6	Orange	M32-XS58-01-071018	126.2	123.7	11%	111	M32-XS58-01-071018	1807369-13	88.0		36%
Trip 6	Red	M32-XS89-01-071018	258.1	258.3	11%	226	M32-XS89-01-071018	1807369-14	190.0		30%
Trip 6	Orange	M33-XS22-01-071218	43.7	41.1	15%	36	M33-XS22-01-071218	1807369-15	12.0		114%
Trip 6	Orange	M33-XS85-01-071218	173.8	173.7	2%	168	M33-XS85-01-071218	1807369-16	100.0		54%
Trip 6	Red	M33-XS93-01-071218	47.0	47.0	12%	39	M33-XS93-01-071218	1807369-17	16.0		98%
Trip 6	Red	T33-XS43-01-071718	65.3	66.0	18%	49	T33-XS43-01-071718	1807452-5	23.0		96%
Trip 1	Pink	M6-XS269-01-04262018	112.4	111.0	6%	103	M6-XS269-01-04262018	1805039-3	180.0	J	46%
Trip 4	Pink	M21-XS259-01-060918	115.5	114.6	7%	106	M21-XS259-01-060918	1806234-5	270		80%
Trip 4	Pink	M21-XS302-02-060918	218.9	228.4	10%	188	M21-XS302-02-060918	1806234-12	270	J	21%
Trip 4	Pink	M21-XS46-01-060818	357.0	359.2	8%	324	M21-XS46-01-060818	1806234-18	400		11%
Trip 6	Orange	M10-XS10A-01-071118	139.9	137.1	9%	131	M10-XS10A-01-071118	1807369-1	250.0		56%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Blue	M15-XS73-01-052118	0.0	0.0	0%	0	M15-XS73-01-052118	1805589-5	310		200%
Trip 3	Blue	M16-XS45-01-052118	1.5	0.0	245%	0	M16-XS45-01-052118	1805589-13	320		198%
Trip 3	Blue	M16-XS166-01-052118	0.0	0.0	0%	0	M16-XS166-01-052118	1805589-9	400		200%
Trip 3	Blue	T20-XS14-01-052218	0.0	0.0	0%	0	T20-XS14-01-052218	1805632-10	13		200%
Trip 3	Blue	T21-XS6-01-052118	0.0	0.0	0%	0	T21-XS6-01-052118	1805589-17	19		200%
Trip 3	Blue	T21-XS35-01-052118	0.0	0.0	0%	0	T21-XS35-01-052118	1805589-14	41		200%
Trip 3	Blue	T21-XS55-01-052118	0.0	0.0	0%	0	T21-XS55-01-052118	1805589-15	36		200%
Trip 3	Blue	T22-XS17-01-052118	0.0	0.0	0%	0	T22-XS17-01-052118	1805589-18	17		200%

Removed Data - Outliers											
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 2	Pink	M4-XS63-02-050718	820.5	787.2	9%	776	M4-XS63-02-050718	1805322-8	1,900		79%
Trip 2	Pink	M4-XS63-01-050718	1,113.5	1,118.7	25%	822	M4-XS63-01-050718	1805322-7	1,900		52%
Trip 6	Orange	M11-XS11-01-071118	981.8	980.0	9%	886	M11-XS11-01-071118	1807369-4	1,500		42%
Trip 1	Pink	M6-XS285-01-04272018	368.5	368.0	5%	346	M6-XS285-01-04272018	1805039-5	820		76%

Notes:

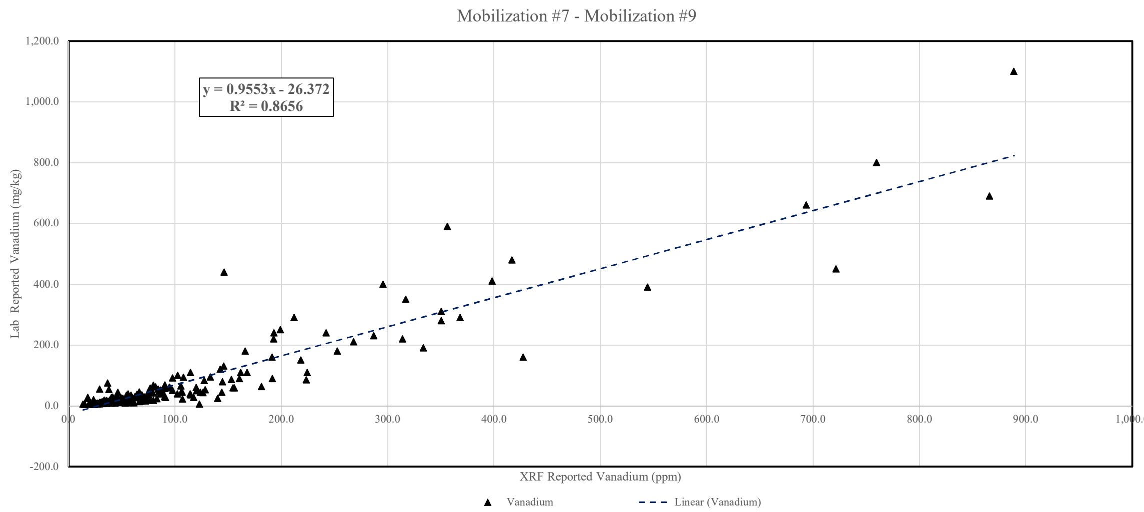
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included											
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M10-XS22-01-082118	90.2	91.3	7%	82	M10-XS22-01-082118	1808494-1	57.0		45%
Trip 7	Red	M10-XS39-01-082118	66.3	65.9	11%	58	M10-XS39-01-082118	1808494-2	27.0		84%
Trip 7	Red	M10-XS43-01-082118	252.6	246.5	14%	206	M10-XS43-01-082118	1808494-3	180.0		34%
Trip 7	Red	M1-XSG2-01-081918	40.0	40.0	8%	36	M1-XSG2-01-081918	1808483-1	8.2		132%
Trip 7	Pink	M34-XS110-01-081218	368.2	356.5	9%	332	M34-XS110-01-081218	1808303-1	290.0		24%
Trip 7	Pink	M34-XS22-01-081218	46.1	45.2	12%	41	M34-XS22-01-081218	1808303-2	16.0		97%
Trip 7	Pink	M34-XS43-01-081218	218.5	221.6	11%	189	M34-XS43-01-081218	1808303-3	150.0		37%
Trip 7	Pink	M34-XS50-01-081218	97.7	93.6	11%	89	M34-XS50-01-081218	1808303-4	51.0		63%
Trip 7	Pink	M34-XS68-01-081218	46.2	46.9	29%	26	M34-XS68-01-081218	1808303-5	22.0		71%
Trip 7	Pink	M35-XS11-01-081218	91.1	90.9	6%	85	M35-XS11-01-081218	1808303-6	27.0		109%
Trip 7	Pink	M35-XS31-01-081218	23.5	22.6	19%	18	M35-XS31-01-081218	1808303-8	13.0		58%
Trip 7	Pink	M35-XS63-01-081218	32.4	31.9	10%	28	M35-XS63-01-081218	1808303-9	9.2		111%
Trip 7	Pink	M35-XS74-01-081318	212.1	212.3	15%	168	M35-XS74-01-081318	1808303-10	290.0		31%
Trip 7	Pink	M35-XS74-02-081318	199.3	204.6	11%	162	M35-XS74-02-081318	1808303-11	250.0		23%
Trip 7	Pink	M36-XS20-01-081218	22.7	21.8	15%	20	M36-XS20-01-081218	1808303-12	13.0		54%
Trip 7	Pink	M36-XS2-01-081218	68.1	66.7	5%	65	M36-XS2-01-081218	1808303-13	21.0	J	106%
Trip 7	Pink	M36-XS3-01-081218	43.8	46.7	16%	32	M36-XS3-01-081218	1808303-14	16.0		93%
Trip 7	Pink	M36-XS31-01-081218	295.6	309.4	17%	218	M36-XS31-01-081218	1808303-15	400.0		30%
Trip 7	Pink	M37-XS144-01-081318	166.2	153.7	50%	96	M37-XS144-01-081318	1808303-17	180.0		8%
Trip 7	Pink	M37-XS2-01-081318	18.0	16.4	39%	10	M37-XS2-01-081318	1808303-18	24.0		28%
Trip 7	Pink	M37-XS31-01-081318	350.6	357.4	9%	306	M37-XS31-01-081318	1808303-20	280.0		22%
Trip 7	Pink	M37-XS44-01-081318	193.1	184.0	22%	160	M37-XS44-01-081318	1808356-2	240.0		22%
Trip 7	Pink	M37-XS50-01-081318	23.6	23.3	6%	22	M37-XS50-01-081318	1808356-3	20.0		17%
Trip 7	Pink	M37-XS7-01-081318	40.4	44.3	49%	15	M37-XS7-01-081318	1808356-4	28.0		36%
Trip 7	Red	M38-XS20-01-081818	64.8	64.3	8%	57	M38-XS20-01-081818	1808483-2	26.0		85%
Trip 7	Red	M3-XS19-01-081718	63.7	65.7	12%	54	M3-XS19-01-081718	1808476-1	27.0		81%
Trip 7	Red	M3-XS41-01-081718	79.3	77.4	10%	71	M3-XS41-01-081718	1808476-2	42.0		62%
Trip 7	Red	M4-XS210-01-081818	114.5	113.3	6%	105	M4-XS210-01-081818	1808483-3	39.0		98%
Trip 7	Red	M4-XSG11-01-081818	29.5	31.1	12%	24	M4-XSG11-01-081818	1808483-4	12.0		84%
Trip 7	Red	M4-XSG2-01-081818	48.9	49.0	7%	44	M4-XSG2-01-081818	1808483-5	22.0		76%
Trip 7	Red	M5-XS131-01-082018	242.0	242.6	7%	221	M5-XS131-01-082018	1808487-1	240.0		1%
Trip 7	Red	M5-XS15-01-081818	74.0	74.7	9%	63	M5-XS15-01-081818	1808483-6	34.0		74%
Trip 7	Red	M5-XS192-01-081818	56.6	57.1	13%	45	M5-XS192-01-081818	1808483-7	16.0		112%
Trip 7	Red	M5-XS199-01-082018	114.8	111.7	5%	110	M5-XS199-01-082018	1808487-2	110.0		4%
Trip 7	Red	M5-XS207A-01-082018	356.1	354.7	5%	335	M5-XS207A-01-082018	1808487-3	590.0		49%
Trip 7	Red	M5-XS261-01-082018	191.3	190.2	7%	175	M5-XS261-01-082018	1808487-4	160.0		18%
Trip 7	Red	M5-XS263-01-082018	416.9	350.4	39%	300	M5-XS263-01-082018	1808487-5	480.0		14%
Trip 7	Red	M5-XS305-01-082018	142.6	137.1	10%	131	M5-XS305-01-082018	1808487-6	120.0		17%
Trip 7	Red	M5-XS476-01-082018	28.1	28.3	9%	24	M5-XS476-01-082018	1808487-7	7.6		115%
Trip 7	Red	M5-XS488-01-082018	29.8	29.5	19%	20	M5-XS488-01-082018	1808487-8	8.4		112%
Trip 7	Red	M6-XS108-01-081618	85.0	82.1	10%	77	M6-XS108-01-081618	1808476-3	47.0	J	58%
Trip 7	Red	M6-XS108-02-081618	79.6	79.3	8%	74	M6-XS108-02-081618	1808476-4	67.0	J	17%
Trip 7	Red	M6-XS198-01-081618	75.0	76.5	9%	65	M6-XS198-01-081618	1808476-5	37.0		68%
Trip 7	Red	M6-XS249-01-081618	86.3	86.1	19%	64	M6-XS249-01-081618	1808476-6	39.0		76%
Trip 7	Red	M6-XS289-01-081618	124.0	124.5	6%	114	M6-XS289-01-081618	1808476-7	44.0		95%
Trip 7	Red	M6-XS324-01-081618	35.6	36.3	8%	31	M6-XS324-01-081618	1808476-8	8.9		120%
Trip 7	Red	M6-XS60-01-081618	41.6	39.0	12%	38	M6-XS60-01-081618	1808476-9	29.0		36%

Data Included											
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M6-XS72-01-081618	114.8	117.0	14%	90	M6-XS72-01-081618	1808476-10	36.0		105%
Trip 7	Pink	M7-XS162A-01-081518	721.5	724.0	11%	629	M7-XS162A-01-081518	1808356-5	450.0		46%
Trip 7	Pink	M7-XS203-01-081418	102.5	97.4	23%	81	M7-XS203-01-081418	1808356-6	100.0		2%
Trip 7	Pink	M7-XS213-01-081518	81.9	71.6	48%	56	M7-XS213-01-081518	1808356-7	62.0		28%
Trip 7	Pink	M7-XS214-01-081518	161.8	155.3	15%	142	M7-XS214-01-081518	1808356-8	110.0		38%
Trip 7	Pink	M7-XS235A-01-081418	192.8	195.3	16%	148	M7-XS235A-01-081418	1808356-9	220.0		13%
Trip 7	Pink	M7-XS244-01-081518	45.8	50.4	29%	24	M7-XS244-01-081518	1808356-10	32.0		36%
Trip 7	Pink	M8-XS55-01-081418	97.7	94.0	18%	79	M8-XS55-01-081418	1808356-20	92.0		6%
Trip 7	Red	M8-XS83-01-081418	544.5	538.7	6%	515	M8-XS83-01-081418	1808476-12	390.0		33%
Trip 7	Pink	M8-XSG16-01-081518	37.9	38.0	10%	33	M8-XSG16-01-081518	1808356-11	54.0		35%
Trip 7	Pink	M8-XSG28-01-081418	36.9	37.2	9%	32	M8-XSG28-01-081418	1808356-12	14.0		90%
Trip 7	Pink	M8-XSG31-01-081518	18.2	18.3	23%	14	M8-XSG31-01-081518	1808356-13	27.0		39%
Trip 7	Pink	M8-XSG37-01-081418	47.9	46.9	12%	43	M8-XSG37-01-081418	1808356-14	15.0		105%
Trip 7	Pink	M8-XSG40-01-081418	29.1	27.8	14%	25	M8-XSG40-01-081418	1808356-15	55.0		62%
Trip 7	Pink	M8-XSG44-01-081418	75.3	68.8	19%	62	M8-XSG44-01-081418	1808356-17	46.0		48%
Trip 7	Pink	M8-XSG44-02-081418	106.9	100.6	14%	92	M8-XSG44-02-081418	1808356-18	45.0		81%
Trip 7	Pink	M8-XSG47-01-081418	56.1	54.6	15%	47	M8-XSG47-01-081418	1808356-19	39.0		36%
Trip 7	Red	M8-XSG6-01-081518	51.4	51.6	10%	42	M8-XSG6-01-081518	1808476-11	13.0		119%
Trip 7	Red	M9-XS19A-01-081718	59.0	56.2	14%	51	M9-XS19A-01-081718	1808483-8	13.0		128%
Trip 7	Red	T10-XSG1-01-081818	38.1	38.6	10%	31	T10-XSG1-01-081818	1808483-10	16.0		82%
Trip 7	Red	T13-XSG16-01-081618	59.0	61.1	18%	41	T13-XSG16-01-081618	1808476-13	9.7		144%
Trip 7	Red	T13-XSG26-01-081618	40.2	40.7	14%	33	T13-XSG26-01-081618	1808476-14	12.0		108%
Trip 7	Red	T13-XSG7-01-081618	34.7	34.2	20%	26	T13-XSG7-01-081618	1808476-15	9.1		117%
Trip 7	Red	T15-XS20-01-081718	27.1	25.4	22%	20	T15-XS20-01-081718	1808483-11	8.4		105%
Trip 7	Red	T15-XSG5-01-081718	42.6	41.8	15%	36	T15-XSG5-01-081718	1808483-12	9.5		127%
Trip 7	Red	T17-XSG17-01-081618	68.1	66.5	18%	54	T17-XSG17-01-081618	1808476-16	15.0		128%
Trip 7	Red	T17-XSG27-01-081618	61.5	65.0	32%	30	T17-XSG27-01-081618	1808476-17	10.0		144%
Trip 7	Red	T17-XSG31-01-081518	53.4	53.9	18%	37	T17-XSG31-01-081518	1808476-18	9.0		142%
Trip 7	Red	T17-XSG7-01-081618	66.6	68.1	9%	57	T17-XSG7-01-081618	1808476-19	14.0		131%
Trip 7	Red	T17-XSG7-02-081618	43.4	43.3	5%	40	T17-XSG7-02-081618	1808476-20	15.0		97%
Trip 7	Red	T1-XSG38-01-081918	27.4	24.5	23%	22	T1-XSG38-01-081918	1808483-13	6.8		120%
Trip 7	Red	T1-XSG49A-01-081918	36.9	37.1	7%	33	T1-XSG49A-01-081918	1808483-14	11.0		108%
Trip 7	Red	T1-XSG5A-01-081918	123.2	25.6	209%	20	T1-XSG5A-01-081918	1808483-15	5.8		182%
Trip 7	Red	T4-XS15A-01-081918	79.8	79.7	9%	70	T4-XS15A-01-081918	1808487-9	18.0		126%
Trip 7	Red	T4-XSG10-01-081918	31.8	31.1	10%	29	T4-XSG10-01-081918	1808483-16	9.9		105%
Trip 7	Red	T4-XSG39-01-081918	24.1	25.4	18%	18	T4-XSG39-01-081918	1808483-17	4.7		135%
Trip 7	Red	T4-XSG50A-01-081918	155.8	158.6	8%	136	T4-XSG50A-01-081918	1808483-18	59.0		90%
Trip 7	Red	T5-XSG10-01-081918	55.3	56.7	5%	50	T5-XSG10-01-081918	1808483-19	20.0		94%
Trip 7	Red	T6-XSG6-01-081918	19.1	19.6	16%	14	T6-XSG6-01-081918	1808487-10	5.7		108%
Trip 7	Red	T6-XSG6-02-081918	21.9	21.1	13%	19	T6-XSG6-02-081918	1808487-11	5.4		121%
Trip 7	Red	T9-XSG12-01-081818	41.5	43.1	18%	32	T9-XSG12-01-081818	1808483-20	12.0		110%
Trip 8	Red	M13-XS112-01-091518	40.5	40.5	12%	35	M13-XS112-01-091518	1809475-1	15		92%
Trip 8	Red	M13-XS258-01-091518	25.6	23.2	28%	18	M13-XS258-01-091518	1809475-2	9		99%
Trip 8	Red	M14-XS62-01-091818	128.6	128.7	6%	121	M14-XS62-01-091818	1809475-21	53		83%
Trip 8	Red	M14-XSG14A-01-091818	314.1	312.6	8%	276	M14-XSG14A-01-091818	1809475-22	220		35%
Trip 8	Red	M14-XSG27A-01-091818	133.4	135.7	7%	117	M14-XSG27A-01-091818	1809475-23	95		34%
Trip 8	Red	M14-XSG41-01-091818	73.6	74.6	7%	66	M14-XSG41-01-091818	1809475-24	30		84%
Trip 8	Red	M14-XSG49-01-091818	37.8	37.7	8%	34	M14-XSG49-01-091818	1809475-25	13		98%
Trip 8	Red	M14-XSG58-01-091818	50.2	52.1	11%	43	M14-XSG58-01-091818	1809475-26	16		103%
Trip 8	Red	M14-XSG6-01-091818	76.6	74.1	17%	62	M14-XSG6-01-091818	1809475-27	58		28%
Trip 8	Red	M15-XSG20-01-091118	74.3	76.6	15%	59	M15-XSG20-01-091118	1809473-20	23		105%
Trip 8	Red	M15-XSG2-01-091118	31.5	33.0	16%	23	M15-XSG2-01-091118	1809473-21	9		113%
Trip 8	Red	M16-XSG13-01-091118	71.0	66.2	24%	51	M16-XSG13-01-091118	1809473-22	30		81%
Trip 8	Red	M16-XSG24-01-091118	140.3	132.3	17%	119	M16-XSG24-01-091118	1809473-23	24		142%
Trip 8	Red	M16-XSG30-01-091518	94.9	88.4	22%	75	M16-XSG30-01-091518	1809475-3	61		43%
Trip 8	Red	M16-XSG38-01-091518	15.0	14.0	18%	12	M16-XSG38-01-091518	1809475-4	5		106%
Trip 8	Red	M17-XS79-01-091318	286.9	274.0	22%	231	M17-XS79-01-091318	1809473-1	230		22%
Trip 8	Red	M17-XSG1-01-091318	39.8	38.8	24%	26	M17-XSG1-01-091318	1809473-2	13		101%
Trip 8	Red	M17-XSG27-01-091318	33.9	33.0	11%	31	M17-XSG27-01-091318	1809473-3	18		61%
Trip 8	Red	M17-XSG36-01-091318	58.8	58.7	9%	53	M17-XSG36-01-091318	1809473-4	35		51%
Trip 8	Red	M17-XSG36-02-091318	54.6	56.5	9%	46	M17-XSG36-02-091318	1809473-5	35		44%
Trip 8	Red	M18-XSG16-01-091318	35.8	34.9	20%	26	M18-XSG16-01-091318	1809473-6	13		93%
Trip 8	Red	M18-XSG30-01-091318	58.7	58.1	22%	41	M18-XSG30-01-091318	1809473-7	32		59%
Trip 8	Red	M18-XSG32-01-091318	32.6	32.7	12%	27	M18-XSG32-01-091318	1809473-8	12		92%
Trip 8	Red	M19-XSG11-01-091318	52.2	47.5	24%	46	M19-XSG11-01-091318	1809473-9	19		93%
Trip 8	Red	M19-XSG19-01-091318	316.9	307.2	15%	277	M19-XSG19-01-091318	1809473-10	350		10%
Trip 8	Red	M19-XSG25-01-091318	78.0	76.4	7%	72	M19-XSG25-01-091318	1809473-11	45		54%
Trip 8	Red	M19-XSG29-01-091318	38.7	37.1	13%	33	M19-XSG29-01-091318	1809473-12	19		68%
Trip 8	Red	M19-XSG39-01-091318	58.3	52.1	38%	40	M19-XSG39-01-091318	1809473-13	30		64%
Trip 8	Red	M19-XSG43-01-091318	75.2	76.0	21%	51	M19-XSG43-01-091318	1809473-14	35		73%
Trip 8	Red	M20-XS146-01-091718	888.9	855.0	16%	768	M20-XS146-01-091718	1809475-28	1,100		21%

Data Included												
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 8	Red	M20-XS243-01-091718	693.5	673.9	11%	621	M20-XS243-01-091718	1809475-29	660		5%
Trip 8	Red	M20-XS247-01-091718	32.6	31.7	15%	26	M20-XS247-01-091718	1809475-30	14		80%
Trip 8	Red	M20-XS267-01-091718	865.9	868.6	6%	788	M20-XS267-01-091718	1809475-31	690		23%
Trip 8	Red	M20-XS271-01-091718	33.5	32.8	9%	30	M20-XS271-01-091718	1809475-32	16		71%
Trip 8	Red	M20-XS30-01-091718	191.7	181.4	11%	177	M20-XS30-01-091718	1809475-33	90		72%
Trip 8	Red	M20-XS335-01-091418	120.4	115.8	12%	108	M20-XS335-01-091418	1809475-5	50		83%
Trip 8	Red	M20-XS422-01-091418	64.5	62.4	16%	54	M20-XS422-01-091418	1809475-6	38		52%
Trip 8	Red	M20-XS58-01-091718	333.6	292.6	33%	278	M20-XS58-01-091718	1809475-34	190		55%
Trip 8	Red	M20-XS60-01-091718	105.6	108.5	11%	84	M20-XS60-01-091718	1809475-35	65		48%
Trip 8	Red	M20-XSG15-01-091418	39.0	37.1	15%	33	M20-XSG15-01-091418	1809475-7	14		94%
Trip 8	Red	M20-XSG28-01-091418	224.3	217.1	17%	183	M20-XSG28-01-091418	1809475-8	110		68%
Trip 8	Red	M20-XSG7-01-091418	22.1	22.4	10%	19	M20-XSG7-01-091418	1809475-9	8		91%
Trip 8	Red	M21-XS1-01-091218	83.2	81.0	22%	65	M21-XS1-01-091218	1809473-24	23		113%
Trip 8	Red	M21-XS317-01-091218	87.1	84.8	15%	74	M21-XS317-01-091218	1809473-25	41		72%
Trip 8	Red	M21-XS323-01-091218	350.5	351.7	6%	311	M21-XS323-01-091218	1809473-26	310		12%
Trip 8	Red	M21-XS366-01-091418	160.5	151.9	29%	113	M21-XS366-01-091418	1809475-10	90		56%
Trip 8	Red	M21-XS366-02-091418	153.1	145.4	18%	123	M21-XS366-02-091418	1809475-11	86		56%
Trip 8	Red	M21-XS465-01-091218	102.3	102.3	7%	91	M21-XS465-01-091218	1809473-27	39		90%
Trip 8	Red	M21-XS503-01-091218	427.3	435.8	10%	368	M21-XS503-01-091218	1809473-28	160		91%
Trip 8	Red	M21-XS511-01-091218	87.8	86.8	12%	77	M21-XS511-01-091218	1809473-29	52		51%
Trip 8	Red	M21-XS536-01-091218	90.4	91.2	5%	85	M21-XS536-01-091218	1809473-30	30		100%
Trip 8	Red	M21-XSG16-01-091218	126.5	132.1	13%	96	M21-XSG16-01-091218	1809473-31	43		99%
Trip 8	Red	M21-XSG38-01-091418	154.7	153.8	4%	144	M21-XSG38-01-091418	1809475-12	59		90%
Trip 8	Red	M21-XSG43-01-091418	181.3	179.4	7%	169	M21-XSG43-01-091418	1809475-13	63		97%
Trip 8	Red	M21-XSG7-01-091218	117.6	115.8	12%	103	M21-XSG7-01-091218	1809473-32	28		123%
Trip 8	Red	M22-XS112-01-091418	144.8	142.6	6%	134	M22-XS112-01-091418	1809475-14	79		59%
Trip 8	Red	M22-XS115-01-091418	51.1	51.3	9%	46	M22-XS115-01-091418	1809475-15	24		72%
Trip 8	Red	M22-XS121-01-091418	52.5	53.4	13%	44	M22-XS121-01-091418	1809475-16	19		94%
Trip 8	Red	M22-XS94-01-091418	54.2	52.2	17%	44	M22-XS94-01-091418	1809475-17	19		96%
Trip 8	Red	M23-XSG1-01-091418	223.4	219.9	9%	201	M23-XSG1-01-091418	1809475-18	85		90%
Trip 8	Red	M23-XSG20-01-091418	39.3	37.2	14%	33	M23-XSG20-01-091418	1809475-19	12		107%
Trip 8	Red	M23-XSG5-01-091418	34.4	35.2	12%	27	M23-XSG5-01-091418	1809475-20	11		103%
Trip 8	Red	M6-XS164-01-091118	72.4	71.7	19%	55	M6-XS164-01-091118	1809473-33	16		128%
Trip 8	Red	M6-XS224-01-091118	107.1	110.3	10%	86	M6-XS224-01-091118	1809473-34	22		132%
Trip 8	Red	M6-XS353A-01-091618	43.6	44.4	7%	38	M6-XS353A-01-091618	1809475-36	9		132%
Trip 8	Red	M6-XS369-01-091618	24.2	25.2	16%	19	M6-XS369-01-091618	1809475-37	6		116%
Trip 8	Red	M6-XS52-01-091118	36.2	36.1	10%	31	M6-XS52-01-091118	1809473-35	11		107%
Trip 8	Red	M6-XSG13A-01-091618	146.1	147.2	4%	136	M6-XSG13A-01-091618	1809475-38	440		100%
Trip 8	Red	M6-XSG22-01-091618	29.0	29.1	15%	24	M6-XSG22-01-091618	1809475-39	10		97%
Trip 8	Red	M7-XSG34-01-091618	33.8	34.7	15%	26	M7-XSG34-01-091618	1809475-40	11		102%
Trip 8	Red	M7-XSG41-01-091618	26.8	26.7	14%	21	M7-XSG41-01-091618	1809475-41	8		106%
Trip 8	Red	T18-XSG7-01-091518	25.2	26.2	21%	18	T18-XSG7-01-091518	1809475-42	9		92%
Trip 8	Red	T19-XS9-01-091118	144.2	146.3	7%	128	T19-XS9-01-091118	1809473-36	44		106%
Trip 8	Red	T20-XSG3-01-091118	48.2	46.1	20%	37	T20-XSG3-01-091118	1809473-37	11		126%
Trip 8	Red	T21-XSG13-01-091118	50.0	49.8	17%	39	T21-XSG13-01-091118	1809473-38	25		67%
Trip 8	Red	T21-XSG26-01-091118	39.5	40.9	8%	35	T21-XSG26-01-091118	1809473-39	15		90%
Trip 8	Red	T22-XS20-01-091118	53.2	52.4	12%	46	T22-XS20-01-091118	1809473-15	12		126%
Trip 8	Red	T23-XSG26-01-091118	33.5	35.3	25%	22	T23-XSG26-01-091118	1809473-16	18		60%
Trip 8	Red	T23-XSG7-01-091118	84.3	83.3	10%	71	T23-XSG7-01-091118	1809473-17	55		42%
Trip 8	Red	T24-XSG2-01-091118	29.8	30.4	11%	26	T24-XSG2-01-091118	1809473-18	11		92%
Trip 8	Red	T24-XSG26-01-091118	36.2	33.8	21%	29	T24-XSG26-01-091118	1809473-19	9		122%
Trip 8	Red	T26-XSG2-01-091518	75.5	74.8	10%	64	T26-XSG2-01-091518	1809475-43	18	J	123%
Trip 8	Red	T26-XSG9-01-091518	32.2	32.7	13%	26	T26-XSG9-01-091518	1809475-44	8		124%
Trip 9	Red	M10-XSG2-01-092818	37.1	35.3	15%	33	M10-XSG2-01-092818	1810122-1	12.0		102%
Trip 9	Blue	M10-XSG4-01-092818	38.2	37.4	7%	35	M10-XSG4-01-092818	1810122-2	13.0		98%
Trip 9	Red	M11-XS47-01-092818	268.1	271.8	17%	206	M11-XS47-01-092818	1810122-3	210.0		24%
Trip 9	Blue	M11-XSG2-01-092818	90.6	95.1	10%	79	M11-XSG2-01-092818	1810122-4	69.0		27%
Trip 9	Blue	M11-XSG25-01-092818	145.8	142.5	14%	123	M11-XSG25-01-092818	1810122-5	130.0		11%
Trip 9	Blue	M11-XSG28-01-092818	52.6	54.0	18%	37	M11-XSG28-01-092818	1810122-6	12.0		126%
Trip 9	Red	M11-XSG33-01-092818	62.5	63.2	10%	51	M11-XSG33-01-092818	1810122-7	29.0		73%
Trip 9	Red	M12-XSG26-01-092818	34.4	33.5	13%	30	M12-XSG26-01-092818	1810122-8	11.0		103%
Trip 9	Blue	M14-XSR1-01-093018	31.5	30.8	13%	27	M14-XSR1-01-093018	1810072-21	13.0		83%
Trip 9	White	M15-XSR1-01-093018	22.8	22.9	13%	18	M15-XSR1-01-093018	1810072-22	6.9		107%
Trip 9	White	M16-XSR1-01-093018	33.9	32.8	16%	28	M16-XSR1-01-093018	1810072-23	14.0		83%
Trip 9	White	M16-XSR6-01-093018	23.7	24.3	18%	18	M16-XSR6-01-093018	1810072-24	7.8		101%
Trip 9	Blue	M17-XSR1-01-093018	28.8	29.8	10%	24	M17-XSR1-01-093018	1810072-25	6.9		123%
Trip 9	Red	M19-XSR2-01-093018	35.9	34.7	13%	31	M19-XSR2-01-093018	1810072-26	8.1		126%
Trip 9	Blue	M19-XSR2-02-093018	29.4	27.7	24%	22	M19-XSR2-02-093018	1810072-27	8.1		114%
Trip 9	Red	M1-XSG4-01-092818	120.2	119.5	9%	108	M1-XSG4-01-092818	1810072-1	60.0		67%
Trip 9	Blue	M20-XSR2-01-093018	25.3	24.2	24%	18	M20-XSR2-01-093018	1810072-28	7.8		106%
Trip 9	White	M23-XSR4-01-093018	35.9	35.5	9%	32	M23-XSR4-01-093018	1810072-29	10.0		113%

Data Included											
			XRF - Vanadium						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 9	Red	M24-XS112-01-092518	50.9	50.2	12%	44	M24-XS112-01-092518	1810032-1	16.0		104%
Trip 9	Red	M24-XS114-01-092518	38.3	40.5	16%	26	M24-XS114-01-092518	1810032-2	12.0		105%
Trip 9	Red	M24-XSG15-01-092518	51.0	47.7	21%	44	M24-XSG15-01-092518	1810032-3	20.0		87%
Trip 9	Red	M24-XSG3-01-092518	35.0	33.9	21%	27	M24-XSG3-01-092518	1810032-4	13.0		92%
Trip 9	Red	M24-XSG32-01-092518	25.4	26.6	15%	20	M24-XSG32-01-092518	1810032-5	7.8		106%
Trip 9	Red	M24-XSR1-01-093018	29.1	27.2	16%	25	M24-XSR1-01-093018	1810072-30	8.3		111%
Trip 9	Blue	M25-XSG12-01-092818	15.2	14.2	35%	10	M25-XSG12-01-092818	1810122-10	6.6		79%
Trip 9	Blue	M25-XSG19-01-092818	39.9	38.1	25%	29	M25-XSG19-01-092818	1810122-11	18.0		76%
Trip 9	Blue	M25-XSG19-02-092818	36.0	36.9	17%	29	M25-XSG19-02-092818	1810122-12	17.0		72%
Trip 9	Blue	M25-XSG5-01-092818	13.7	12.5	28%	10	M25-XSG5-01-092818	1810122-13	5.1		92%
Trip 9	Red	M27-XS116-01-092618	40.5	38.2	25%	32	M27-XS116-01-092618	1810072-2	16.0		87%
Trip 9	Red	M27-XS149-01-092618	39.1	39.0	9%	35	M27-XS149-01-092618	1810072-3	14.0		94%
Trip 9	Red	M27-XS150-01-092618	37.5	37.1	11%	31	M27-XS150-01-092618	1810072-4	13.0	J	97%
Trip 9	Red	M27-XS163-01-092618	62.4	63.2	14%	52	M27-XS163-01-092618	1810072-5	30.0		70%
Trip 9	Red	M27-XSG28-01-092618	46.7	48.4	11%	38	M27-XSG28-01-092618	1810072-6	14.0		108%
Trip 9	Red	M27-XSG28-02-092618	44.1	44.0	12%	39	M27-XSG28-02-092618	1810072-7	14.0		104%
Trip 9	Red	M27-XSG48-01-092618	41.6	42.2	10%	36	M27-XSG48-01-092618	1810072-8	14.0		99%
Trip 9	Red	M27-XSG6-01-092618	44.6	43.6	9%	39	M27-XSG6-01-092618	1810072-9	30.0		39%
Trip 9	Red, Blue	M28-XS162-01-092818	59.9	57.5	17%	46	M28-XS162-01-092818	1810122-14	18.0		108%
Trip 9	White	M28-XS19-01-092918	36.1	35.3	18%	30	M28-XS19-01-092918	1810122-15	9.6		116%
Trip 9	Red	M28-XS29-01-092618	398.1	400.5	8%	351	M28-XS29-01-092618	1810032-6	410.0		3%
Trip 9	Blue	M28-XSG18-01-092918	23.0	22.4	13%	20	M28-XSG18-01-092918	1810122-16	8.1		96%
Trip 9	Red	M28-XSG49-01-092618	39.3	44.3	34%	12	M28-XSG49-01-092618	1810032-7	18.0		74%
Trip 9	Red, White	M28-XSG54-01-092918	55.3	54.3	10%	47	M28-XSG54-01-092918	1810122-17	17.0		106%
Trip 9	Red	M28-XSG7-01-092618	759.6	745.9	10%	688	M28-XSG7-01-092618	1810032-8	800.0		5%
Trip 9	White	M28-XSG76-01-092918	32.0	31.0	9%	29	M28-XSG76-01-092918	1810122-18	12.0		91%
Trip 9	Blue	M28-XSR1-01-093018	23.1	23.1	18%	17	M28-XSR1-01-093018	1810072-31	5.7		121%
Trip 9	Red	M28-XSR1-02-093018	27.1	27.4	23%	19	M28-XSR1-02-093018	1810072-32	5.8		129%
Trip 9	Red	M29-XS19-01-092518	127.5	123.2	23%	100	M29-XS19-01-092518	1810032-9	83.0		42%
Trip 9	Red	M29-XS42-01-092518	36.5	35.6	6%	35	M29-XS42-01-092518	1810032-10	13.0		95%
Trip 9	Red	M29-XS59-01-092518	167.8	166.6	17%	128	M29-XS59-01-092518	1810032-11	110.0		42%
Trip 9	Red	M29-XS64-01-092518	59.3	59.7	12%	51	M29-XS64-01-092518	1810032-12	30.0		66%
Trip 9	Red	M29-XSG1-01-092518	39.8	38.9	9%	37	M29-XSG1-01-092518	1810032-13	11.0		113%
Trip 9	Red	M29-XSG25-01-092518	59.8	59.5	6%	56	M29-XSG25-01-092518	1810032-14	22.0		92%
Trip 9	Red	M29-XSG35-01-092518	33.2	34.0	14%	27	M29-XSG35-01-092518	1810032-15	9.9		108%
Trip 9	Blue	M29-XSR4-01-093018	55.0	59.6	23%	35	M29-XSR4-01-093018	1810072-33	16.0		110%
Trip 9	Red	M29-XSR7-01-093018	40.6	41.1	16%	33	M29-XSR7-01-093018	1810072-34	13.0		103%
Trip 9	White	M2-XSR3-01-093018	21.6	21.1	19%	17	M2-XSR3-01-093018	1810072-35	7.9		93%
Trip 9	White	M30-XS144-01-092918	69.3	66.4	21%	57	M30-XS144-01-092918	1810122-19	27.0		88%
Trip 9	White	M30-XS185-01-092918	43.7	42.3	16%	35	M30-XS185-01-092918	1810122-20	14.0		103%
Trip 9	White	M30-XS62-01-092918	66.7	62.2	14%	60	M30-XS62-01-092918	1810122-21	45.0		39%
Trip 9	White	M30-XSG18-01-092918	44.4	44.9	13%	38	M30-XSG18-01-092918	1810122-22	14.0		104%
Trip 9	White	M30-XSG29-01-092918	40.6	42.4	16%	30	M30-XSG29-01-092918	1810122-23	12.0		109%
Trip 9	White	M30-XSG43-01-092918	33.0	32.8	16%	27	M30-XSG43-01-092918	1810122-24	10.0		107%
Trip 9	White	M30-XSG45-01-092918	24.4	25.2	10%	20	M30-XSG45-01-092918	1810122-25	6.7		114%
Trip 9	Red, White	M30-XSG6-01-092918	107.9	80.5	58%	55	M30-XSG6-01-092918	1810122-26	94.0		14%
Trip 9	Blue	M30-XSG61-01-092918	19.9	21.3	26%	11	M30-XSG61-01-092918	1810122-27	5.3		116%
Trip 9	White	M30-XSR5-01-093018	38.9	38.7	11%	33	M30-XSR5-01-093018	1810072-36	9.9		119%
Trip 9	Red	M31-XS1-01-092918	68.8	68.6	14%	57	M31-XS1-01-092918	1810122-28	36.0		63%
Trip 9	Blue	M31-XS39-01-092918	34.5	35.3	14%	27	M31-XS39-01-092918	1810122-29	11.0		103%
Trip 9	White	M31-XS8-01-092918	86.3	84.3	14%	73	M31-XS8-01-092918	1810122-30	52.0		50%
Trip 9	White	M31-XSG1-01-092918	24.5	23.5	11%	22	M31-XSG1-01-092918	1810122-31	8.8		94%
Trip 9	White	M31-XSG12-01-092918	42.4	40.5	20%	32	M31-XSG12-01-092918	1810122-32	11.0		118%
Trip 9	White	M31-XSG17-01-092918	31.9	30.7	27%	22	M31-XSG17-01-092918	1810122-33	9.0		112%
Trip 9	Red	M31-XSG9-01-092918	24.8	24.8	5%	23	M31-XSG9-01-092918	1810122-34	6.9		113%
Trip 9	Red	M32-XSG23-01-092918	37.1	36.4	17%	32	M32-XSG23-01-092918	1810072-10	15.0		85%
Trip 9	Red	M32-XSG26-01-092918	95.3	95.9	7%	86	M32-XSG26-01-092918	1810072-11	59.0		47%
Trip 9	Red	M32-XSG34-01-092918	40.7	41.2	11%	33	M32-XSG34-01-092918	1810072-12	14.0		98%
Trip 9	Red	M32-XSG46-01-092918	32.2	31.4	10%	28	M32-XSG46-01-092918	1810072-13	11.0		98%
Trip 9	Red	M32-XSG9-01-092918	36.9	35.8	13%	31	M32-XSG9-01-092918	1810072-14	75.0		68%
Trip 9	Red	M34-XSG15-01-092718	46.5	46.5	7%	42	M34-XSG15-01-092718	1810072-15	44.0		5%
Trip 9	Red	M35-XSG20-01-092718	50.5	50.8	11%	42	M35-XSG20-01-092718	1810072-16	19.0		91%
Trip 9	Red	M35-XSG4-01-092718	36.1	35.3	22%	26	M35-XSG4-01-092718	1810072-17	13.0		94%
Trip 9	Red	M36-XSG1-01-092718	75.6	72.2	10%	69	M36-XSG1-01-092718	1810072-18	26.0		98%
Trip 9	White	M6-XSR1-01-093018	27.4	27.2	18%	20	M6-XSR1-01-093018	1810072-37	6.2		126%
Trip 9	White	M7-XSR1-01-093018	48.6	51.1	20%	35	M7-XSR1-01-093018	1810072-38	13.0		116%
Trip 9	White	M7-XSR1-02-093018	41.2	43.9	16%	31	M7-XSR1-02-093018	1810072-39	12.0		110%
Trip 9	Blue	M8-XSR1-01-093018	105.9	107.3	19%	71	M8-XSR1-01-093018	1810072-40	44.0		83%
Trip 9	White	T17-XSR1-01-093018	32.6	30.7	18%	28	T17-XSR1-01-093018	1810072-41	7.5		125%
Trip 9	Red	T30-XS20-01-092518	33.9	34.3	7%	30	T30-XS20-01-092518	1810032-16	10.0		109%
Trip 9	Red	T30-XS28-01-092518	34.0	33.8	7%	31	T30-XS28-01-092518	1810032-17	9.4		113%

Data Included											
Trip	XRF Color	XRF ID	XRF - Vanadium				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 9	Red	T30-XS8-01-092518	30.0	30.0	13%	25	T30-XS8-01-092518	1810032-18	7.6		119%
Trip 9	Red	T31-XSG7-01-092518	22.5	22.2	16%	17	T31-XSG7-01-092518	1810032-19	6.4		112%
Trip 9	Red	T31-XSG9-01-092518	24.3	25.3	18%	17	T31-XSG9-01-092518	1810032-20	6.7		114%
Trip 9	Red	T5-XSG3-01-092818	23.4	22.7	19%	17	T5-XSG3-01-092818	1810072-19	7.9		99%
Trip 9	Red	T5-XSG3-02-092818	23.6	24.7	10%	19	T5-XSG3-02-092818	1810072-20	7.7		102%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Vanadium: Average Ex Situ XRF (ppm)	XRF - Vanadium: Median Ex Situ XRF (ppm)	XRF - Vanadium: Relative Standard Deviation	XRF - Vanadium: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 7	Pink	M35-XS20-01-081318	4.9	0.0	159%	0	M35-XS20-01-081318	1808303-7	9.8		68%
Trip 7	Pink	M37-XS23-01-081318	1.3	0.0	245%	0	M37-XS23-01-081318	1808303-19	8.1		145%
Trip 7	Pink	M37-XS38-01-081318	4.4	4.3	110%	0	M37-XS38-01-081318	1808356-1	8.1		60%
Trip 7	Pink	M8-XSG4-01-081518	12.2	13.0	56%	0	M8-XSG4-01-081518	1808356-16	15.0		20%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Vanadium: Average Ex Situ XRF (ppm)	XRF - Vanadium: Median Ex Situ XRF (ppm)	XRF - Vanadium: Relative Standard Deviation	XRF - Vanadium: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 7	Red	M9-XS28A-01-081718	1,847.3	1,639.4	28%	1,421	M9-XS28A-01-081718	1808483-9	610		101%
Trip 7	Pink	M37-XS124A-01-081318	492.3	480.3	13%	399	M37-XS124A-01-081318	1808303-16	1,200		84%
Trip 9	Red	M12-XSG3-01-092818	199.6	50.2	186%	40	M12-XSG3-01-092818	1810122-9	11		179%

Notes:

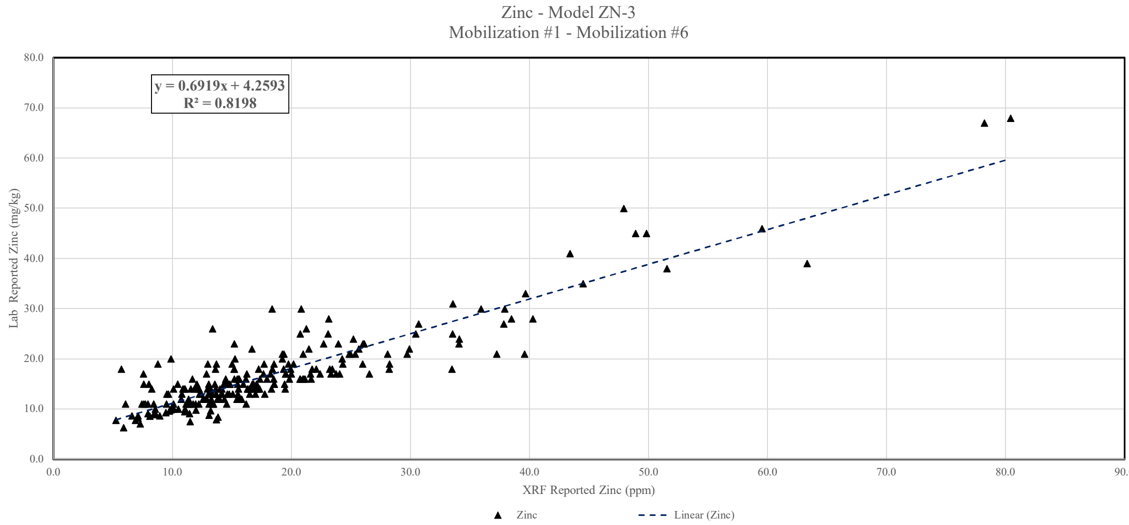
Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence



Data Included in Model ZN-3

Trip	XRF Color	XRF ID	XRF - Zinc: Average Ex Situ XRF (ppm)	XRF - Zinc: Median Ex Situ XRF (ppm)	XRF - Zinc: Relative Standard Deviation	XRF - Zinc: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 1	Pink	M2-XS15-02-042418	6.1	6.0	17%	5	M2-XS15-02-042418	1805041-2	11.0		58%
Trip 1	Pink	M2-XS32-01-042418	8.4	8.1	15%	7	M2-XS32-01-042418	1805041-3	11.0		27%
Trip 1	Pink	M2-XS73-01-042418	5.7	5.7	15%	4	M2-XS73-01-042418	1805041-5	18.0		104%
Trip 1	Pink	M3-XS34-01-043018	19.5	19.0	13%	17	M3-XS34-01-043018	1805042-1	14.0		33%
Trip 1	Pink	M3-XS36-01-043018	18.2	18.2	3%	18	M3-XS36-01-043018	1805042-2	17.0		7%
Trip 1	Pink	M6-XS140-01-042818	13.2	13.7	8%	11	M6-XS140-01-042818	1805041-6	14.0		6%
Trip 1	Orange	M6-XS159-01-04262018	14.7	14.4	10%	13	M6-XS159-01-04262018	1805039-1	15.0		2%
Trip 1	Pink	M6-XS251-01-04272018	24.3	24.2	15%	20	M6-XS251-01-04272018	1805039-2	20.0		19%
Trip 1	Pink	M6-XS269-01-04262018	17.2	17.1	8%	15	M6-XS269-01-04262018	1805039-3	18.0		4%
Trip 1	Pink	M6-XS269-02-04262018	18.5	18.1	7%	17	M6-XS269-02-04262018	1805039-4	19.0		3%
Trip 1	Pink	M6-XS285-01-04272018	13.3	13.6	11%	11	M6-XS285-01-04272018	1805039-5	26.0		64%
Trip 1	Pink	T10-XS1-01-042518	24.0	23.9	0%	23	T10-XS1-01-042518	1805036-1	17.0		34%
Trip 1	Pink	T10-XS20-01-042518	14.8	14.7	7%	14	T10-XS20-01-042518	1805036-2	15.0		1%
Trip 1	Pink	T10-XS33-01-042518	16.9	16.9	6%	16	T10-XS33-01-042518	1805036-3	14.0		19%
Trip 1	Pink	T10-XS56-01-042518	20.7	20.9	7%	19	T10-XS56-01-042518	1805036-4	16.0		26%
Trip 1	Pink	T10-XS78-01-042518	19.8	20.0	12%	17	T10-XS78-01-042518	1805036-5	16.0		21%
Trip 1	Pink	T11-XS1-01-042518	23.3	23.2	3%	22	T11-XS1-01-042518	1805036-6	17.0		31%
Trip 1	Pink	T11-XS20-01-042518	20.9	21.2	7%	18	T11-XS20-01-042518	1805036-7	16.0		27%
Trip 1	Pink	T11-XS60-01-042518	11.4	11.3	6%	11	T11-XS60-01-042518	1805036-8	11.0		4%
Trip 1	Pink	T17-XS1-02-04262018	8.5	8.4	17%	7	T17-XS1-02-04262018	1805039-7	10.0	J	16%
Trip 1	Pink	T17-XS143-01-04262018	19.2	19.0	13%	16	T17-XS143-01-04262018	1805039-8	20.0		4%
Trip 1	Pink	T17-XS194-01-04272018	13.2	13.6	10%	11	T17-XS194-01-04272018	1805039-10	13.0		2%
Trip 1	Pink	T17-XS194-02-04272018	12.3	12.8	16%	9	T17-XS194-02-04272018	1805039-11	13.0		6%
Trip 1	Pink	T17-XS20-01-04262018	15.5	16.0	14%	12	T17-XS20-01-04262018	1805039-12	16.0		3%
Trip 1	Pink	T17-XS208-01-042818	12.9	12.9	6%	12	T17-XS208-01-042818	1805041-7	19.0		38%
Trip 1	Pink	T17-XS257-01-04272018	17.3	17.4	5%	16	T17-XS257-01-04272018	1805039-14	16.0		8%
Trip 1	Pink	T17-XS287-01-04272018	23.1	24.1	9%	20	T17-XS287-01-04272018	1805039-15	28.0		19%
Trip 1	Pink	T17-XS328-01-04272018	21.4	21.4	9%	19	T17-XS328-01-04272018	1805039-17	22.0		3%
Trip 1	Pink	T17-XS377-01-042818	21.7	20.9	12%	20	T17-XS377-01-042818	1805041-10	18.0		19%
Trip 1	Pink	T17-XS393-01-043018	15.6	14.8	19%	13	T17-XS393-01-043018	1805042-5	16.0		3%
Trip 1	Pink	T17-XS417-01-04272018	21.0	21.4	8%	18	T17-XS417-01-04272018	1805039-18	16.0		27%
Trip 1	Pink	T17-XS438-01-042818	9.5	9.6	6%	8	T17-XS438-01-042818	1805041-11	11.0		15%
Trip 1	Pink	T17-XS44-01-04262018	16.7	16.8	12%	14	T17-XS44-01-04262018	1805039-19	15.0		11%
Trip 1	Pink	T17-XS442-01-04272018	15.2	15.0	9%	14	T17-XS442-01-04272018	1805039-20	18.0		17%
Trip 1	Pink	T17-XS46-01-042618	15.5	15.1	12%	13	T17-XS46-01-042618	1805041-12	13.0		17%
Trip 1	Pink	T17-XS473-01-042818	18.4	18.2	7%	17	T17-XS473-01-042818	1805041-13	18.0		2%
Trip 1	Pink	T17-XS479-01-042818	19.3	19.9	7%	17	T17-XS479-01-042818	1805041-14	21.0		8%
Trip 1	Pink	T17-XS479-02-042818	20.8	21.1	6%	19	T17-XS479-02-042818	1805041-15	30.0		36%
Trip 1	Pink	T17-XS603-01-042818	19.5	19.4	8%	17	T17-XS603-01-042818	1805041-16	17.0		14%
Trip 1	Pink	T17-XS659-01-043018	13.4	13.3	15%	10	T17-XS659-01-043018	1805042-6	11.0		20%
Trip 1	Pink	T17-XS679-01-043018	17.9	18.5	10%	15	T17-XS679-01-043018	1805042-7	16.0		11%
Trip 1	Pink	T17-XS704-01-043018	13.2	13.2	8%	12	T17-XS704-01-043018	1805042-8	9.7		30%
Trip 1	Pink	T7-XS11-01-042418	8.4	8.5	1%	7	T7-XS11-01-042418	1805036-9	8.9		6%
Trip 1	Pink	T7-XS5-01-042418	7.1	7.7	19%	5	T7-XS5-01-042418	1805036-10	8.2		14%
Trip 1	Pink	T7-XS58-01-042418	6.6	6.5	23%	4	T7-XS58-01-042418	1805036-11	8.7		28%
Trip 1	Pink	T7-XS7-01-042418	5.2	5.3	27%	3	T7-XS7-01-042418	1805036-12	7.8		39%
Trip 1	Pink	T7-XS9-01-042418	7.1	7.3	15%	5	T7-XS9-01-042418	1805036-13	8.7		20%

Data Included in Model ZN-3											
			XRF - Zinc						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 1	Pink	T8-XS15-01-042418	11.4	11.4	12%	10	T8-XS15-01-042418	1805036-14	11.0		3%
Trip 1	Pink	T8-XS23-01-042418	11.5	11.5	10%	10	T8-XS23-01-042418	1805036-15	14.0		19%
Trip 1	Pink	T8-XS6-01-042418	7.9	7.9	10%	7	T8-XS6-01-042418	1805036-16	9.1		14%
Trip 1	Pink	T9-XS217-01-042518	17.1	16.9	9%	16	T9-XS217-01-042518	1805036-17	14.0		20%
Trip 1	Pink	T9-XS61-01-042518	19.4	19.4	5%	18	T9-XS61-01-042518	1805036-18	15.0		26%
Trip 1	Orange	T9-XS61-02-042518	18.5	18.7	7%	17	T9-XS61-02-042518	1805041-17	16.0		14%
Trip 1	Pink	T9-XS86-01-042518	14.1	14.2	5%	13	T9-XS86-01-042518	1805036-19	13.0		8%
Trip 1	Pink	T9-XS93-01-042518	15.5	15.1	14%	12	T9-XS93-01-042518	1805036-20	12.0		25%
Trip 2	Orange	M1-XS31-01-051218	9.7	10.1	15%	8	M1-XS31-01-051218	1805328-1	9.6	J	1%
Trip 2	Pink	M1-XS32-01-051218	8.1	8.4	13%	6	M1-XS32-01-051218	1805328-2	8.6	J	6%
Trip 2	Pink	M4-XS136-01-050918	9.5	9.0	19%	8	M4-XS136-01-050918	1805322-1	13.0		31%
Trip 2	Pink	M4-XS18-01-050718	35.9	35.7	7%	33	M4-XS18-01-050718	1805322-2	30.0		18%
Trip 2	Orange	M4-XS219-01-051018	19.5	19.1	11%	16	M4-XS219-01-051018	1805322-3	17.0		14%
Trip 2	Pink	M4-XS238-01-051018	39.6	38.8	7%	37	M4-XS238-01-051018	1805322-4	21.0		61%
Trip 2	Pink	M4-XS45-01-050718	12.0	12.0	9%	10	M4-XS45-01-050718	1805322-6	15.0		22%
Trip 2	Pink	M4-XS63-01-050718	24.9	25.4	9%	21	M4-XS63-01-050718	1805322-7	21.0		17%
Trip 2	Pink	M4-XS63-02-050718	23.0	22.7	6%	21	M4-XS63-02-050718	1805322-8	25.0		8%
Trip 2	Pink	M4-XS78-01-051018	22.4	21.5	25%	17	M4-XS78-01-051018	1805322-9	17.0		27%
Trip 2	Orange	M5-XS115-01-051118	14.3	14.6	7%	13	M5-XS115-01-051118	1805322-10	12.0		18%
Trip 2	Pink	M5-XS385-01-051118	10.1	10.0	11%	9	M5-XS385-01-051118	1805322-11	10.0		1%
Trip 2	Pink	M5-XS69-01-051118	14.4	14.3	12%	12	M5-XS69-01-051118	1805322-12	15.0		4%
Trip 2	Orange	M6-XS41-01-051118	7.6	8.0	21%	5	M6-XS41-01-051118	1805322-13	11.0		37%
Trip 2	Pink	M6-XS44-01-051018	12.1	12.0	8%	11	M6-XS44-01-051018	1805322-14	14.0		14%
Trip 2	Pink	M7-XS181-01-051018	12.9	12.6	14%	11	M7-XS181-01-051018	1805322-16	14.0		8%
Trip 2	Orange	M7-XS181-02-051018	13.5	13.2	11%	12	M7-XS181-02-051018	1805322-17	15.0		10%
Trip 2	Orange	M7-XS39-01-051018	11.1	11.4	7%	10	M7-XS39-01-051018	1805322-18	11.0		1%
Trip 2	Orange	M7-XS74-01-051018	19.7	20.0	17%	16	M7-XS74-01-051018	1805322-19	19.0		4%
Trip 2	Orange	M7-XS77-01-051018	26.0	26.9	8%	22	M7-XS77-01-051018	1805322-20	23.0		12%
Trip 2	Pink	M8-XS100-01-050918	11.9	11.5	14%	10	M8-XS100-01-050918	1805328-3	11.0		8%
Trip 2	Pink	M8-XS102-01-050918	80.4	80.1	3%	78	M8-XS102-01-050918	1805328-4	68.0		17%
Trip 2	Pink	M8-XS102-02-050918	78.2	79.6	6%	69	M8-XS102-02-050918	1805328-5	67.0		15%
Trip 2	Pink	M8-XS110-01-050918	15.7	14.8	28%	11	M8-XS110-01-050918	1805328-6	12.0		27%
Trip 2	Orange	M8-XS19-01-051018	18.5	18.3	9%	17	M8-XS19-01-051018	1805328-7	15.0		21%
Trip 2	Orange	M8-XS32-01-051018	28.1	28.2	5%	26	M8-XS32-01-051018	1805328-8	21.0		29%
Trip 2	Pink	M8-XS94-01-050918	17.2	16.1	14%	15	M8-XS94-01-050918	1805328-9	14.0		20%
Trip 2	Pink	T13-XS24-01-050818	11.7	11.6	16%	9	T13-XS24-01-050818	1805322-22	16.0		31%
Trip 2	Pink	T14-XS12-01-050818	15.0	15.0	10%	13	T14-XS12-01-050818	1805322-23	13.0		15%
Trip 2	Pink	T14-XS27-01-050818	11.3	10.8	10%	11	T14-XS27-01-050818	1805322-24	11.0		2%
Trip 2	Pink	T15-XS2-01-050818	16.3	16.1	20%	12	T15-XS2-01-050818	1805322-25	14.0		15%
Trip 2	Pink	T15-XS45-01-050818	11.8	12.2	19%	9	T15-XS45-01-050818	1805322-26	14.0		17%
Trip 2	Pink	T17-XS122-01-050718	20.2	20.0	8%	18	T17-XS122-01-050718	1805322-27	19.0		6%
Trip 2	Pink	T17-XS176-01-050718	13.8	14.0	16%	10	T17-XS176-01-050718	1805322-28	12.0		14%
Trip 2	Pink	T17-XS178-01-050718	12.4	12.2	7%	11	T17-XS178-01-050718	1805322-29	13.0		5%
Trip 2	Pink	T17-XS619-01-050718	13.3	13.2	13%	11	T17-XS619-01-050718	1805322-30	13.0		3%
Trip 2	Pink	T17-XS619-02-050718	12.9	12.3	11%	12	T17-XS619-02-050718	1805322-31	12.0		7%
Trip 2	Pink	T17-XS645-01-050718	14.2	14.4	4%	13	T17-XS645-01-050718	1805322-32	13.0		9%
Trip 2	Pink	T17-XS669-01-050718	9.9	9.6	11%	9	T17-XS669-01-050718	1805322-33	10.0		1%
Trip 2	Pink	T1-XS104-01-051318	34.1	33.7	9%	31	T1-XS104-01-051318	1805328-10	24.0		35%
Trip 2	Pink	T1-XS20-01-051318	18.5	19.2	10%	16	T1-XS20-01-051318	1805328-11	15.0		21%
Trip 2	Pink	T1-XS54-01-051318	17.0	17.0	9%	15	T1-XS54-01-051318	1805328-12	13.0		26%
Trip 2	Pink	T1-XS54-02-051318	17.7	17.9	7%	16	T1-XS54-02-051318	1805328-13	13.0		31%
Trip 2	Pink	T1-XS69-01-051318	21.6	22.0	7%	19	T1-XS69-01-051318	1805328-14	17.0		24%
Trip 2	Orange	T3-XS10-01-051218	11.7	11.8	10%	10	T3-XS10-01-051218	1805328-15	11.0		6%
Trip 2	Orange	T3-XS5-01-051218	11.0	10.5	14%	10	T3-XS5-01-051218	1805328-16	10.0		10%
Trip 2	Pink	T4-XS23-01-051218	8.6	9.3	22%	6	T4-XS23-01-051218	1805328-17	9.2	J	7%
Trip 2	Orange	T4-XS32-01-051218	11.0	10.6	14%	9	T4-XS32-01-051218	1805328-18	9.5	J	15%
Trip 2	Pink	T4-XS43-01-051218	9.9	10.1	8%	9	T4-XS43-01-051218	1805328-19	9.9	J	0%
Trip 2	Pink	T5-XS18-01-051418	11.3	11.7	8%	10	T5-XS18-01-051418	1805328-20	11.0		3%
Trip 2	Pink	T6-XS2-01-051218	5.9	6.0	17%	4	T6-XS2-01-051218	1805328-21	6.3	J	7%
Trip 2	Orange	T6-XS25-01-051218	7.3	7.1	11%	7	T6-XS25-01-051218	1805328-22	7.1	J	2%
Trip 3	Pink	M14-XS64-01-052418	13.6	13.7	8%	12	M14-XS64-01-052418	1805632-3	13		5%
Trip 3	Pink	M15-XS3-01-052118	15.6	15.5	16%	12	M15-XS3-01-052118	1805589-2	16		3%
Trip 3	Pink	M15-XS22-01-052118	15.2	15.0	7%	14	M15-XS22-01-052118	1805589-1	18		17%
Trip 3	Pink	M15-XS46-01-052118	15.4	15.3	13%	13	M15-XS46-01-052118	1805589-3	16		4%
Trip 3	Pink	M15-XS46-02-052118	14.8	14.7	12%	13	M15-XS46-02-052118	1805589-4	15		1%
Trip 3	Blue	M15-XS73-01-052118	8.8	8.7	9%	8	M15-XS73-01-052118	1805589-5	19		74%
Trip 3	Pink	M15-XS82-01-052118	48.9	49.2	5%	45	M15-XS82-01-052118	1805589-6	45		8%
Trip 3	Pink	M15-XS93-01-052118	7.9	8.2	17%	6	M15-XS93-01-052118	1805589-7	11		32%
Trip 3	Pink	M16-XS4-01-052118	14.5	14.6	9%	12	M16-XS4-01-052118	1805589-12	16		10%
Trip 3	Pink	M16-XS30-01-052118	16.2	16.4	8%	14	M16-XS30-01-052118	1805589-10	17		5%
Trip 3	Pink	M16-XS31-01-052118	10.1	9.9	5%	10	M16-XS31-01-052118	1805589-11	11		9%

Data Included in Model ZN-3												
			XRF - Zinc						ALS Results			
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 3	Blue	M16-XS45-01-052118	9.9	9.7	13%	8	M16-XS45-01-052118	1805589-13	20		68%
Trip 3	Pink	M16-XS128-01-052118	30.4	30.2	12%	27	M16-XS128-01-052118	1805589-8	25		20%
Trip 3	Pink	M16-XS154-01-052618	21.6	21.9	13%	17	M16-XS154-01-052618	1806235-2	16		30%
Trip 3	Blue	M16-XS166-01-052118	7.5	7.6	10%	6	M16-XS166-01-052118	1805589-9	17		77%
Trip 3	Pink	M16-XS177-01-052618	13.7	13.7	13%	11	M16-XS177-01-052618	1806235-3	13		5%
Trip 3	Pink	M16-XS191-01-052618	15.9	16.2	10%	14	M16-XS191-01-052618	1806235-4	15		6%
Trip 3	Pink	M16-XS191-02-052618	16.3	16.5	11%	14	M16-XS191-02-052618	1806235-5	14		15%
Trip 3	Pink	M17-XS55-01-052618	20.7	20.9	7%	18	M17-XS55-01-052618	1806235-6	16		26%
Trip 3	Pink	M17-XS83-01-052618	20.7	20.4	15%	17	M17-XS83-01-052618	1806235-7	25	J	19%
Trip 3	Pink	M17-XS83-02-052618	20.0	20.4	9%	17	M17-XS83-02-052618	1806235-8	17	J	16%
Trip 3	Pink	M18-XS161-01-052518	26.5	25.5	9%	25	M18-XS161-01-052518	1805632-6	17		44%
Trip 3	Pink	M19-XS22-02-052318	14.3	13.8	9%	13	M19-XS22-02-052318	1805632-8	15		5%
Trip 3	Pink	M19-XS22-01-052318	14.5	14.8	9%	12	M19-XS22-01-052318	1805632-7	15		3%
Trip 3	Pink	M19-XS43-01-052318	13.8	13.2	21%	11	M19-XS43-01-052318	1805632-9	12		14%
Trip 3	Blue	T21-XS6-01-052118	7.7	7.2	25%	6	T21-XS6-01-052118	1805589-17	11		35%
Trip 3	Blue	T21-XS35-01-052118	7.6	7.6	9%	7	T21-XS35-01-052118	1805589-14	15		66%
Trip 3	Blue	T21-XS55-01-052118	8.0	8.2	8%	7	T21-XS55-01-052118	1805589-15	15		61%
Trip 3	Pink	T21-XS55-02-052118	17.1	17.4	9%	14	T21-XS55-02-052118	1805589-16	15		13%
Trip 3	Blue	T22-XS17-01-052118	8.3	8.4	12%	7	T22-XS17-01-052118	1805589-18	14		52%
Trip 3	Pink	T22-XS64-01-052218	13.9	14.0	13%	11	T22-XS64-01-052218	1805632-11	12		15%
Trip 3	Pink	T23-XS23-01-052118	19.9	19.7	6%	19	T23-XS23-01-052118	1805589-19	18		10%
Trip 3	Pink	T24-XS48-01-052418	43.4	42.5	7%	40	T24-XS48-01-052418	1805632-12	41		6%
Trip 4	Pink	M13-XS72-01-060618	59.5	59.1	7%	54	M13-XS72-01-060618	1806235-1	46.0		26%
Trip 4	Pink	M20-XS11-01-060618	14.5	14.2	14%	11	M20-XS11-01-060618	1806235-9	11.0		28%
Trip 4	Pink	M20-XS130-01-060418	22.1	21.8	8%	20	M20-XS130-01-060418	1806235-10	18.0		20%
Trip 4	Pink	M20-XS166-01-060518	23.2	23.3	8%	20	M20-XS166-01-060518	1806235-11	18.0		25%
Trip 4	Pink	M20-XS18-01-060618	16.5	15.9	13%	15	M20-XS18-01-060618	1806235-12	13.0		23%
Trip 4	Pink	M20-XS185-01-060418	13.1	12.6	14%	11	M20-XS185-01-060418	1806235-13	11.0		17%
Trip 4	Pink	M20-XS231-01-060418	18.3	17.9	18%	15	M20-XS231-01-060418	1806235-14	14.0		27%
Trip 4	Pink	M20-XS278-01-060418	63.3	64.4	8%	56	M20-XS278-01-060418	1806235-15	39.0		48%
Trip 4	Pink	M20-XS306-01-060518	34.1	32.5	15%	30	M20-XS306-01-060518	1806235-16	23.0		39%
Trip 4	Pink	M20-XS312-01-060518	15.4	14.9	10%	14	M20-XS312-01-060518	1806235-17	12.0		25%
Trip 4	Pink	M20-XS365-01-060618	11.9	12.1	22%	9	M20-XS365-01-060618	1806235-18	9.8		20%
Trip 4	Pink	M20-XS365-02-060618	11.4	10.9	13%	10	M20-XS365-02-060618	1806235-19	9.1	J	23%
Trip 4	Pink	M20-XS5-01-060518	37.8	38.0	6%	34	M20-XS5-01-060518	1806235-20	27.0		33%
Trip 4	Pink	M20-XS86-01-060618	10.9	10.8	16%	9	M20-XS86-01-060618	1806235-21	14.0		25%
Trip 4	Pink	M21-XS122-01-060818	51.5	51.4	4%	48	M21-XS122-01-060818	1806234-1	38.0		30%
Trip 4	Pink	M21-XS126-01-060818	28.2	28.6	15%	21	M21-XS126-01-060818	1806234-2	18.0		44%
Trip 4	Pink	M21-XS14-01-060818	38.5	38.5	17%	31	M21-XS14-01-060818	1806234-3	28.0		31%
Trip 4	Pink	M21-XS175-01-060818	25.6	26.0	3%	24	M21-XS175-01-060818	1806234-4	22.0		15%
Trip 4	Pink	M21-XS225-01-060518	37.2	37.2	15%	29	M21-XS225-01-060518	1806235-22	21.0		56%
Trip 4	Pink	M21-XS259-01-060918	19.3	19.4	10%	16	M21-XS259-01-060918	1806234-5	18.0		7%
Trip 4	Pink	M21-XS260-01-060918	25.3	25.4	3%	24	M21-XS260-01-060918	1806234-6	21.0		19%
Trip 4	Pink	M21-XS27-01-060818	12.5	12.7	11%	11	M21-XS27-01-060818	1806234-7	12.0		4%
Trip 4	Pink	M21-XS27-02-060818	13.0	12.7	15%	11	M21-XS27-02-060818	1806234-8	13.0		0%
Trip 4	Pink	M21-XS282-01-060918	10.5	11.0	13%	8	M21-XS282-01-060918	1806234-9	10.0		5%
Trip 4	Pink	M21-XS290-01-060918	37.9	37.4	7%	36	M21-XS290-01-060918	1806234-10	30.0		23%
Trip 4	Pink	M21-XS292-01-060518	17.3	17.9	15%	14	M21-XS292-01-060518	1806235-23	14.0		21%
Trip 4	Pink	M21-XS302-01-060918	16.4	16.6	14%	13	M21-XS302-01-060918	1806234-11	14.0		16%
Trip 4	Pink	M21-XS302-02-060918	16.6	16.8	9%	14	M21-XS302-02-060918	1806234-12	14.0		17%
Trip 4	Pink	M21-XS334-01-060918	40.3	39.0	12%	35	M21-XS334-01-060918	1806234-13	28.0		36%
Trip 4	Pink	M21-XS377-01-060918	13.4	12.4	21%	11	M21-XS377-01-060918	1806234-14	11.0		20%
Trip 4	Pink	M21-XS40-01-060818	44.5	43.8	6%	41	M21-XS40-01-060818	1806234-15	35.0		24%
Trip 4	Pink	M21-XS403-01-060818	8.9	8.5	25%	6	M21-XS403-01-060818	1806234-16	8.7	J	3%
Trip 4	Pink	M21-XS419-01-060818	30.7	30.1	6%	29	M21-XS419-01-060818	1806234-17	27.0		13%
Trip 4	Pink	M21-XS46-01-060818	21.1	21.0	11%	18	M21-XS46-01-060818	1806234-18	16.0		28%
Trip 4	Pink	M21-XS477-01-060818	28.2	27.1	14%	25	M21-XS477-01-060818	1806234-19	19.0		39%
Trip 4	Pink	M21-XS541-01-060818	13.2	13.6	8%	12	M21-XS541-01-060818	1806234-20	12.0		10%
Trip 4	Pink	M21-XS596-01-060518	16.5	16.1	9%	15	M21-XS596-01-060518	1806235-24	14.0		16%
Trip 4	Pink	M21-XS615-01-060518	11.3	10.7	12%	10	M21-XS615-01-060518	1806235-25	12.0		6%
Trip 4	Pink	M21-XS619-01-060618	23.9	24.1	15%	20	M21-XS619-01-060618	1806235-26	23.0		4%
Trip 4	Pink	M22-XS14-01-060418	33.5	33.8	9%	29	M22-XS14-01-060418	1806235-27	18.0		60%
Trip 4	Pink	M22-XS30-01-060418	15.8	15.3	17%	13	M22-XS30-01-060418	1806235-28	12.0		27%
Trip 4	Pink	M22-XS40-01-060518	33.5	34.6	16%	25	M22-XS40-01-060518	1806235-29	25.0		29%
Trip 4	Pink	M22-XS60-01-060418	16.8	17.6	13%	13	M22-XS60-01-060418	1806235-30	15.0		11%
Trip 4	Pink	M22-XS87-01-060418	29.7	30.5	9%	25	M22-XS87-01-060418	1806235-31	21.0		34%
Trip 4	Pink	M23-XS102-01-061018	33.5	34.3	11%	29	M23-XS102-01-061018	1806233-1	31.0		8%
Trip 4	Pink	M23-XS123-01-061018	10.8	10.3	14%	9	M23-XS123-01-061018	1806233-2	13.0		19%
Trip 4	Pink	M23-XS20-01-061018	26.1	25.6	10%	23	M23-XS20-01-061018	1806233-3	23.0		13%
Trip 4	Pink	M23-XS48-01-061018	12.2	12.2	12%	11	M23-XS48-01-061018	1806233-4	11.0		10%
Trip 4	Pink	M23-XS54-01-061118	13.6	12.8	18%	11	M23-XS54-01-061118	1806312-1	18.0		28%

Data Included in Model ZN-3											
			XRF - Zinc						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 4	Pink	M23-XS64-01-061018	13.0	12.8	8%	12	M23-XS64-01-061018	1806233-5	15.0		14%
Trip 4	Pink	M23-XS70-01-061018	15.8	15.4	14%	13	M23-XS70-01-061018	1806233-6	12.0		27%
Trip 4	Pink	M23-XS79-01-061018	14.6	15.0	12%	12	M23-XS79-01-061018	1806233-7	13.0		11%
Trip 4	Pink	M24-XS100-01-061118	15.5	15.6	14%	12	M24-XS100-01-061118	1806312-3	15.0		3%
Trip 4	Pink	M24-XS128-01-061118	25.2	25.8	8%	21	M24-XS128-01-061118	1806312-4	24.0		5%
Trip 4	Pink	T18-XS14-01-061118	15.5	15.0	12%	13	T18-XS14-01-061118	1806312-5	14.0		10%
Trip 4	Pink	T25-XS2-01-060618	13.3	13.3	8%	12	T25-XS2-01-060618	1806235-32	11.0		19%
Trip 4	Pink	T26-XS1-01-061018	13.7	13.2	10%	12	T26-XS1-01-061018	1806233-8	7.9	J	53%
Trip 4	Pink	T26-XS8-01-061018	13.0	13.4	16%	9	T26-XS8-01-061018	1806233-9	8.8	J	39%
Trip 4	Pink	T27-XS19-01-061018	9.4	10.0	15%	7	T27-XS19-01-061018	1806233-10	9.3	J	1%
Trip 4	Pink	T27-XS6-01-061018	14.8	13.9	19%	12	T27-XS6-01-061018	1806233-11	13.0		13%
Trip 5	Pink	M26-XS13-01-061818	6.9	7.1	14%	5	M26-XS13-01-061818	1806558-1	7.8	J	13%
Trip 5	Pink	M26-XS25-01-061818	23.4	22.9	17%	18	M26-XS25-01-061818	1806558-2	18		26%
Trip 5	Pink	M27-XS21-01-061918	21.0	18.9	30%	15	M27-XS21-01-061918	1806558-10	21		0%
Trip 5	Pink	M27-XS29-01-061818	24.3	24.2	9%	21	M27-XS29-01-061818	1806558-14	19		25%
Trip 5	Pink	M27-XS38-01-061918	15.2	14.8	10%	14	M27-XS38-01-061918	1806558-15	16		5%
Trip 5	Pink	M27-XS108-01-061918	17.7	17.6	10%	16	M27-XS108-01-061918	1806558-3	19		7%
Trip 5	Pink	M27-XS109-01-061918	26.0	26.6	5%	24	M27-XS109-01-061918	1806558-4	19		31%
Trip 5	Pink	M27-XS123-01-061818	7.4	7.9	20%	5	M27-XS123-01-061818	1806558-5	11		39%
Trip 5	Pink	M27-XS188-01-061918	29.9	30.1	6%	27	M27-XS188-01-061918	1806558-6	22		30%
Trip 5	Pink	M27-XS197-01-061918	23.7	23.4	12%	21	M27-XS197-01-061918	1806558-7	17		33%
Trip 5	Pink	M27-XS210-02-061818	12.2	12.0	4%	12	M27-XS210-02-061818	1806558-9	14	J	14%
Trip 5	Pink	M27-XS210-01-061818	19.2	19.5	8%	17	M27-XS210-01-061818	1806558-8	21	J	9%
Trip 5	Pink	M27-XS239-01-061818	11.5	11.7	11%	9	M27-XS239-01-061818	1806558-11	7.5	J	42%
Trip 5	Pink	M27-XS275-01-061918	16.7	16.4	13%	14	M27-XS275-01-061918	1806558-12	22		28%
Trip 5	Pink	M27-XS283-01-061818	21.2	20.7	14%	17	M27-XS283-01-061818	1806558-13	26		20%
Trip 5	Pink	M28-XS8-01-062018	13.8	13.3	12%	12	M28-XS8-01-062018	1806558-21	8.4	J	49%
Trip 5	Pink	M28-XS43-01-062018	10.4	10.8	14%	8	M28-XS43-01-062018	1806558-20	15		36%
Trip 5	Pink	M28-XS105-01-062018	14.0	13.9	11%	12	M28-XS105-01-062018	1806558-16	14		0%
Trip 5	Pink	M28-XS148-01-062018	22.7	22.4	16%	18	M28-XS148-01-062018	1806558-17	23		1%
Trip 5	Pink	M28-XS155-01-062018	13.6	14.3	19%	9	M28-XS155-01-062018	1806558-18	14		3%
Trip 5	Pink	M28-XS170-01-062018	49.8	49.0	11%	44	M28-XS170-01-062018	1806558-19	45		10%
Trip 5	Pink	M30-XS138-01-062218	18.3	17.8	18%	16	M30-XS138-01-062218	1806693-1	30		48%
Trip 5	Pink	T32-XS5-01-062018	16.2	16.3	2%	16	T32-XS5-01-062018	1806558-22	11		38%
Trip 6	Orange	M10-XS10A-01-071118	14.1	13.4	14%	12	M10-XS10A-01-071118	1807369-1	14		1%
Trip 6	Orange	M10-XS31-01-071118	10.7	10.2	22%	8	M10-XS31-01-071118	1807369-2	12		11%
Trip 6	Orange	M10-XS31-02-071118	11.2	11.0	14%	10	M10-XS31-02-071118	1807369-3	11		2%
Trip 6	Orange	M11-XS11-01-071118	9.7	9.9	17%	7	M11-XS11-01-071118	1807369-4	13		30%
Trip 6	Red	M11-XS7-01-071118	12.8	12.6	17%	9	M11-XS7-01-071118	1807369-5	12		6%
Trip 6	Orange	M24-XS115-01-071418	47.9	46.8	10%	42	M24-XS115-01-071418	1807369-7	50		4%
Trip 6	Red	M25-XS16-01-071718	13.7	13.2	11%	12	M25-XS16-01-071718	1807452-1	19		33%
Trip 6	Red	M25-XS23-01-071718	17.6	15.5	25%	14	M25-XS23-01-071718	1807452-2	17		4%
Trip 6	Red	M25-XS47-01-071718	10.1	10.0	11%	9	M25-XS47-01-071718	1807452-3	14		33%
Trip 6	Red	M25-XS88-01-071718	11.0	11.3	9%	9	M25-XS88-01-071718	1807452-4	14		24%
Trip 6	Orange	M30-XS127-01-071618	15.2	14.3	10%	14	M30-XS127-01-071618	1807369-9	23		41%
Trip 6	Orange	M30-XS170-01-071618	15.2	15.4	21%	12	M30-XS170-01-071618	1807369-10	20		27%
Trip 6	Red	M30-XS95-01-071618	12.8	12.6	7%	12	M30-XS95-01-071618	1807369-11	17		28%
Trip 6	Red	M31-XS9-01-071018	11.5	11.2	19%	8	M31-XS9-01-071018	1807369-12	11		4%
Trip 6	Orange	M32-XS58-01-071018	11.0	11.1	12%	9	M32-XS58-01-071018	1807369-13	14		24%
Trip 6	Red	M32-XS89-01-071018	24.8	25.9	15%	19	M32-XS89-01-071018	1807369-14	21		17%
Trip 6	Orange	M33-XS22-01-071218	17.0	16.4	17%	13	M33-XS22-01-071218	1807369-15	15		13%
Trip 6	Orange	M33-XS85-01-071218	15.0	14.8	10%	13	M33-XS85-01-071218	1807369-16	19		24%
Trip 6	Red	M33-XS93-01-071218	16.2	16.3	8%	14	M33-XS93-01-071218	1807369-17	16		1%
Trip 6	Red	T33-XS43-01-071718	39.6	39.3	15%	33	T33-XS43-01-071718	1807452-5	33		18%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

U = Not detected

XRF = X-ray fluorescence

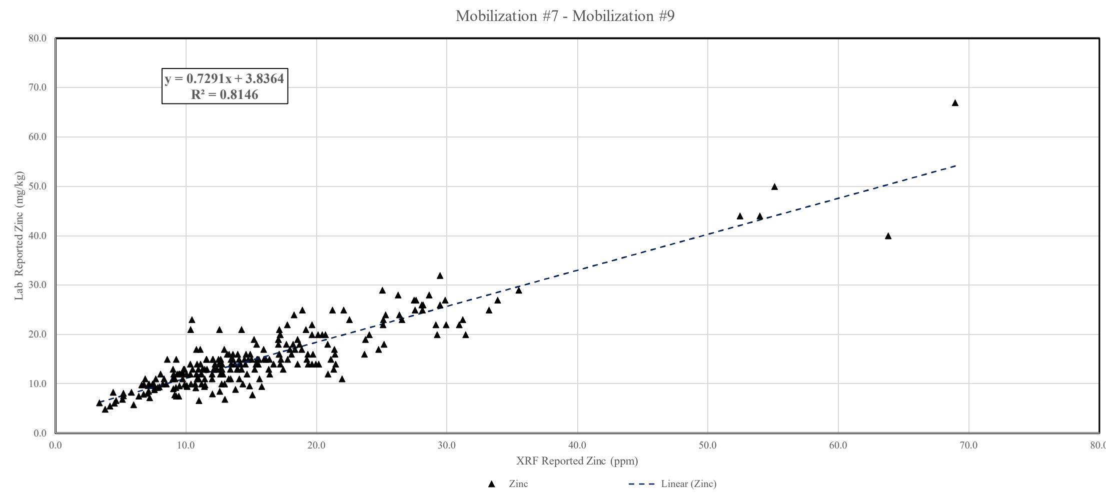
Removed Data - Below Limit of Detection

Trip	XRF Color	XRF ID	XRF - Zinc: Average Ex Situ XRF (ppm)	XRF - Zinc: Median Ex Situ XRF (ppm)	XRF - Zinc: Relative Standard Deviation	XRF - Zinc: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 4	Pink	T18-XS27-01-061118	1.9	2.4	83%	0	T18-XS27-01-061118	1806312-6	5.5	J	98%
Trip 6	Red	M12-XS27-01-071518	0.7	0.0	155%	0	M12-XS27-01-071518	1807369-6	5.1	U	154%
Trip 1	Pink	M2-XS15-01-042418	5.8	6.0	18%	4	M2-XS15-01-042418	1805041-1	8.1	U	32%
Trip 1	Pink	M2-XS59-01-042418	4.8	4.7	25%	4	M2-XS59-01-042418	1805041-4	7.5	U	43%
Trip 2	Pink	M6-XS81-01-051018	8.4	8.2	22%	5	M6-XS81-01-051018	1805322-15	7.9	U	6%
Trip 3	Pink	M14-XS36-01-052418	9.5	10.2	13%	8	M14-XS36-01-052418	1805632-1	9.9	U	4%
Trip 3	Pink	M14-XS40-01-052418	11.7	11.4	15%	10	M14-XS40-01-052418	1805632-2	9.8	U	17%
Trip 3	Pink	M14-XS67-01-052418	14.8	13.9	13%	13	M14-XS67-01-052418	1805632-4	9.2	U	47%
Trip 3	Pink	M18-XS155-01-052518	12.0	12.0	10%	10	M18-XS155-01-052518	1805632-5	7.3	U	49%
Trip 3	Blue	T20-XS14-01-052218	7.2	7.2	16%	6	T20-XS14-01-052218	1805632-10	8.8	U	21%

Removed Data - Outliers

Trip	XRF Color	XRF ID	XRF - Zinc: Average Ex Situ XRF (ppm)	XRF - Zinc: Median Ex Situ XRF (ppm)	XRF - Zinc: Relative Standard Deviation	XRF - Zinc: Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	ALS Results: Lab Result (mg/kg)	ALS Results: Lab Qualifier	Relative Percent Difference
Trip 1	Pink	T17-XS304-01-042818	11.1	11.3	5%	10	T17-XS304-01-042818	1805041-9	120.0		166%
Trip 2	Pink	T13-XS12-01-050818	19.5	19.0	11%	17	T13-XS12-01-050818	1805322-21	88.0		128%
Trip 3	Pink	T23-XS40-01-052118	19.0	19.0	7%	18	T23-XS40-01-052118	1805589-20	92		131%
Trip 1	Pink	T17-XS317-01-04272018	14.8	14.4	12%	13	T17-XS317-01-04272018	1805039-16	56.0		116%
Trip 1	Pink	T17-XS1-01-04262018	7.4	7.8	18%	5	T17-XS1-01-04262018	1805039-6	43.0	J	141%
Trip 2	Pink	M4-XS4-01-050718	9.9	10.0	10%	9	M4-XS4-01-050718	1805322-5	41.0		122%
Trip 1	Pink	T17-XS273-01-042818	17.7	17.5	7%	16	T17-XS273-01-042818	1805041-8	41.0	J	79%
Trip 1	Orange	T17-XS144-01-04262018	63.2	62.4	7%	58	T17-XS144-01-04262018	1805039-9	73.0		14%
Trip 1	Pink	T17-XS251-01-04272018	17.4	17.3	4%	17	T17-XS251-01-04272018	1805039-13	38.0		74%
Trip 1	Pink	T17-XS369-01-043018	18.3	17.8	9%	17	T17-XS369-01-043018	1805042-4	33.0		57%
Trip 5	Pink	M30-XS222-01-062218	25.0	25.5	6%	22	M30-XS222-01-062218	1806693-2	37		39%

Notes:
Average ex situ XRF is the average of a minimum of six measurements collected using XRF instrument in a laboratory setting.
ALS = ALS Environmental
J = Estimated value
mg/kg = milligrams per kilogram
ppm = parts per million
U = Not detected
XRF = X-ray fluorescence



Data Included											
			XRF - Zinc						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M10-XS22-01-082118	12.0	11.8	14%	10	M10-XS22-01-082118	1808494-1	11.0		9%
Trip 7	Red	M10-XS39-01-082118	12.2	12.6	12%	10	M10-XS39-01-082118	1808494-2	14.0		14%
Trip 7	Red	M10-XS43-01-082118	11.4	11.2	18%	9	M10-XS43-01-082118	1808494-3	13.0		13%
Trip 7	Red	M1-XSG2-01-081918	15.4	15.8	7%	14	M1-XSG2-01-081918	1808483-1	14.0		9%
Trip 7	Pink	M34-XS110-01-081218	18.5	18.4	16%	15	M34-XS110-01-081218	1808303-1	14.0		28%
Trip 7	Pink	M34-XS22-01-081218	18.4	19.0	7%	16	M34-XS22-01-081218	1808303-2	17.0		8%
Trip 7	Pink	M34-XS43-01-081218	18.0	17.9	14%	15	M34-XS43-01-081218	1808303-3	17.0		5%
Trip 7	Pink	M34-XS50-01-081218	31.2	31.3	12%	26	M34-XS50-01-081218	1808303-4	23.0		30%
Trip 7	Pink	M34-XS68-01-081218	54.0	55.5	11%	47	M34-XS68-01-081218	1808303-5	44.0		20%
Trip 7	Pink	M35-XS11-01-081218	63.8	63.2	14%	50	M35-XS11-01-081218	1808303-6	40.0		46%
Trip 7	Pink	M35-XS20-01-081318	29.9	30.2	4%	28	M35-XS20-01-081318	1808303-7	22.0		31%
Trip 7	Pink	M35-XS31-01-081218	23.7	23.4	5%	22	M35-XS31-01-081218	1808303-8	19.0		22%
Trip 7	Pink	M35-XS63-01-081218	10.1	10.1	7%	9	M35-XS63-01-081218	1808303-9	9.5	J	6%
Trip 7	Pink	M35-XS74-01-081318	9.7	9.9	10%	8	M35-XS74-01-081318	1808303-10	12.0		21%
Trip 7	Pink	M35-XS74-02-081318	9.5	9.7	14%	7	M35-XS74-02-081318	1808303-11	9.6	J	1%
Trip 7	Pink	M36-XS20-01-081218	9.9	9.2	21%	8	M36-XS20-01-081218	1808303-12	9.9		0%
Trip 7	Pink	M36-XS2-01-081218	20.2	19.2	18%	17	M36-XS2-01-081218	1808303-13	14.0		36%
Trip 7	Pink	M36-XS3-01-081218	7.1	7.2	15%	6	M36-XS3-01-081218	1808303-14	8.5	J	17%
Trip 7	Pink	M36-XS31-01-081218	20.9	21.1	13%	17	M36-XS31-01-081218	1808303-15	18.0		15%
Trip 7	Pink	M37-XS124A-01-081318	28.1	27.9	5%	26	M37-XS124A-01-081318	1808303-16	26.0		8%
Trip 7	Pink	M37-XS144-01-081318	27.6	26.0	13%	24	M37-XS144-01-081318	1808303-17	25.0		10%
Trip 7	Pink	M37-XS2-01-081318	27.6	28.0	10%	24	M37-XS2-01-081318	1808303-18	27.0		2%
Trip 7	Pink	M37-XS23-01-081318	10.5	10.8	23%	7	M37-XS23-01-081318	1808303-19	23.0		75%
Trip 7	Pink	M37-XS31-01-081318	6.7	6.2	21%	6	M37-XS31-01-081318	1808303-20	7.9	J	16%
Trip 7	Pink	M37-XS44-01-081318	19.6	19.4	18%	16	M37-XS44-01-081318	1808356-2	14.0		34%
Trip 7	Pink	M37-XS50-01-081318	29.5	30.1	7%	26	M37-XS50-01-081318	1808356-3	32.0		8%
Trip 7	Pink	M37-XS7-01-081318	29.5	28.8	9%	26	M37-XS7-01-081318	1808356-4	26.0		13%
Trip 7	Red	M38-XS20-01-081818	18.2	17.4	9%	17	M38-XS20-01-081818	1808483-2	18.0		1%
Trip 7	Red	M3-XS19-01-081718	7.4	7.2	22%	5	M3-XS19-01-081718	1808476-1	10.0		30%
Trip 7	Red	M3-XS41-01-081718	11.6	10.8	17%	10	M3-XS41-01-081718	1808476-2	13.0		11%
Trip 7	Red	M4-XS210-01-081818	3.8	3.5	19%	3	M4-XS210-01-081818	1808483-3	4.9	J	25%
Trip 7	Red	M4-XSG11-01-081818	7.6	7.5	20%	6	M4-XSG11-01-081818	1808483-4	9.2	J	19%
Trip 7	Red	M4-XSG2-01-081818	5.8	5.5	16%	5	M4-XSG2-01-081818	1808483-5	8.3	J	35%
Trip 7	Red	M5-XS131-01-082018	12.7	12.8	7%	11	M5-XS131-01-082018	1808487-1	15.0		17%
Trip 7	Red	M5-XS15-01-081818	4.6	4.6	32%	3	M5-XS15-01-081818	1808483-6	6.6	J	35%
Trip 7	Red	M5-XS192-01-081818	22.1	22.2	7%	20	M5-XS192-01-081818	1808483-7	25.0		12%
Trip 7	Red	M5-XS199-01-082018	7.7	7.7	25%	5	M5-XS199-01-082018	1808487-2	11.0		36%
Trip 7	Red	M5-XS207A-01-082018	9.3	9.0	13%	8	M5-XS207A-01-082018	1808487-3	15.0		47%
Trip 7	Red	M5-XS261-01-082018	10.3	10.3	16%	8	M5-XS261-01-082018	1808487-4	14.0		30%
Trip 7	Red	M5-XS263-01-082018	10.0	9.1	37%	5	M5-XS263-01-082018	1808487-5	12.0		18%
Trip 7	Red	M5-XS305-01-082018	10.3	10.3	15%	8	M5-XS305-01-082018	1808487-6	12.0		15%
Trip 7	Red	M5-XS476-01-082018	19.2	19.2	10%	16	M5-XS476-01-082018	1808487-7	21.0		9%
Trip 7	Red	M5-XS488-01-082018	12.9	12.4	12%	11	M5-XS488-01-082018	1808487-8	17.0		27%
Trip 7	Red	M6-XS108-01-081618	13.4	12.9	21%	11	M6-XS108-01-081618	1808476-3	15.0		11%
Trip 7	Red	M6-XS108-02-081618	12.0	12.2	23%	7	M6-XS108-02-081618	1808476-4	15.0		22%
Trip 7	Red	M6-XS198-01-081618	17.2	16.4	21%	14	M6-XS198-01-081618	1808476-5	16.0		7%
Trip 7	Red	M6-XS249-01-081618	16.4	15.1	36%	9	M6-XS249-01-081618	1808476-6	12.0		31%
Trip 7	Red	M6-XS289-01-081618	10.8	10.9	22%	8	M6-XS289-01-081618	1808476-7	12.0		11%
Trip 7	Red	M6-XS324-01-081618	9.2	8.8	16%	8	M6-XS324-01-081618	1808476-8	11.0		18%
Trip 7	Red	M6-XS60-01-081618	9.4	9.0	15%	8	M6-XS60-01-081618	1808476-9	12.0		24%
Trip 7	Pink	M7-XS162A-01-081518	25.3	24.5	28%	17	M7-XS162A-01-081518	1808356-5	24.0		5%
Trip 7	Pink	M7-XS203-01-081418	22.5	22.0	11%	20	M7-XS203-01-081418	1808356-6	23.0		2%
Trip 7	Pink	M7-XS213-01-081518	12.7	13.5	19%	9	M7-XS213-01-081518	1808356-7	14.0		9%
Trip 7	Pink	M7-XS214-01-081518	15.4	15.5	10%	14	M7-XS214-01-081518	1808356-8	15.0		3%

Trip	XRF Color	XRF ID	XRF - Zinc				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 7	Pink	M7-XS235A-01-081418	28.6	28.5	9%	25	M7-XS235A-01-081418	1808356-9	28.0		2%
Trip 7	Pink	M7-XS244-01-081518	14.8	14.5	19%	12	M7-XS244-01-081518	1808356-10	15.0		2%
Trip 7	Pink	M8-XS55-01-081418	22.0	20.7	14%	19	M8-XS55-01-081418	1808356-20	11.0		66%
Trip 7	Red	M8-XS83-01-081418	16.7	16.9	13%	13	M8-XS83-01-081418	1808476-12	14.0		18%
Trip 7	Pink	M8-XSG16-01-081518	14.5	14.3	10%	13	M8-XSG16-01-081518	1808356-11	15.0		4%
Trip 7	Pink	M8-XSG28-01-081418	15.0	15.3	6%	14	M8-XSG28-01-081418	1808356-12	15.0		0%
Trip 7	Pink	M8-XSG31-01-081518	19.6	20.0	16%	16	M8-XSG31-01-081518	1808356-13	20.0		2%
Trip 7	Pink	M8-XSG37-01-081418	17.3	17.5	9%	14	M8-XSG37-01-081418	1808356-14	15.0		14%
Trip 7	Pink	M8-XSG40-01-081418	13.5	13.2	5%	13	M8-XSG40-01-081418	1808356-15	14.0		4%
Trip 7	Pink	M8-XSG4-01-081518	18.1	17.4	11%	16	M8-XSG4-01-081518	1808356-16	16.0		12%
Trip 7	Pink	M8-XSG44-01-081418	12.7	11.2	33%	10	M8-XSG44-01-081418	1808356-17	10.0		24%
Trip 7	Pink	M8-XSG44-02-081418	13.0	13.0	12%	10	M8-XSG44-02-081418	1808356-18	10.0		26%
Trip 7	Pink	M8-XSG47-01-081418	19.3	19.5	14%	16	M8-XSG47-01-081418	1808356-19	16.0		19%
Trip 7	Red	M8-XSG6-01-081518	13.9	14.6	15%	10	M8-XSG6-01-081518	1808476-11	16.0		14%
Trip 7	Red	T10-XSG1-01-081818	16.0	15.0	14%	14	T10-XSG1-01-081818	1808483-10	17.0		6%
Trip 7	Red	T13-XSG26-01-081618	18.5	18.7	5%	17	T13-XSG26-01-081618	1808476-14	19.0		2%
Trip 7	Red	T13-XSG7-01-081618	14.6	14.6	9%	13	T13-XSG7-01-081618	1808476-15	16.0		9%
Trip 7	Red	T15-XS20-01-081718	7.1	7.3	24%	5	T15-XS20-01-081718	1808483-11	8.1	J	14%
Trip 7	Red	T15-XSG5-01-081718	13.3	13.0	13%	11	T15-XSG5-01-081718	1808483-12	11.0		19%
Trip 7	Red	T17-XSG7-02-081618	12.8	12.6	10%	11	T17-XSG7-02-081618	1808476-20	13.0		2%
Trip 7	Red	T1-XSG38-01-081918	14.1	14.1	7%	13	T1-XSG38-01-081918	1808483-13	14.0		1%
Trip 7	Red	T1-XSG49A-01-081918	11.4	11.5	8%	10	T1-XSG49A-01-081918	1808483-14	11.0		4%
Trip 7	Red	T4-XS15A-01-081918	68.9	71.5	9%	56	T4-XS15A-01-081918	1808487-9	67.0		3%
Trip 7	Red	T4-XSG10-01-081918	6.8	7.0	18%	4	T4-XSG10-01-081918	1808483-16	9.9		38%
Trip 7	Red	T4-XSG39-01-081918	6.4	6.5	23%	5	T4-XSG39-01-081918	1808483-17	7.5	J	16%
Trip 7	Red	T4-XSG50A-01-081918	52.5	53.5	9%	47	T4-XSG50A-01-081918	1808483-18	44.0		18%
Trip 7	Red	T5-XSG10-01-081918	29.9	29.7	8%	27	T5-XSG10-01-081918	1808483-19	27.0		10%
Trip 7	Red	T6-XSG6-02-081918	3.4	3.4	22%	2	T6-XSG6-02-081918	1808487-11	6.2	J	59%
Trip 7	Red	T9-XSG12-01-081818	17.8	17.6	7%	17	T9-XSG12-01-081818	1808483-20	15.0		17%
Trip 8	Red	M13-XS112-01-091518	9.3	9.4	24%	7	M13-XS112-01-091518	1809475-1	12.0		25%
Trip 8	Red	M14-XS62-01-091818	8.5	8.3	19%	7	M14-XS62-01-091818	1809475-21	10.0	J	16%
Trip 8	Red	M14-XSG14A-01-091818	10.1	9.1	34%	7	M14-XSG14A-01-091818	1809475-22	9.7		4%
Trip 8	Red	M14-XSG27A-01-091818	17.2	16.8	23%	13	M14-XSG27A-01-091818	1809475-23	21.0		20%
Trip 8	Red	M14-XSG41-01-091818	20.0	20.0	11%	16	M14-XSG41-01-091818	1809475-24	14.0		35%
Trip 8	Red	M14-XSG49-01-091818	15.3	15.3	11%	13	M14-XSG49-01-091818	1809475-25	13.0		16%
Trip 8	Red	M14-XSG58-01-091818	25.1	23.7	20%	21	M14-XSG58-01-091818	1809475-26	23.0		9%
Trip 8	Red	M14-XSG6-01-091818	28.1	26.3	17%	24	M14-XSG6-01-091818	1809475-27	25.0		12%
Trip 8	Red	M15-XSG2-01-091118	12.4	12.1	16%	9	M15-XSG2-01-091118	1809473-21	13.0		5%
Trip 8	Red	M16-XSG13-01-091118	28.2	28.0	15%	24	M16-XSG13-01-091118	1809473-22	26.0		8%
Trip 8	Red	M16-XSG30-01-091518	6.6	6.3	24%	5	M16-XSG30-01-091518	1809475-3	9.8	J	39%
Trip 8	Red	M17-XS79-01-091318	13.6	13.4	6%	12	M17-XS79-01-091318	1809473-1	15.0		10%
Trip 8	Red	M17-XSG1-01-091318	18.9	17.8	14%	16	M17-XSG1-01-091318	1809473-2	17.0		10%
Trip 8	Red	M17-XSG27-01-091318	12.1	11.9	9%	11	M17-XSG27-01-091318	1809473-3	15.0		22%
Trip 8	Red	M17-XSG36-01-091318	7.5	8.0	29%	5	M17-XSG36-01-091318	1809473-4	9.9		27%
Trip 8	Red	M17-XSG36-02-091318	7.2	7.3	34%	4	M17-XSG36-02-091318	1809473-5	10.0		33%
Trip 8	Red	M18-XSG16-01-091318	17.1	16.6	16%	15	M18-XSG16-01-091318	1809473-6	16.0		7%
Trip 8	Red	M18-XSG30-01-091318	11.6	11.3	18%	9	M18-XSG30-01-091318	1809473-7	15.0		26%
Trip 8	Red	M18-XSG32-01-091318	14.2	14.1	16%	11	M18-XSG32-01-091318	1809473-8	21.0		38%
Trip 8	Red	M19-XSG11-01-091318	15.5	15.9	13%	12	M19-XSG11-01-091318	1809473-9	14.0		10%
Trip 8	Red	M19-XSG19-01-091318	10.4	10.2	30%	6	M19-XSG19-01-091318	1809473-10	21.0		68%
Trip 8	Red	M19-XSG25-01-091318	16.4	16.0	14%	14	M19-XSG25-01-091318	1809473-11	15.0		9%
Trip 8	Red	M19-XSG29-01-091318	9.0	9.3	23%	6	M19-XSG29-01-091318	1809473-12	9.0	J	0%
Trip 8	Red	M19-XSG39-01-091318	12.0	11.5	16%	10	M19-XSG39-01-091318	1809473-13	12.0		0%
Trip 8	Red	M19-XSG43-01-091318	13.4	13.4	23%	8	M19-XSG43-01-091318	1809473-14	11.0		20%
Trip 8	Red	M20-XS146-01-091718	6.9	6.6	26%	5	M20-XS146-01-091718	1809475-28	11.0		46%
Trip 8	Red	M20-XS243-01-091718	9.8	9.7	10%	9	M20-XS243-01-091718	1809475-29	13.0		28%
Trip 8	Red	M20-XS247-01-091718	17.2	17.8	11%	14	M20-XS247-01-091718	1809475-30	14.0		21%
Trip 8	Red	M20-XS267-01-091718	11.6	11.4	30%	7	M20-XS267-01-091718	1809475-31	15.0		26%
Trip 8	Red	M20-XS271-01-091718	10.8	10.9	12%	9	M20-XS271-01-091718	1809475-32	14.0		26%
Trip 8	Red	M20-XS30-01-091718	14.1	13.8	11%	12	M20-XS30-01-091718	1809475-33	15.0		6%
Trip 8	Red	M20-XS335-01-091418	10.7	10.6	16%	8	M20-XS335-01-091418	1809475-5	10.0		7%
Trip 8	Red	M20-XS422-01-091418	16.3	15.3	22%	13	M20-XS422-01-091418	1809475-6	13.0		23%
Trip 8	Red	M20-XS58-01-091718	13.9	13.4	16%	11	M20-XS58-01-091718	1809475-34	13.0		7%
Trip 8	Red	M20-XS60-01-091718	18.7	18.8	8%	17	M20-XS60-01-091718	1809475-35	18.0		4%
Trip 8	Red	M20-XSG15-01-091418	17.8	18.3	15%	14	M20-XSG15-01-091418	1809475-7	22.0		21%
Trip 8	Red	M20-XSG28-01-091418	12.6	12.1	12%	11	M20-XSG28-01-091418	1809475-8	13.0		3%
Trip 8	Red	M20-XSG7-01-091418	5.2	4.9	28%	3	M20-XSG7-01-091418	1809475-9	8.1	J	44%
Trip 8	Red	M21-XS317-01-091218	19.7	19.9	18%	15	M21-XS317-01-091218	1809473-25	16.0		21%
Trip 8	Red	M21-XS323-01-091218	12.2	13.0	27%	7	M21-XS323-01-091218	1809473-26	13.0		6%
Trip 8	Red	M21-XS366-01-091418	7.1	7.2	23%	4	M21-XS366-01-091418	1809475-10	9.7	J	31%
Trip 8	Red	M21-XS366-02-091418	7.4	7.3	16%	6	M21-XS366-02-091418	1809475-11	9.7	J	27%
Trip 8	Red	M21-XS465-01-091218	17.1	16.9	8%	15	M21-XS465-01-091218	1809473-27	18.0		5%
Trip 8	Red	M21-XS511-01-091218	15.4	15.7	12%	12	M21-XS511-01-091218	1809473-29	18.0		16%
Trip 8	Red	M21-XS536-01-091218	24.0	24.1	14%	19	M21-XS536-01-091218	1809473-30	20.0		18%
Trip 8	Red	M21-XSG38-01-091418	25.1	25.5	12%	20	M21-XSG38-01-091418	1809475-12	22.0		13%
Trip 8	Red	M21-XSG43-01-091418	5.2	5.5	20%	4	M21-XSG43-01-091418	1809475-13	7.6	J	38%
Trip 8	Red	M22-XS112-01-091418	16.1	15.8	10%	14	M22-XS112-01-091418	1809475-14	15.0		7%
Trip 8	Red	M22-XS115-01-091418	13.4	13.7	7%	12	M22-XS115-01-091418	1809475-15	13.0		3%
Trip 8	Red	M22-XS121-01-091418	14.3	14.6	12%	11	M22-XS121-01-091418	1809475-16	13.0		9%
Trip 8	Red	M22-XS94-01-091418	12.6	12.1	16%	10	M22-XS94-01-091418	1809475-17	12.0		5%

Analyte: Zinc XRFs Used: Red, Pink, Blue, White Field Mobilization #: Mobilization 7-9 Field Mobilization Dates: August 12, 2018 - September 30, 2018

Trip	XRF Color	XRF ID	XRF - Zinc				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 8	Red	M23-XSG1-01-091418	20.7	20.7	12%	17	M23-XSG1-01-091418	1809475-18	20.0		3%
Trip 8	Red	M23-XSG20-01-091418	11.5	11.5	15%	9	M23-XSG20-01-091418	1809475-19	9.8		16%
Trip 8	Red	M23-XSG5-01-091418	10.4	10.1	14%	9	M23-XSG5-01-091418	1809475-20	10.0		4%
Trip 8	Red	M6-XS353A-01-091618	20.1	19.9	12%	17	M6-XS353A-01-091618	1809475-36	20.0		1%
Trip 8	Red	M6-XS369-01-091618	5.1	5.1	34%	3	M6-XS369-01-091618	1809475-37	6.9	J	29%
Trip 8	Red	M6-XS52-01-091118	9.7	9.6	12%	8	M6-XS52-01-091118	1809473-35	11.0		12%
Trip 8	Red	M6-XSG13A-01-091618	17.7	18.1	7%	16	M6-XSG13A-01-091618	1809475-38	18.0		2%
Trip 8	Red	M6-XSG22-01-091618	9.2	9.3	8%	8	M6-XSG22-01-091618	1809475-39	9.3	J	1%
Trip 8	Red	M7-XSG34-01-091618	15.6	15.8	9%	13	M7-XSG34-01-091618	1809475-40	15.0		4%
Trip 8	Red	M7-XSG41-01-091618	11.3	11.1	12%	10	M7-XSG41-01-091618	1809475-41	13.0		14%
Trip 8	Red	T18-XSG7-01-091518	12.5	13.2	17%	9	T18-XSG7-01-091518	1809475-42	14.0		11%
Trip 8	Red	T21-XSG26-01-091118	12.1	12.1	17%	10	T21-XSG26-01-091118	1809473-39	13.0		7%
Trip 8	Red	T23-XSG26-01-091118	11.2	10.9	21%	9	T23-XSG26-01-091118	1809473-16	12.0		7%
Trip 8	Red	T23-XSG7-01-091118	15.2	14.3	14%	13	T23-XSG7-01-091118	1809473-17	19.0		22%
Trip 8	Red	T24-XSG2-01-091118	12.1	11.6	16%	10	T24-XSG2-01-091118	1809473-18	13.0		7%
Trip 8	Red	T26-XSG2-01-091518	11.0	12.1	23%	8	T26-XSG2-01-091518	1809475-43	6.6	J	50%
Trip 8	Red	T26-XSG9-01-091518	9.1	9.0	12%	8	T26-XSG9-01-091518	1809475-44	7.8	J	16%
Trip 9	Red	M10-XSG2-01-092818	13.7	14.1	11%	11	M10-XSG2-01-092818	1810122-1	14.0		2%
Trip 9	Blue	M10-XSG4-01-092818	19.4	18.9	13%	17	M10-XSG4-01-092818	1810122-2	14.0		32%
Trip 9	Red	M11-XS47-01-092818	14.0	14.1	9%	12	M11-XS47-01-092818	1810122-3	13.0		7%
Trip 9	Blue	M11-XSG2-01-092818	10.7	10.5	8%	10	M11-XSG2-01-092818	1810122-4	9.2	J	15%
Trip 9	Blue	M11-XSG25-01-092818	14.1	12.8	25%	11	M11-XSG25-01-092818	1810122-5	11.0		25%
Trip 9	Blue	M11-XSG28-01-092818	33.2	32.6	19%	25	M11-XSG28-01-092818	1810122-6	25.0		28%
Trip 9	Red	M11-XSG33-01-092818	13.6	13.1	12%	12	M11-XSG33-01-092818	1810122-7	16.0		16%
Trip 9	Red	M12-XSG26-01-092818	11.2	11.3	13%	9	M12-XSG26-01-092818	1810122-8	12.0		7%
Trip 9	Blue	M14-XSR1-01-093018	11.2	10.6	14%	10	M14-XSR1-01-093018	1810072-21	10.0		11%
Trip 9	White	M15-XSR1-01-093018	15.1	14.8	6%	14	M15-XSR1-01-093018	1810072-22	7.8	J	64%
Trip 9	White	M16-XSR1-01-093018	14.9	14.3	11%	13	M16-XSR1-01-093018	1810072-23	9.6		43%
Trip 9	White	M16-XSR6-01-093018	20.9	20.7	10%	19	M16-XSR6-01-093018	1810072-24	12.0		54%
Trip 9	Blue	M17-XSR1-01-093018	12.6	11.5	19%	11	M17-XSR1-01-093018	1810072-25	8.5		39%
Trip 9	Red	M19-XSR2-01-093018	11.4	11.1	13%	10	M19-XSR2-01-093018	1810072-26	9.5		18%
Trip 9	Blue	M19-XSR2-02-093018	14.3	13.6	19%	12	M19-XSR2-02-093018	1810072-27	10.0		36%
Trip 9	Red	M1-XSG4-01-092818	10.9	11.3	11%	9	M1-XSG4-01-092818	1810072-1	13.0		17%
Trip 9	Blue	M20-XSR2-01-093018	9.4	8.4	21%	8	M20-XSR2-01-093018	1810072-28	7.5	J	23%
Trip 9	White	M23-XSR4-01-093018	21.1	21.0	8%	19	M23-XSR4-01-093018	1810072-29	15.0		34%
Trip 9	Red	M24-XS112-01-092518	20.4	20.4	13%	17	M24-XS112-01-092518	1810032-1	20.0		2%
Trip 9	Red	M24-XS114-01-092518	14.2	14.5	9%	12	M24-XS114-01-092518	1810032-2	14.0		1%
Trip 9	Red	M24-XSG15-01-092518	17.2	15.9	24%	14	M24-XSG15-01-092518	1810032-3	20.0		15%
Trip 9	Red	M24-XSG3-01-092518	8.6	7.3	38%	5	M24-XSG3-01-092518	1810032-4	15.0		55%
Trip 9	Red	M24-XSG32-01-092518	9.0	9.2	17%	7	M24-XSG32-01-092518	1810032-5	11.0		20%
Trip 9	Red	M24-XSR1-01-093018	13.3	13.1	11%	12	M24-XSR1-01-093018	1810072-30	16.0		18%
Trip 9	Blue	M25-XSG12-01-092818	4.5	4.5	25%	3	M25-XSG12-01-092818	1810122-10	6.1	J	30%
Trip 9	Blue	M25-XSG19-01-092818	15.5	15.1	9%	14	M25-XSG19-01-092818	1810122-11	15.0		3%
Trip 9	Blue	M25-XSG19-02-092818	16.0	15.5	16%	13	M25-XSG19-02-092818	1810122-12	15.0		6%
Trip 9	Blue	M25-XSG5-01-092818	4.2	4.5	25%	3	M25-XSG5-01-092818	1810122-13	5.5	J	28%
Trip 9	Red	M27-XS116-01-092618	9.8	9.5	7%	9	M27-XS116-01-092618	1810072-2	12.0		20%
Trip 9	Red	M27-XS149-01-092618	9.0	9.1	19%	7	M27-XS149-01-092618	1810072-3	12.0		28%
Trip 9	Red	M27-XS150-01-092618	9.0	9.0	15%	7	M27-XS150-01-092618	1810072-4	13.0		36%
Trip 9	Red	M27-XS163-01-092618	17.1	17.3	11%	15	M27-XS163-01-092618	1810072-5	19.0		11%
Trip 9	Red	M27-XSG28-01-092618	11.1	11.2	11%	10	M27-XSG28-01-092618	1810072-6	17.0		42%
Trip 9	Red	M27-XSG28-02-092618	10.8	10.7	20%	7	M27-XSG28-02-092618	1810072-7	17.0		45%
Trip 9	Red	M27-XSG48-01-092618	25.1	23.9	11%	23	M27-XSG48-01-092618	1810072-8	29.0		15%
Trip 9	Red	M27-XSG6-01-092618	8.0	8.1	16%	6	M27-XSG6-01-092618	1810072-9	12.0		40%
Trip 9	Red, Blue	M28-XS162-01-092818	55.1	55.0	16%	43	M28-XS162-01-092818	1810122-14	50.0		10%
Trip 9	White	M28-XS19-01-092918	25.2	22.1	25%	20	M28-XS19-01-092918	1810122-15	18.0		33%
Trip 9	Red	M28-XS29-01-092618	12.6	12.8	8%	11	M28-XS29-01-092618	1810032-6	21.0		50%
Trip 9	Blue	M28-XSG18-01-092918	12.8	12.8	8%	11	M28-XSG18-01-092918	1810122-16	12.0		7%
Trip 9	Red	M28-XSG49-01-092618	19.7	22.6	35%	6	M28-XSG49-01-092618	1810032-7	22.0		11%
Trip 9	Red, White	M28-XSG54-01-092918	33.9	34.3	14%	24	M28-XSG54-01-092918	1810122-17	27.0		23%
Trip 9	Red	M28-XSG7-01-092618	4.4	4.7	34%	2	M28-XSG7-01-092618	1810032-8	8.3	J	61%
Trip 9	White	M28-XSG76-01-092918	21.4	21.4	6%	20	M28-XSG76-01-092918	1810122-18	17.0		23%
Trip 9	Blue	M28-XSR1-01-093018	9.2	8.9	22%	7	M28-XSR1-01-093018	1810072-31	7.5	J	21%
Trip 9	Red	M28-XSR1-02-093018	7.2	7.1	8%	7	M28-XSR1-02-093018	1810072-32	7.2	J	0%
Trip 9	Red	M29-XS19-01-092518	26.2	25.3	11%	23	M29-XS19-01-092518	1810032-9	28.0		6%
Trip 9	Red	M29-XS42-01-092518	13.2	12.8	16%	11	M29-XS42-01-092518	1810032-10	16.0		20%
Trip 9	Red	M29-XS59-01-092518	18.3	17.8	19%	14	M29-XS59-01-092518	1810032-11	24.0		27%
Trip 9	Red	M29-XS64-01-092518	9.5	9.1	18%	8	M29-XS64-01-092518	1810032-12	12.0		23%
Trip 9	Red	M29-XSG25-01-092518	7.8	7.4	25%	6	M29-XSG25-01-092518	1810032-14	9.3	J	17%
Trip 9	Red	M29-XSG35-01-092518	13.4	13.4	10%	12	M29-XSG35-01-092518	1810032-15	14.0		4%
Trip 9	Blue	M29-XSR4-01-093018	23.7	23.3	25%	16	M29-XSR4-01-093018	1810072-33	16.0		39%
Trip 9	Red	M29-XSR7-01-093018	27.5	27.1	23%	17	M29-XSR7-01-093018	1810072-34	27.0		2%
Trip 9	White	M2-XSR3-01-093018	12.0	11.8	12%	10	M2-XSR3-01-093018	1810072-35	8.0	J	40%
Trip 9	White	M30-XS144-01-092918	24.8	25.1	13%	19	M30-XS144-01-092918	1810122-19	17.0		37%
Trip 9	White	M30-XS185-01-092918	35.5	36.5	7%	32	M30-XS185-01-092918	1810122-20	29.0		20%
Trip 9	White	M30-XS62-01-092918	21.4	20.8	14%	18	M30-XS62-01-092918	1810122-21	16.0		29%
Trip 9	White	M30-XSG18-01-092918	29.1	27.7	20%	23	M30-XSG18-01-092918	1810122-22	22.0		28%
Trip 9	White	M30-XSG29-01-092918	26.5	25.8	8%	24	M30-XSG29-01-092918	1810122-23	23.0		14%
Trip 9	White	M30-XSG43-01-092918	14.7	14.6	7%	14	M30-XSG43-01-092918	1810122-24	12.0		20%
Trip 9	White	M30-XSG45-01-092918	15.6	16.1	22%	11	M30-XSG45-01-092918	1810122-25	11.0		35%
Trip 9	Red, White	M30-XSG6-01-092918	14.5	14.4	30%	7	M30-XSG6-01-092918	1810122-26	14.0		4%

Trip	XRF Color	XRF ID	XRF - Zinc				Sample Name	Lab ID	ALS Results		Relative Percent Difference
			Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)			Lab Result (mg/kg)	Lab Qualifier	
Trip 9	Blue	M30-XSG61-01-092918	6.0	5.7	27%	4	M30-XSG61-01-092918	1810122-27	5.8	J	3%
Trip 9	White	M30-XSR5-01-093018	21.3	21.9	11%	17	M30-XSR5-01-093018	1810072-36	13.0		48%
Trip 9	Red	M31-XS1-01-092918	30.9	25.5	46%	18	M31-XS1-01-092918	1810122-28	22.0		34%
Trip 9	Blue	M31-XS39-01-092918	14.9	14.7	13%	12	M31-XS39-01-092918	1810122-29	16.0		7%
Trip 9	White	M31-XS8-01-092918	31.4	31.7	15%	24	M31-XS8-01-092918	1810122-30	20.0		44%
Trip 9	White	M31-XSG1-01-092918	13.8	13.6	9%	12	M31-XSG1-01-092918	1810122-31	8.9		43%
Trip 9	White	M31-XSG12-01-092918	29.2	28.2	13%	25	M31-XSG12-01-092918	1810122-32	20.0		38%
Trip 9	White	M31-XSG17-01-092918	17.4	16.5	11%	16	M31-XSG17-01-092918	1810122-33	13.0		29%
Trip 9	Red	M31-XSG9-01-092918	7.9	8.0	7%	7	M31-XSG9-01-092918	1810122-34	9.4	J	17%
Trip 9	Red	M32-XSG23-01-092918	21.2	21.1	8%	19	M32-XSG23-01-092918	1810072-10	25.0		16%
Trip 9	Red	M32-XSG26-01-092918	11.1	11.5	9%	10	M32-XSG26-01-092918	1810072-11	14.0		23%
Trip 9	Red	M32-XSG34-01-092918	26.4	26.5	6%	24	M32-XSG34-01-092918	1810072-12	24.0		9%
Trip 9	Red	M32-XSG46-01-092918	10.8	11.1	15%	9	M32-XSG46-01-092918	1810072-13	11.0		1%
Trip 9	Red	M32-XSG9-01-092918	10.5	10.2	16%	8	M32-XSG9-01-092918	1810072-14	13.0		21%
Trip 9	Red	M34-XSG15-01-092718	17.2	16.6	9%	16	M34-XSG15-01-092718	1810072-15	20.0		15%
Trip 9	Red	M35-XSG20-01-092718	18.9	19.8	25%	13	M35-XSG20-01-092718	1810072-16	25.0		28%
Trip 9	Red	M35-XSG4-01-092718	8.3	7.4	36%	6	M35-XSG4-01-092718	1810072-17	11.0		28%
Trip 9	Red	M36-XSG1-01-092718	17.1	16.2	13%	16	M36-XSG1-01-092718	1810072-18	19.0		11%
Trip 9	White	M6-XSR1-01-093018	15.8	16.0	15%	12	M6-XSR1-01-093018	1810072-37	9.5		50%
Trip 9	White	M7-XSR1-01-093018	21.5	21.6	7%	20	M7-XSR1-01-093018	1810072-38	14.0		42%
Trip 9	White	M7-XSR1-02-093018	19.3	19.2	15%	15	M7-XSR1-02-093018	1810072-39	15.0		25%
Trip 9	Blue	M8-XSR1-01-093018	15.5	16.5	22%	9	M8-XSR1-01-093018	1810072-40	14.0		10%
Trip 9	White	T17-XSR1-01-093018	13.0	12.6	19%	9	T17-XSR1-01-093018	1810072-41	6.9	J	61%
Trip 9	Red	T30-XS20-01-092518	12.5	12.7	6%	11	T30-XS20-01-092518	1810032-16	15.0		18%
Trip 9	Red	T30-XS28-01-092518	12.6	12.4	8%	11	T30-XS28-01-092518	1810032-17	14.0		11%
Trip 9	Red	T30-XS8-01-092518	11.0	11.2	8%	10	T30-XS8-01-092518	1810032-18	11.0		0%
Trip 9	Red	T31-XSG7-01-092518	7.6	7.4	15%	6	T31-XSG7-01-092518	1810032-19	8.8	J	15%
Trip 9	Red	T31-XSG9-01-092518	8.2	8.5	17%	6	T31-XSG9-01-092518	1810032-20	10.0		20%
Trip 9	Red	T5-XSG3-01-092818	9.5	9.6	12%	8	T5-XSG3-01-092818	1810072-19	12.0		23%
Trip 9	Red	T5-XSG3-02-092818	9.9	9.9	12%	8	T5-XSG3-02-092818	1810072-20	13.0		27%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

Removed Data - Below Limit of Detection											
			XRF - Zinc						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Pink	M37-XS38-01-081318	11.1	10.7	16%	9	M37-XS38-01-081318	1808356-1	92.0		157%
Trip 7	Red	T1-XSG5A-01-081918	132.4	9.2	246%	7	T1-XSG5A-01-081918	1808483-15	9.9		172%
Trip 8	Red	T21-XSG13-01-091118	18.3	18.5	10%	15	T21-XSG13-01-091118	1809473-38	32.0		55%
Trip 9	Red	M12-XSG3-01-092818	189.1	22.7	217%	18	M12-XSG3-01-092818	1810122-9	14.0		172%

Removed Data - Outliers											
			XRF - Zinc						ALS Results		
Trip	XRF Color	XRF ID	Average Ex Situ XRF (ppm)	Median Ex Situ XRF (ppm)	Relative Standard Deviation	Minimum of Ex Situ XRF (ppm)	Sample Name	Lab ID	Lab Result (mg/kg)	Lab Qualifier	Relative Percent Difference
Trip 7	Red	M6-XS72-01-081618	0.0	0.0	0%	0	M6-XS72-01-081618	1808476-10	15.0		200%
Trip 7	Red	M9-XS19A-01-081718	0.0	0.0	0%	0	M9-XS19A-01-081718	1808483-8	11.0		200%
Trip 7	Red	M9-XS28A-01-081718	0.0	0.0	0%	0	M9-XS28A-01-081718	1808483-9	22.0		200%
Trip 7	Red	T13-XSG16-01-081618	0.0	0.0	0%	0	T13-XSG16-01-081618	1808476-13	17.0		200%
Trip 7	Red	T17-XSG17-01-081618	0.0	0.0	0%	0	T17-XSG17-01-081618	1808476-16	12.0		200%
Trip 7	Red	T17-XSG27-01-081618	0.0	0.0	0%	0	T17-XSG27-01-081618	1808476-17	17.0		200%
Trip 7	Red	T17-XSG31-01-081518	0.0	0.0	0%	0	T17-XSG31-01-081518	1808476-18	13.0		200%
Trip 7	Red	T17-XSG7-01-081618	0.0	0.0	0%	0	T17-XSG7-01-081618	1808476-19	12.0		200%
Trip 7	Red	T6-XSG6-01-081918	3.2	3.2	68%	0	T6-XSG6-01-081918	1808487-10	6.4	J	67%
Trip 8	Red	M13-XS258-01-091518	2.7	2.7	64%	0	M13-XS258-01-091518	1809475-2	5.8	J	74%
Trip 8	Red	M15-XSG20-01-091118	0.0	0.0	0%	0	M15-XSG20-01-091118	1809473-20	18.0		200%
Trip 8	Red	M16-XSG24-01-091118	0.0	0.0	0%	0	M16-XSG24-01-091118	1809473-23	89.0		200%
Trip 8	Red	M16-XSG38-01-091518	0.4	0.0	245%	0	M16-XSG38-01-091518	1809475-4	5.8	J	173%
Trip 8	Red	M21-XS1-01-091218	0.0	0.0	0%	0	M21-XS1-01-091218	1809473-24	18.0		200%
Trip 8	Red	M21-XS503-01-091218	0.0	0.0	0%	0	M21-XS503-01-091218	1809473-28	12.0		200%
Trip 8	Red	M21-XSG16-01-091218	0.0	0.0	0%	0	M21-XSG16-01-091218	1809473-31	20.0		200%
Trip 8	Red	M21-XSG7-01-091218	0.0	0.0	0%	0	M21-XSG7-01-091218	1809473-32	11.0		200%
Trip 8	Red	M6-XS164-01-091118	0.0	0.0	0%	0	M6-XS164-01-091118	1809473-33	6.3	J	200%
Trip 8	Red	M6-XS224-01-091118	0.0	0.0	0%	0	M6-XS224-01-091118	1809473-34	19.0		200%
Trip 8	Red	T19-XS9-01-091118	0.0	0.0	0%	0	T19-XS9-01-091118	1809473-36	15.0		200%
Trip 8	Red	T20-XSG3-01-091118	2.1	0.0	245%	0	T20-XSG3-01-091118	1809473-37	13.0		144%
Trip 8	Red	T22-XS20-01-091118	0.0	0.0	0%	0	T22-XS20-01-091118	1809473-15	13.0		200%
Trip 8	Red	T24-XSG26-01-091118	0.0	0.0	0%	0	T24-XSG26-01-091118	1809473-19	12.0		200%
Trip 9	Red	M29-XSG1-01-092518	2.2	2.2	88%	0	M29-XSG1-01-092518	1810032-13	7.0	J	106%

Notes:

Average ex situ XRF is the average of the measurements collected using XRF instrument in a laboratory setting.

ALS = ALS Environmental

J = Estimated value

mg/kg = milligrams per kilogram

ppm = parts per million

XRF = X-ray fluorescence

ATTACHMENT B5

EX SITU SOIL CUP REGRESSION MODELS

TABLE OF CONTENTS

Section **Page**

1.0 SUMMARY OF MODEL PARAMETERS B5-1
2.0 ARSENIC SOIL CUP SAMPLE REGRESSION B5-3
3.0 IRON SOIL CUP SAMPLE REGRESSION B5-5
4.0 LEAD SOIL CUP SAMPLE REGRESSION B5-7
5.0 MANGANESE SOIL CUP SAMPLE REGRESSION B5-11
6.0 MOLYBDENUM SOIL CUP SAMPLE REGRESSION B5-13
7.0 THORIUM SOIL CUP SAMPLE REGRESSION B5-15
8.0 URANIUM SOIL CUP SAMPLE REGRESSION B5-19
9.0 VANADIUM SOIL CUP SAMPLE REGRESSION B5-23
10.0 ZINC SOIL CUP SAMPLE REGRESSION B5-25

LIST OF TABLES

Table B5-1. Summary of Ex Situ Soil Cup Regression Model Parameters............................ B5-1

LIST OF FIGURES

Figure B5-1. Soil Cup Regression Model for Arsenic (Blue XRF).. B5-3
Figure B5-2. Soil Cup Regression Model for Arsenic (Red XRF).. B5-3
Figure B5-3. Soil Cup Regression Model for Arsenic (White XRF) B5-4
Figure B5-4. Comparison of Soil Cup Regression Models B5-4
Figure B5-5. Soil Cup Regression Model for Iron (Blue XRF) B5-5
Figure B5-6. Soil Cup Regression Model for Iron (Red XRF)... B5-5
Figure B5-7. Soil Cup Regression Model for Iron (White XRF) B5-6
Figure B5-8. Comparison of Soil Cup Regression Models B5-6
Figure B5-9. Soil Cup Regression Model (<30 ppm) for Lead (Blue XRF) B5-7
Figure B5-10. Soil Cup Regression Model (All Data) for Lead (Blue XRF).......................... B5-7
Figure B5-11. Soil Cup Regression Model (<30 ppm) for Lead (Red XRF) B5-8
Figure B5-12. Soil Cup Regression Model (All Data) for Lead (Red XRF)........................... B5-8
Figure B5-13. Soil Cup Regression Model (<30 ppm) for Lead (White XRF) B5-9
Figure B5-14. Soil Cup Regression Model (All Data) for Lead (White XRF)........................ B5-9
Figure B5-15. Comparison of Soil Cup Regression Models (<30 ppm) B5-10
Figure B5-16. Comparison of Soil Cup Regression Models (All Data) B5-10
Figure B5-17. Soil Cup Regression Model for Manganese (Blue XRF) B5-11
Figure B5-18. Soil Cup Regression Model for Manganese (Red XRF) B5-11
Figure B5-19. Soil Cup Regression Model for Manganese (White XRF)............................. B5-12
Figure B5-20. Comparison of Soil Cup Regression Models B5-12
Figure B5-21. Soil Cup Regression Model for Molybdenum (Blue XRF)............................ B5-13
Figure B5-22. Soil Cup Regression Model for Molybdenum (Red XRF)............................. B5-13
Figure B5-23. Soil Cup Regression Model for Molybdenum (White XRF) B5-14

LIST OF FIGURES (CONTINUED)

Figure B5-24. Comparison of Soil Cup Regression Models B5-14
Figure B5-25. Soil Cup Regression Model (<12 ppm) for Thorium (Blue XRF)................. B5-15
Figure B5-26. Soil Cup Regression Model (All Data) for Thorium (Blue XRF).................. B5-15
Figure B5-27. Soil Cup Regression Model (<12 ppm) for Thorium (Red XRF) B5-16
Figure B5-28. Soil Cup Regression Model (All Data) for Thorium (Red XRF)................... B5-16
Figure B5-29. Soil Cup Regression Model (<12 ppm) for Thorium (White XRF)................ B5-17
Figure B5-30. Soil Cup Regression Model (All Data) for Thorium (White XRF)................ B5-17
Figure B5-31. Comparison of Soil Cup Regression Models (<12 ppm) B5-18
Figure B5-33. Soil Cup Regression Model (<100 ppm) for Uranium (Blue XRF)................ B5-19
Figure B5-34. Soil Cup Regression Model (All Data) for Uranium (Blue XRF).................. B5-19
Figure B5-35. Soil Cup Regression Model (<100 ppm) for Uranium (Red XRF)................ B5-20
Figure B5-36. Soil Cup Regression Model (All Data) for Uranium (Red XRF).................... B5-20
Figure B5-37. Soil Cup Regression Model (<100 ppm) for Uranium (White XRF).............. B5-21
Figure B5-38. Soil Cup Regression Model (All Data) for Uranium (White XRF) B5-21
Figure B5-39. Comparison of Soil Cup Regression Models (<100 ppm) B5-22
Figure B5-40. Comparison of Soil Cup Regression Models (All Data)................................ B5-22
Figure B5-41. Soil Cup Regression Model for Vanadium (Blue XRF) B5-23
Figure B5-42. Soil Cup Regression Model for Vanadium (Red XRF).................................. B5-23
Figure B5-43. Soil Cup Regression Model for Vanadium (White XRF) B5-24
Figure B5-44. Comparison of Soil Cup Regression Models B5-24
Figure B5-45. Soil Cup Regression Model for Zinc (Blue XRF).. B5-25
Figure B5-46. Soil Cup Regression Model for Zinc (Red XRF)... B5-25
Figure B5-47. Soil Cup Regression Model for Zinc (White XRF).. B5-26
Figure B5-48. Comparison of Soil Cup Regression Models B5-26

1.0 SUMMARY OF MODEL PARAMETERS

Table B5-1. Summary of Ex Situ Soil Cup Regression Model Parameters

Analyte	XRF Instrument Used	Scenario	XRD Data Applied To	Total # of Data Pairs Used in Model Development[1]	XRF_{MIN} (ppm)	XRF_{MAX} (ppm)	Censored Data Pairs Removed[2]	Outliers Data Pairs Removed[3]	XRF_O	R^2	R	Slope (m)	y-intercept (b)
Arsenic	Blue	Soil Cup	All	44	1.8	43	14	0	0.95	0.99	0.99	0.9353	-0.8868
	Red				2.4	43	18	0	0.54	0.99	0.99	0.9163	-0.4927
	White				2.1	44	8	0	1.10	0.99	0.99	0.9184	-1.01447
Iron	Blue	Soil Cup	All	44	4,480	44,741	0	0	2,271	0.95	0.98	0.5549	-1260.2
	Red				4,323	45,574	0	0	2,136	0.96	0.98	0.5499	-1174.4
	White				4,615	46,976	0	0	2,326	0.96	0.98	0.5338	-1241.4
Lead	Blue	Soil Cup	≥ 30 ppm	44	3.3	106	0	0	2.47	0.93	0.96	0.8981	-2.2205
			< 30 ppm	41	3.3	22	0	1	1.79	0.91	0.96	0.8708	-1.5555
	Red		≥ 30 ppm	44	3.3	108	0	0	3.93	0.99	0.99	0.9474	-3.7272
			< 30 ppm	41	4.4	24	0	0	2.66	0.85	0.92	0.8084	-2.147
	White		≥ 30 ppm	44	3.3	112	0	0	3.17	0.99	1.00	0.9048	-2.8651
			< 30 ppm	41	4.2	23	0	0	2.67	0.91	0.95	0.8555	-2.2856
Manganese	Blue	Soil Cup	All	44	43	711	0	0	-56	0.72	0.85	0.7212	40.253
	Red				52	739	0	0	-28	0.81	0.90	0.8088	22.556
	White				60	846	0	0	-28	0.83	0.91	0.6934	19.463
Thorium	Blue	Soil Cup	≥ 12 ppm	38	1.4	62	5	1	1.39	0.99	0.99	0.7281	-1.0085
			< 12 ppm	37	2.0	13	5	1	-0.63	0.85	0.92	0.4237	0.2687
	Red		≥ 12 ppm	34	1.6	65	10	0	0.70	0.99	1.00	0.6838	-0.4775
			< 12 ppm	33	1.6	12	10	0	-1.49	0.86	0.93	0.4030	0.5985
	White		≥ 12 ppm	41	2.1	60	0	0	1.45	0.99	0.99	0.7510	-1.0862
			< 12 ppm	40	2.1	13	0	0	-0.43	0.87	0.93	0.4395	0.1879
Uranium	Blue	Soil Cup	≥ 100 ppm	42	3.7	464	1	1	1.06	0.98	0.99	0.7996	-0.8484
			< 100 ppm	32	3.7	96	1	1	3.29	0.87	0.93	0.8342	-2.7423
	Red		≥ 100 ppm	43	3.6	428	1	0	3.66	0.98	0.99	0.8326	-3.0441
			< 100 ppm	33	3.6	97	1	0	3.95	0.88	0.94	0.8431	-3.3273
	White		≥ 100 ppm	43	4.6	423	1	0	3.75	0.97	0.99	0.8461	-3.1709
			< 100 ppm	34	4.6	92	1	0	5.00	0.83	0.91	0.8702	-4.3499
Vanadium	Blue	Soil Cup	All	44	39	1,344	0	0	63	0.96	0.98	0.7840	-49.411
	Red				35	1,201	0	0	65	0.96	0.98	0.8298	-53.525
	White				31	1,225	0	0	69	0.95	0.98	0.7705	-52.847

Table B5-1. Summary of Ex Situ Soil Cup Regression Model Parameters

Analyte	XRF Instrument Used	Scenario	XRD Data Applied To	Total # of Data Pairs Used in Model Development[1]	XRF_{MIN} (ppm)	XRF_{MAX} (ppm)	Censored Data Pairs Removed[2]	Outliers Data Pairs Removed[3]	XRF_O	R^2	R	Slope (m)	y-intercept (b)
Zinc	Blue	Soil Cup	All	44	8	96	0	0	1	0.97	0.98	0.7449	-0.801
	Red				6	96	0	0	-1	0.96	0.98	0.7249	0.9051
	White				13	105	0	0	5	0.98	0.99	0.6940	-3.7665

Notes:

[1] Total data pairs used in regression model development.
[2] Refers to the number of data pairs removed from the model development that included either (1) a minimum of one XRF measurement containing a LOD value or (2) a laboratory reported concentration below the laboratory MDL.
[3] Refers to the number of data pairs removed from the model development that were identified as extreme outliers by visual inspection or residual analysis. Models are shown for both with and without outliers in this attachment.

LOD Limit of detection for XRF
MDL Method detection limit for laboratory
NA Not applicable
ppm Parts per million
R Pearson's correlation coeffiicent
R^2 Coefficient of determination
XRF X-ray fluoresence
XRF_{MAX} Defined as the maximum raw in situ XRF measurement value used in the regression model development.
XRF_{MIN} Defined as the minimum raw in situ XRF measurement value used in the regression model development.
XRF_O Defined as the XRF measurement value equal to the laboratory equivalent value of 0 milligrams per kilogram when using the regression model (that is, the x-value when the y-value is zero).

2.0 ARSENIC SOIL CUP SAMPLE REGRESSION

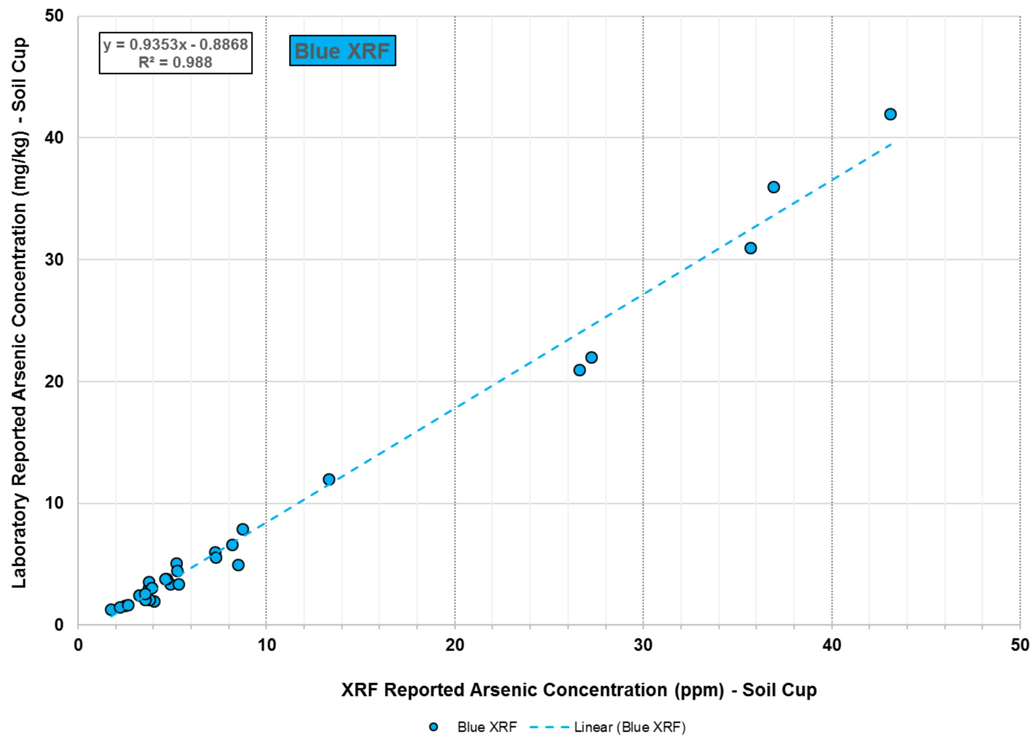


Figure B5-1. Soil Cup Regression Model for Arsenic (Blue XRF)

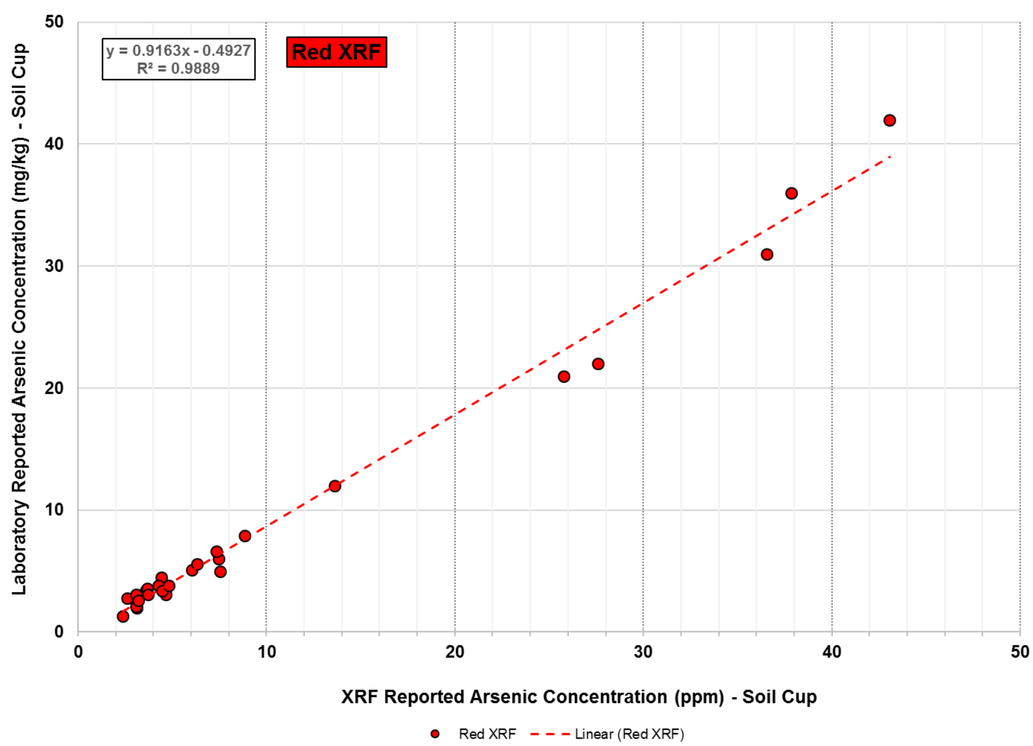


Figure B5-2. Soil Cup Regression Model for Arsenic (Red XRF)

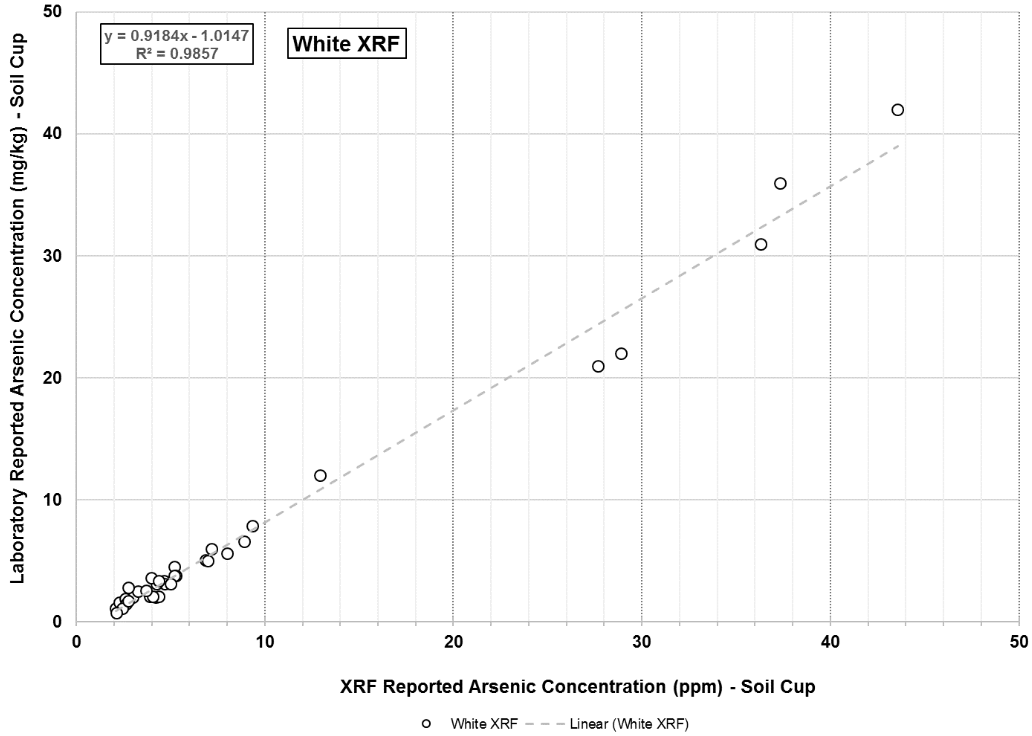


Figure B5-3. Soil Cup Regression Model for Arsenic (White XRF)

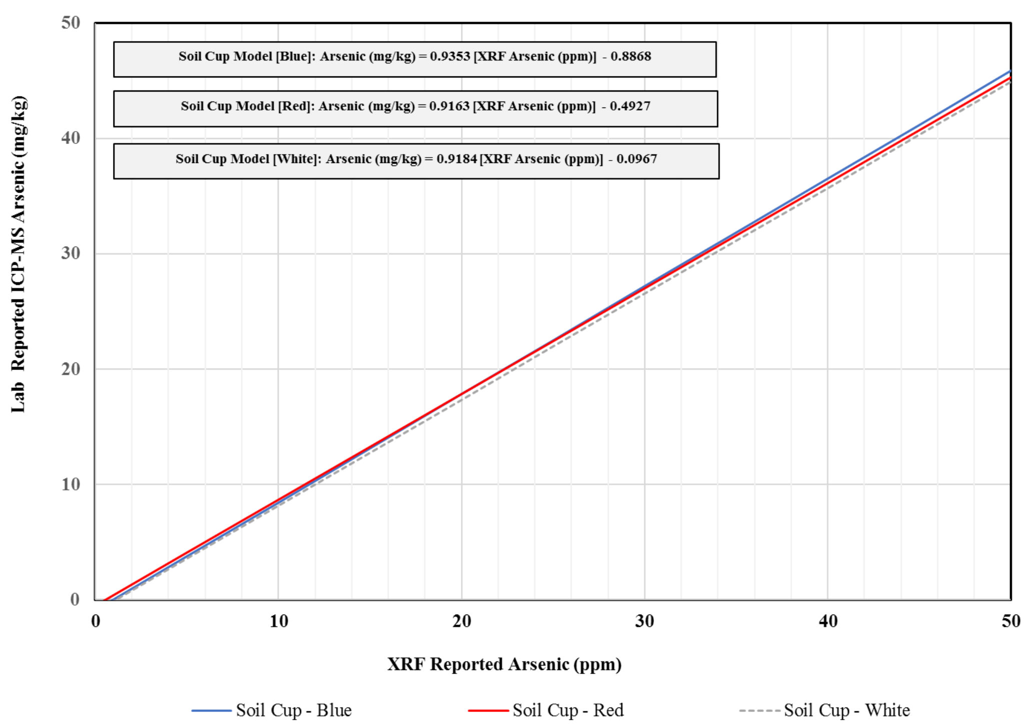


Figure B5-4. Comparison of Soil Cup Regression Models

3.0 IRON SOIL CUP SAMPLE REGRESSION

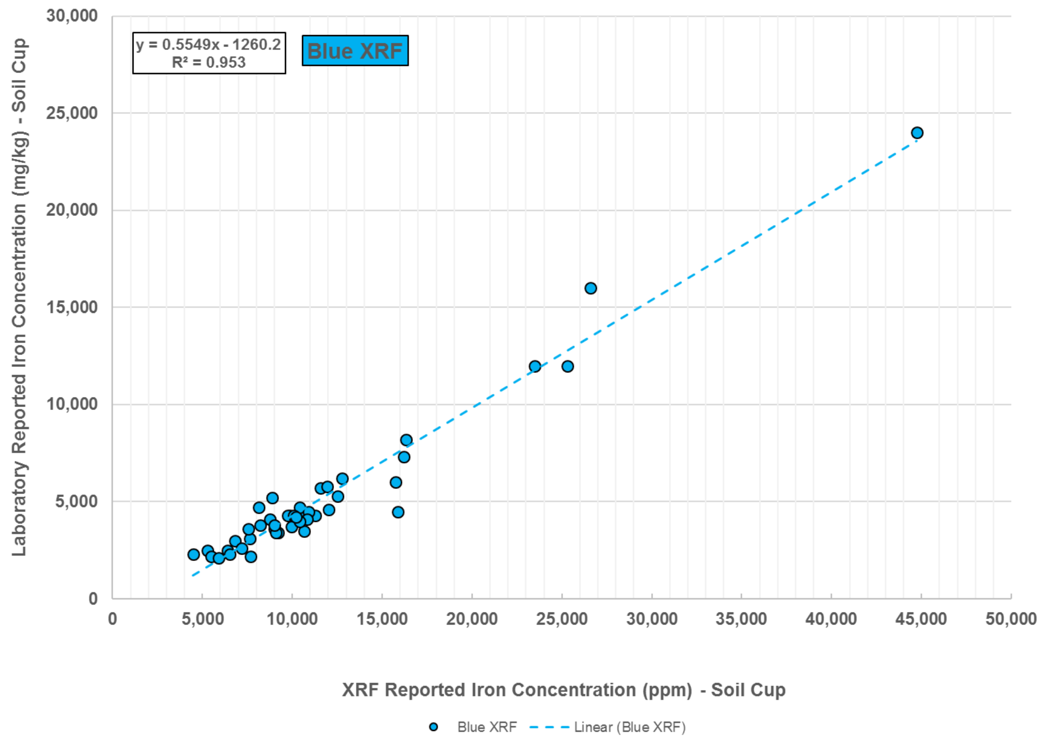


Figure B5-5. Soil Cup Regression Model for Iron (Blue XRF)

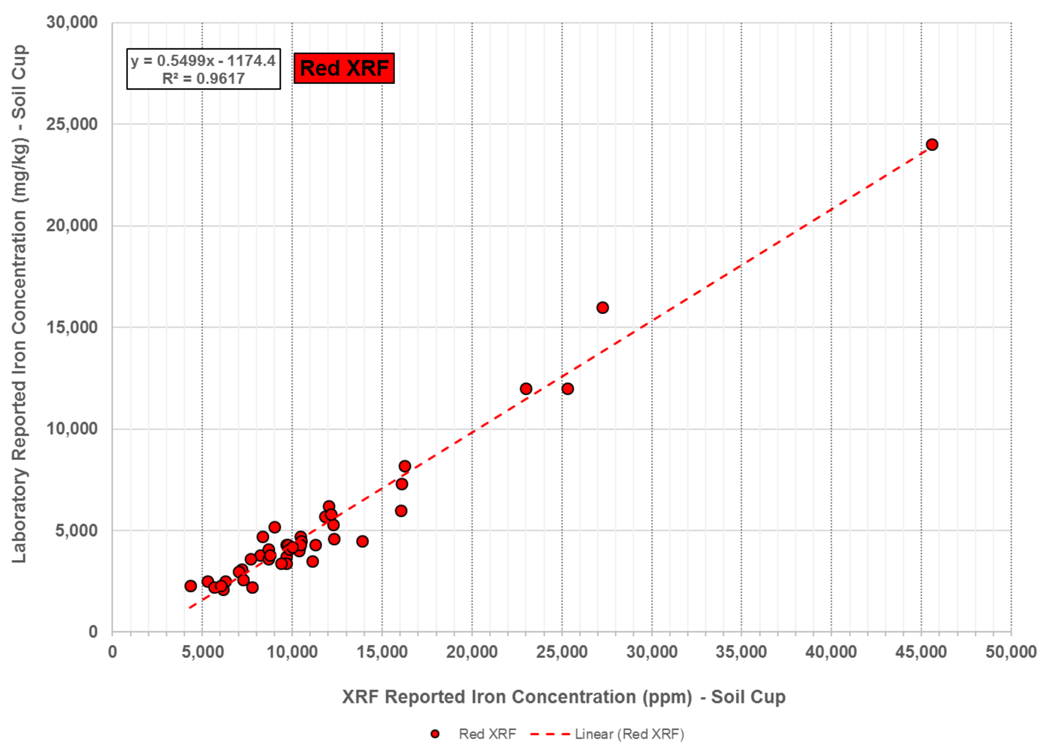


Figure B5-6. Soil Cup Regression Model for Iron (Red XRF)

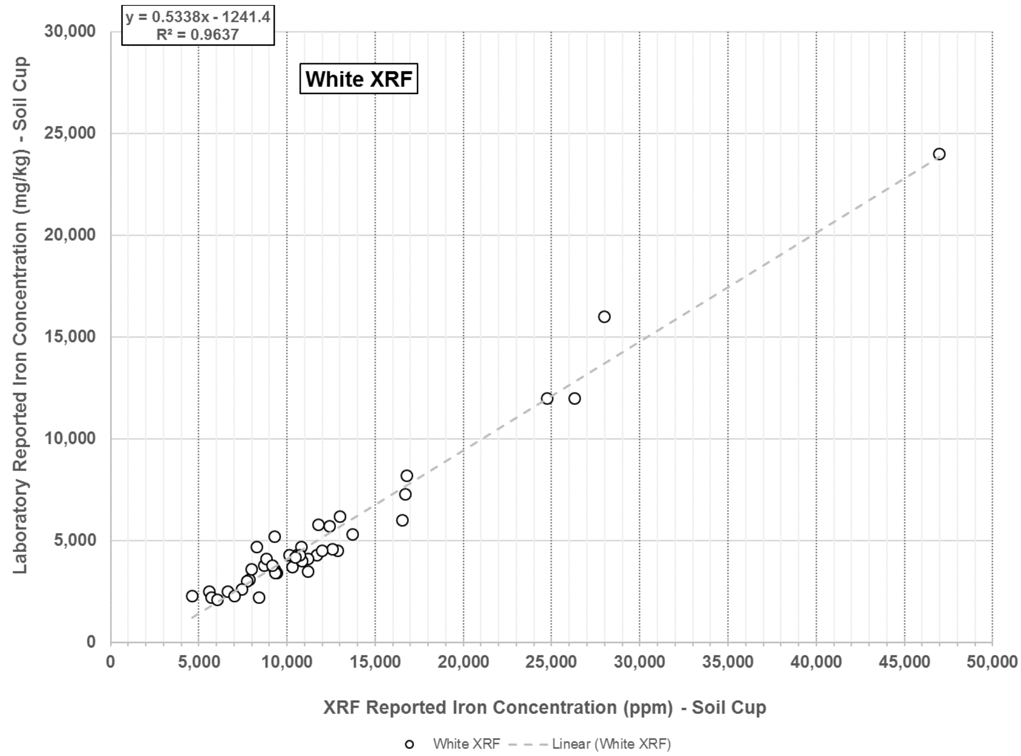


Figure B5-7. Soil Cup Regression Model for Iron (White XRF)

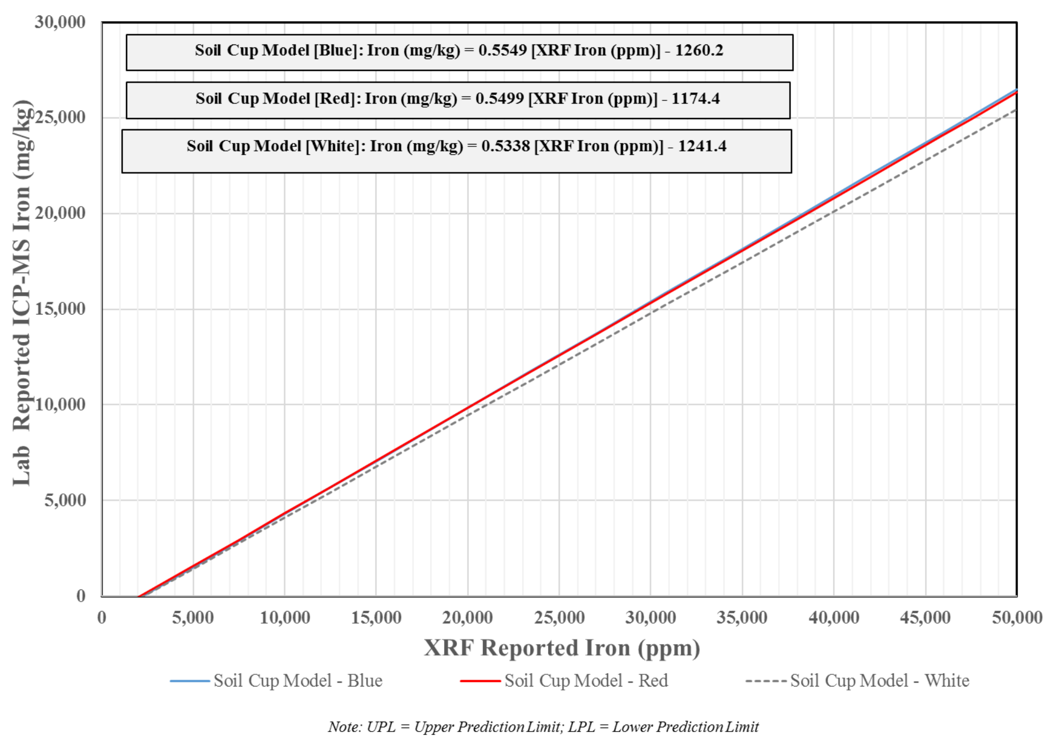


Figure B5-8. Comparison of Soil Cup Regression Models

4.0 LEAD SOIL CUP SAMPLE REGRESSION

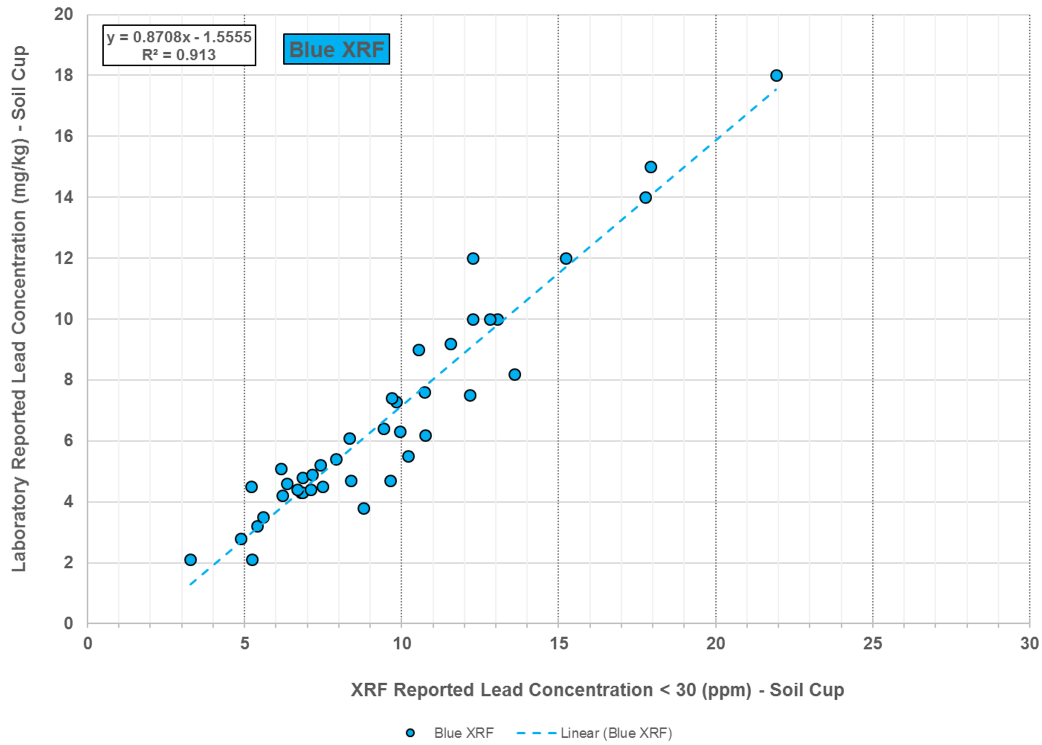


Figure B5-9. Soil Cup Regression Model (<30 ppm) for Lead (Blue XRF)

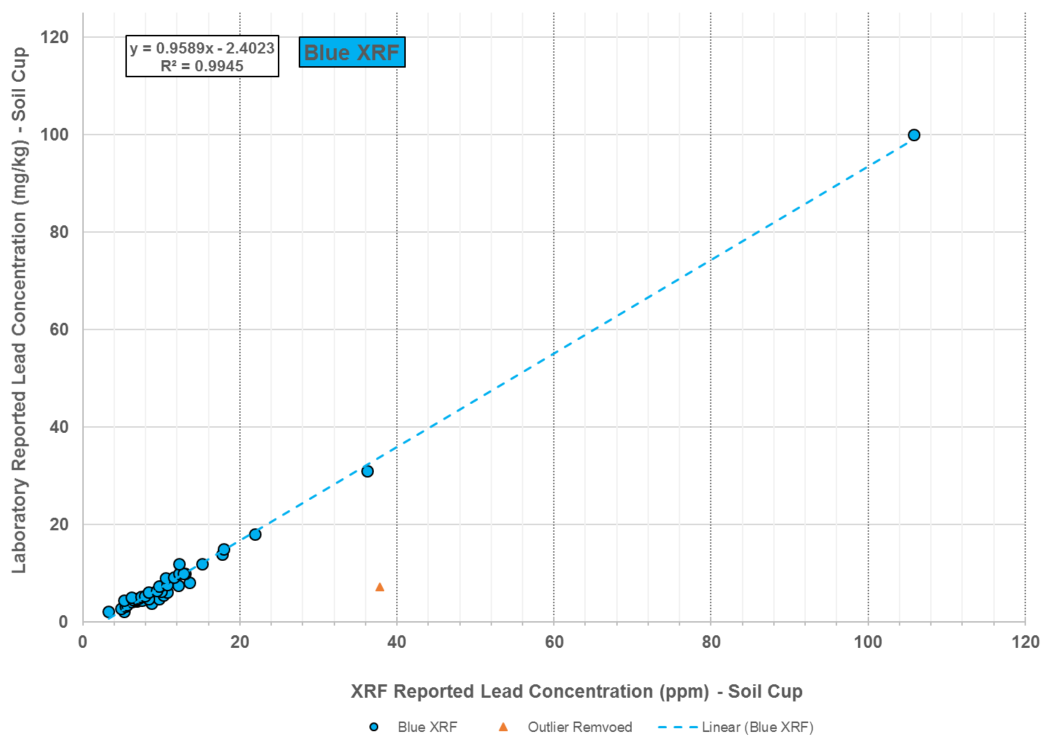


Figure B5-10. Soil Cup Regression Model (All Data) for Lead (Blue XRF)

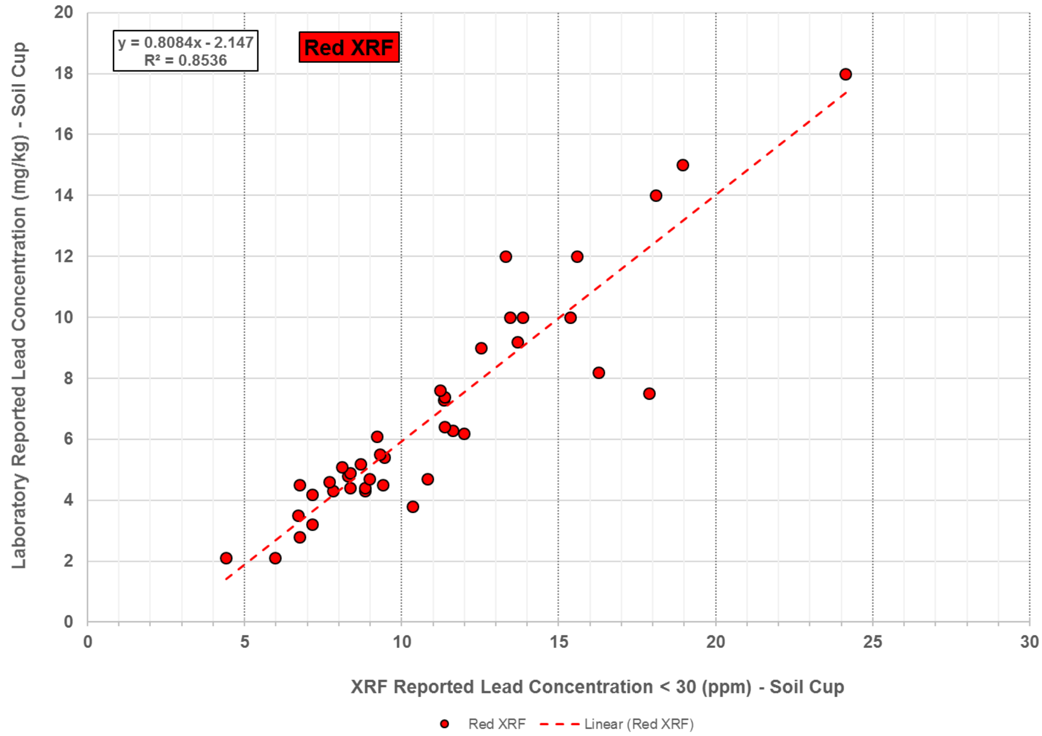


Figure B5-11. Soil Cup Regression Model (<30 ppm) for Lead (Red XRF)

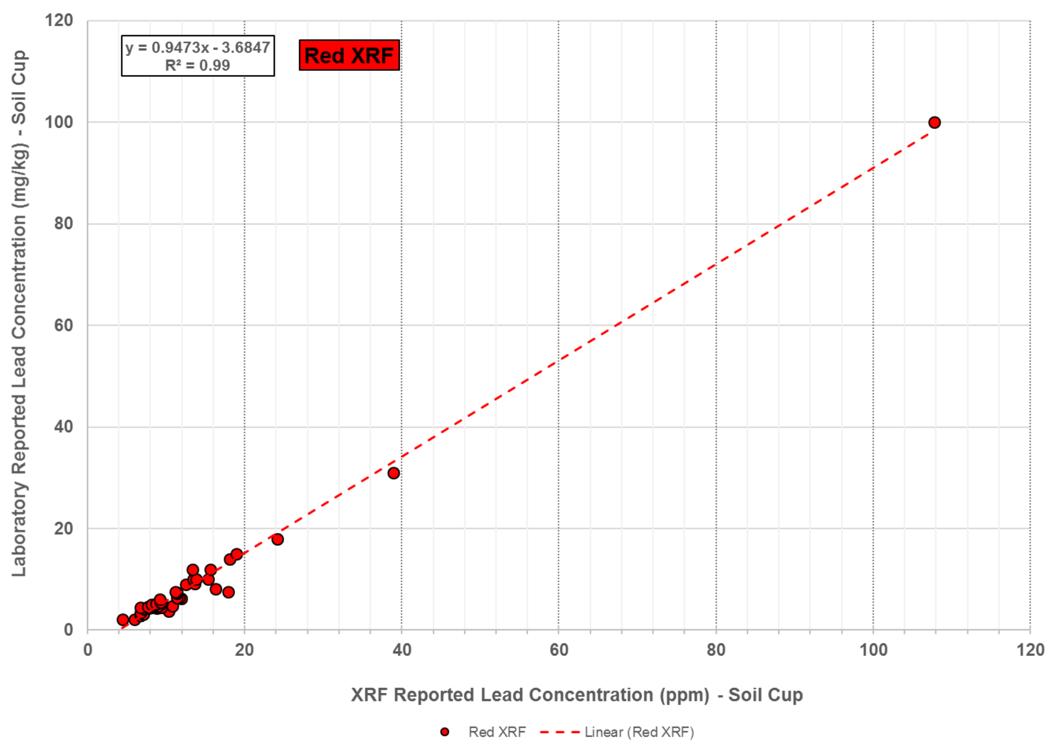


Figure B5-12. Soil Cup Regression Model (All Data) for Lead (Red XRF)

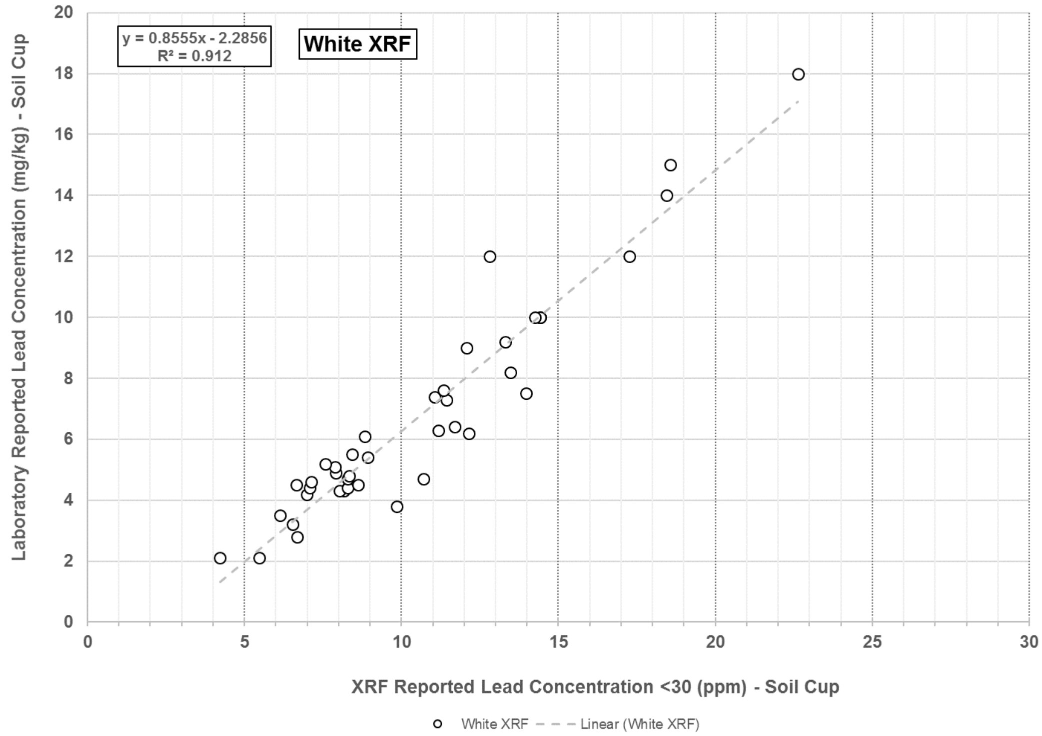


Figure B5-13. Soil Cup Regression Model (<30 ppm) for Lead (White XRF)

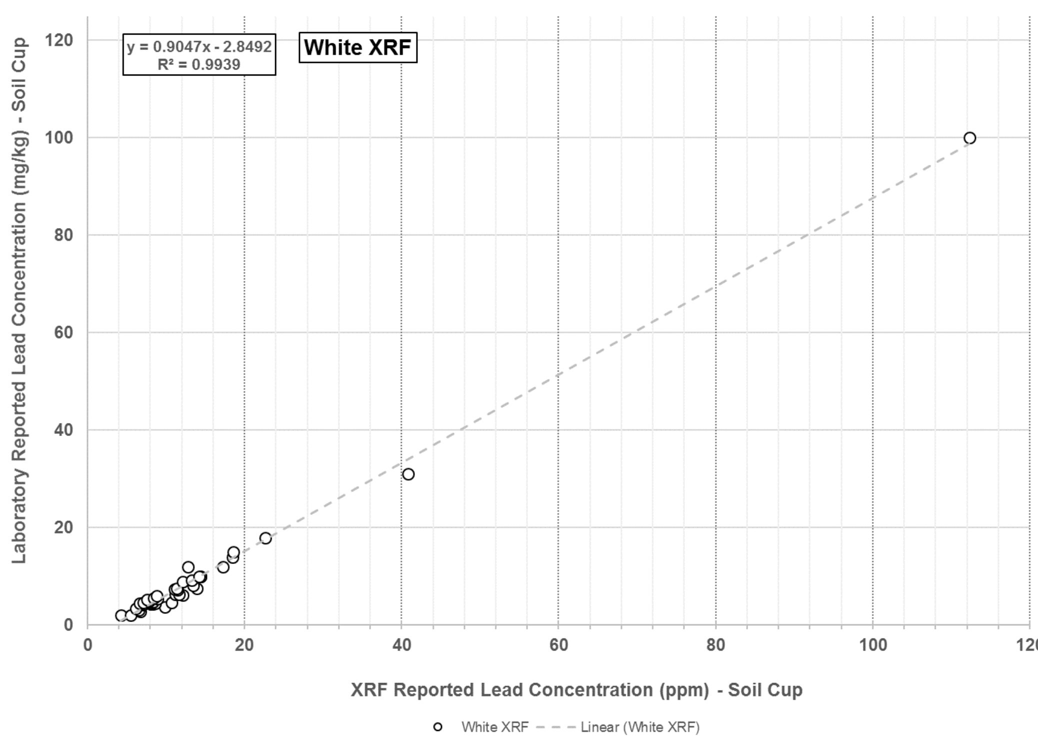


Figure B5-14. Soil Cup Regression Model (All Data) for Lead (White XRF)

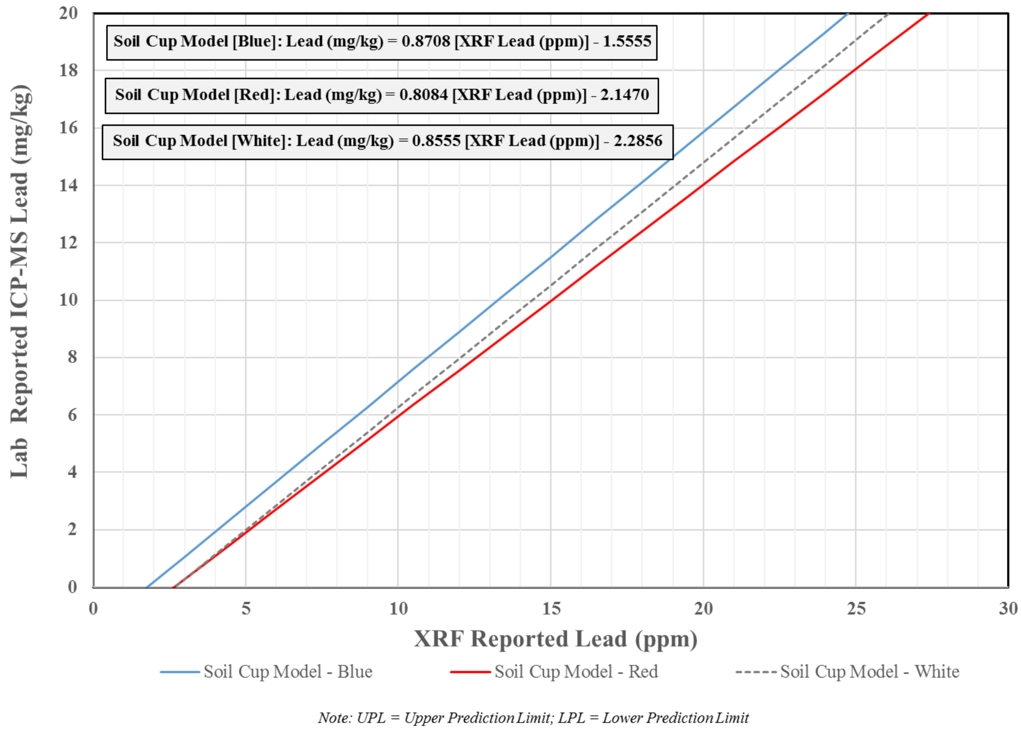


Figure B5-15. Comparison of Soil Cup Regression Models (<30 ppm)

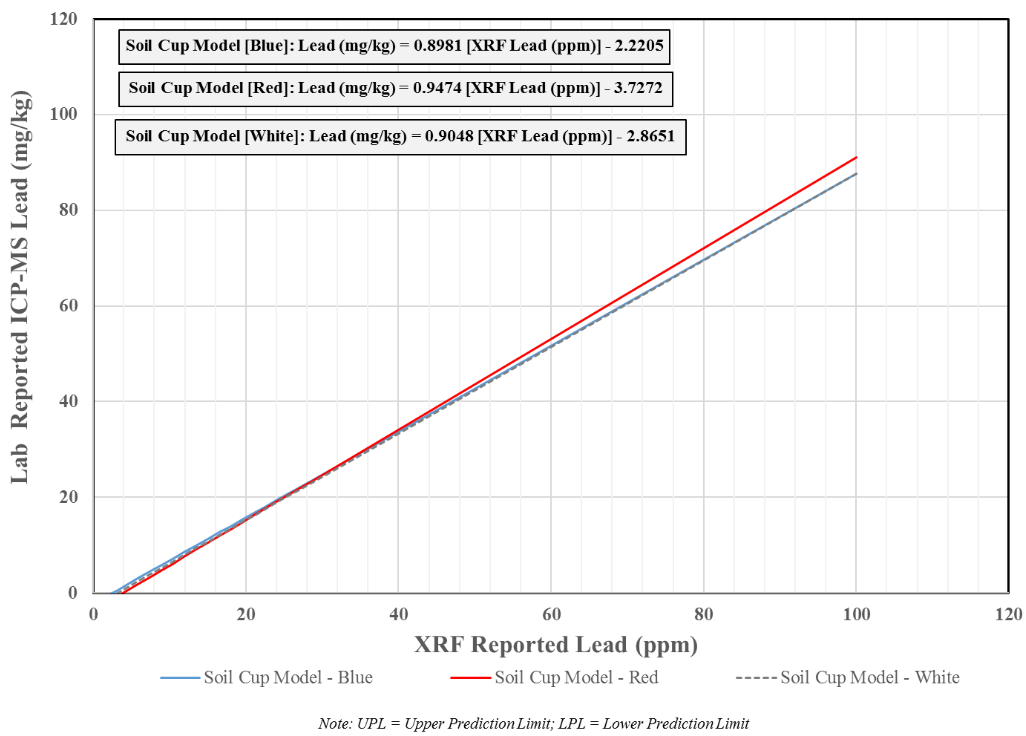


Figure B5-16. Comparison of Soil Cup Regression Models (All Data)

5.0 MANGANESE SOIL CUP SAMPLE REGRESSION

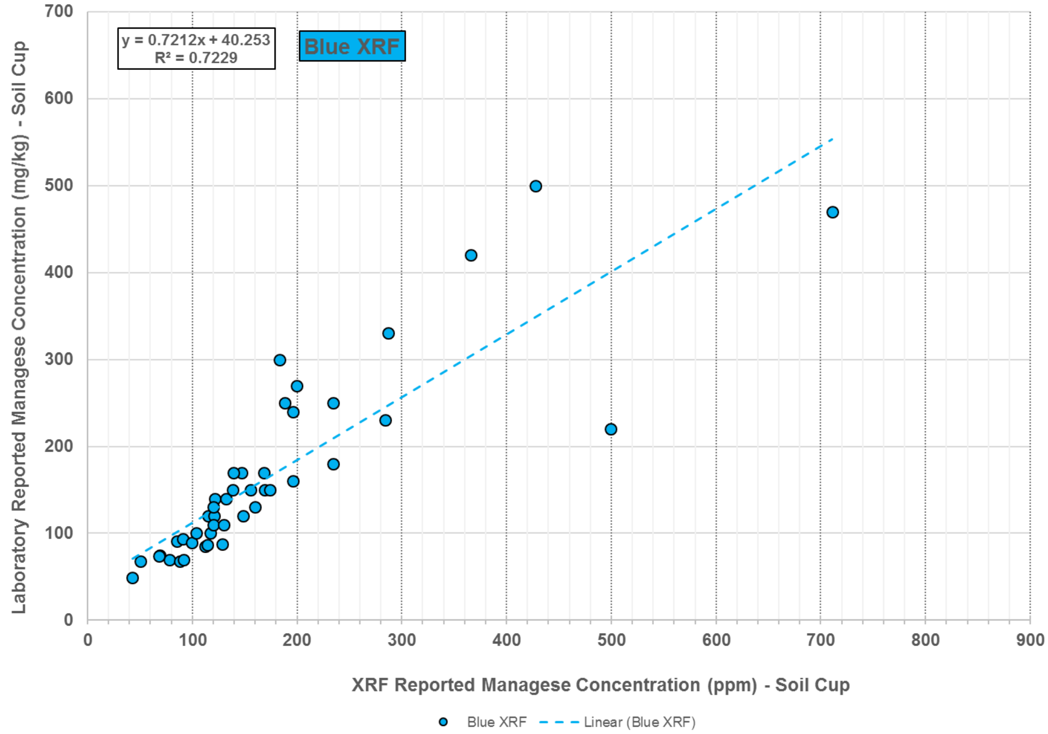


Figure B5-17. Soil Cup Regression Model for Manganese (Blue XRF)

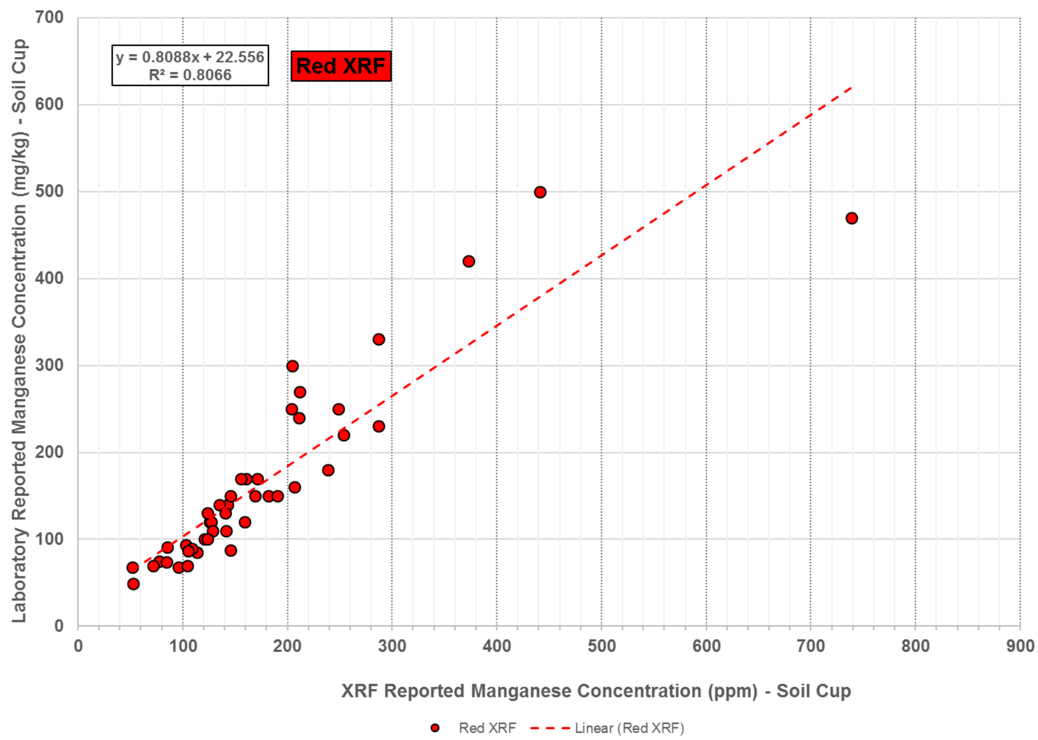


Figure B5-18. Soil Cup Regression Model for Manganese (Red XRF)

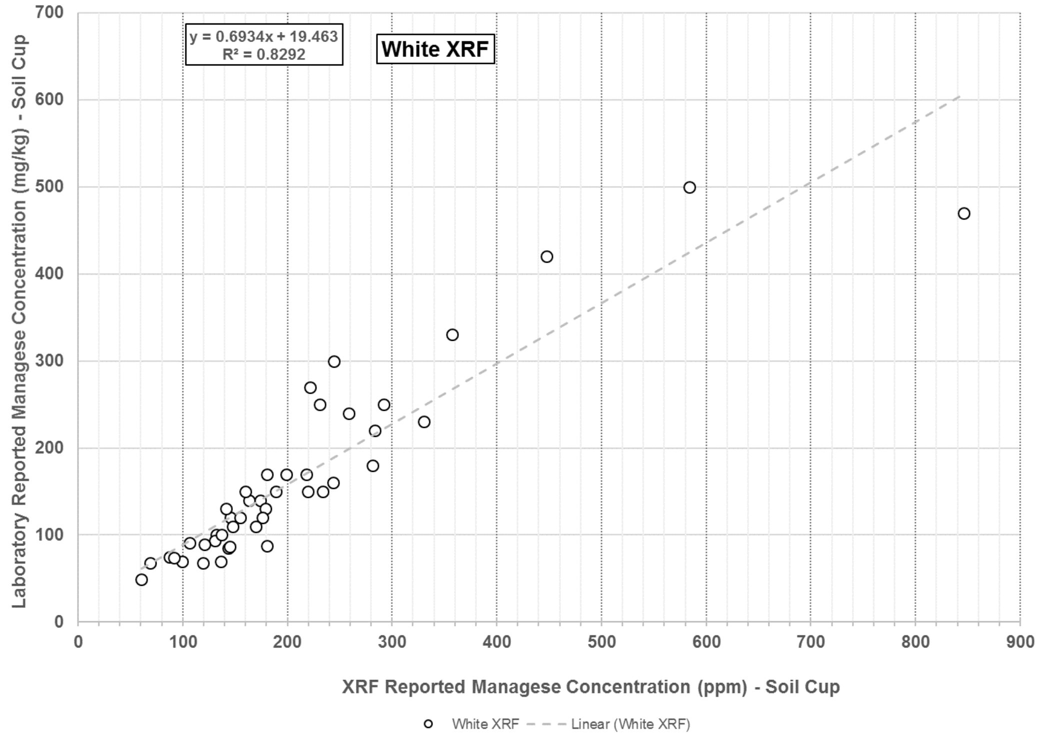


Figure B5-19. Soil Cup Regression Model for Manganese (White XRF)

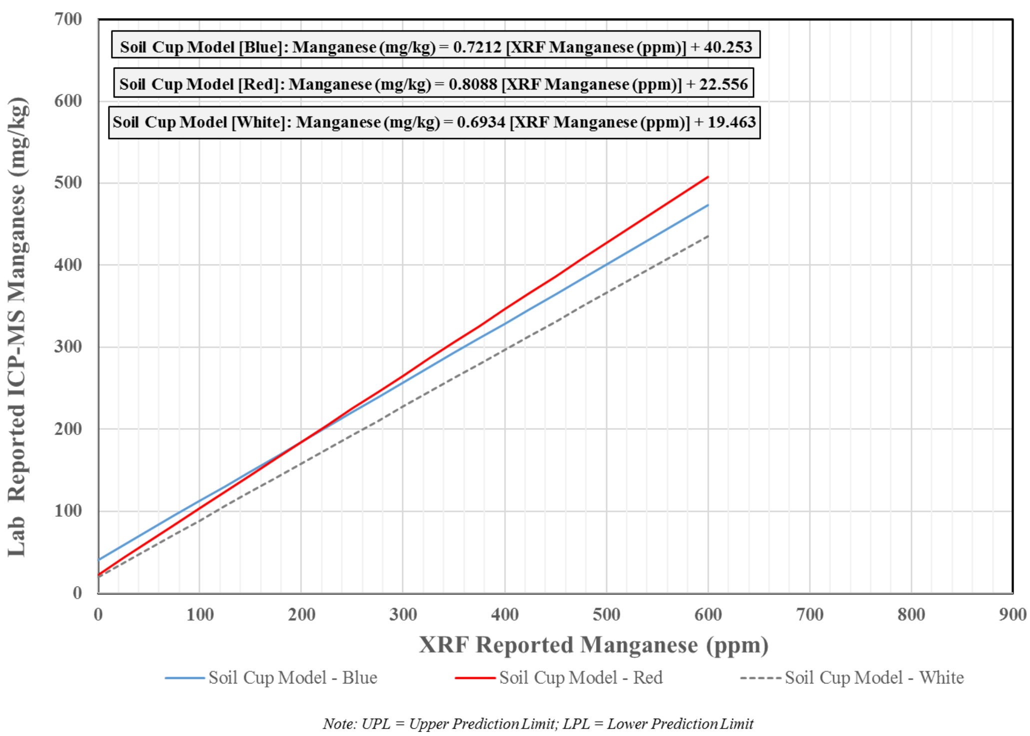


Figure B5-20. Comparison of Soil Cup Regression Models

6.0 MOLYBDENUM SOIL CUP SAMPLE REGRESSION

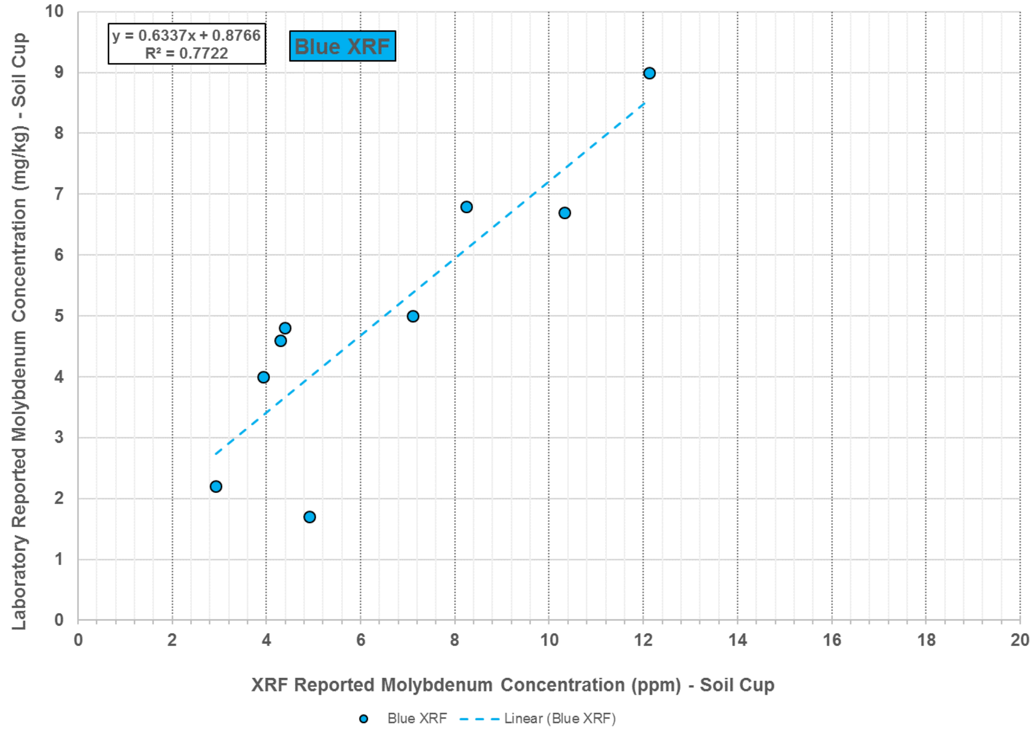


Figure B5-21. Soil Cup Regression Model for Molybdenum (Blue XRF)

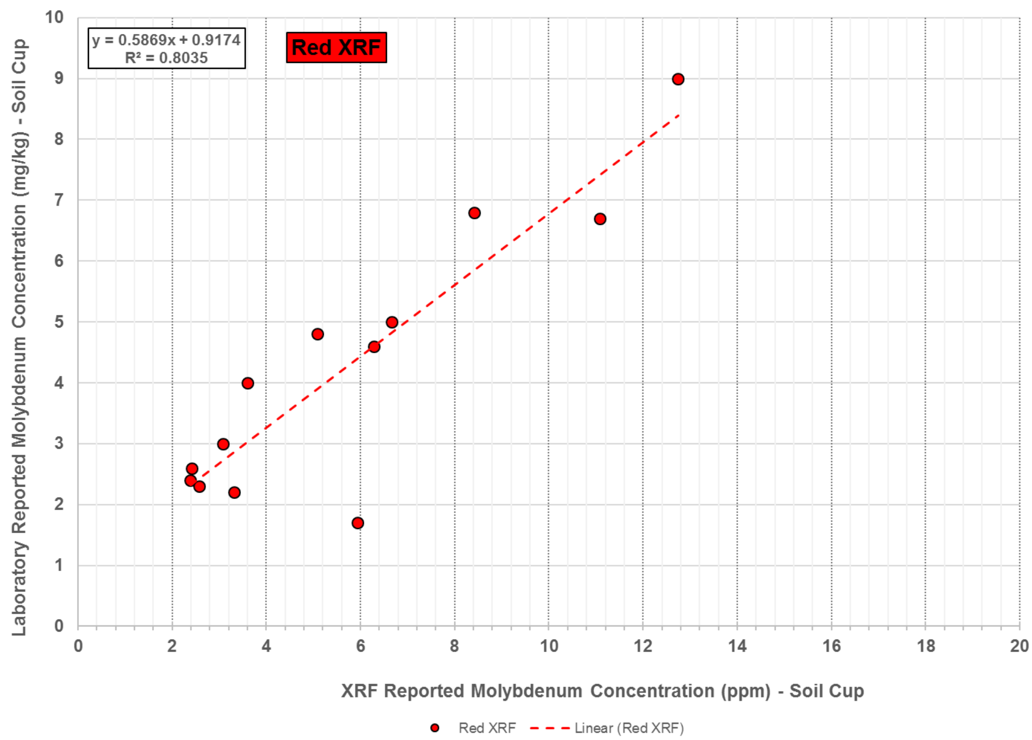


Figure B5-22. Soil Cup Regression Model for Molybdenum (Red XRF)

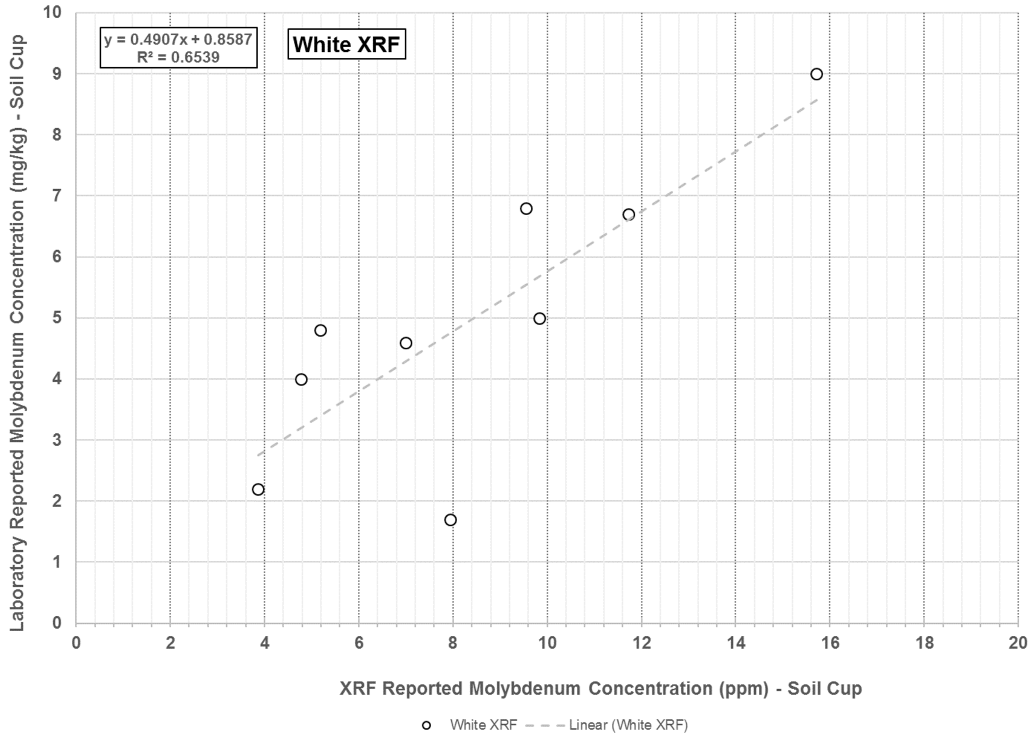


Figure B5-23. Soil Cup Regression Model for Molybdenum (White XRF)

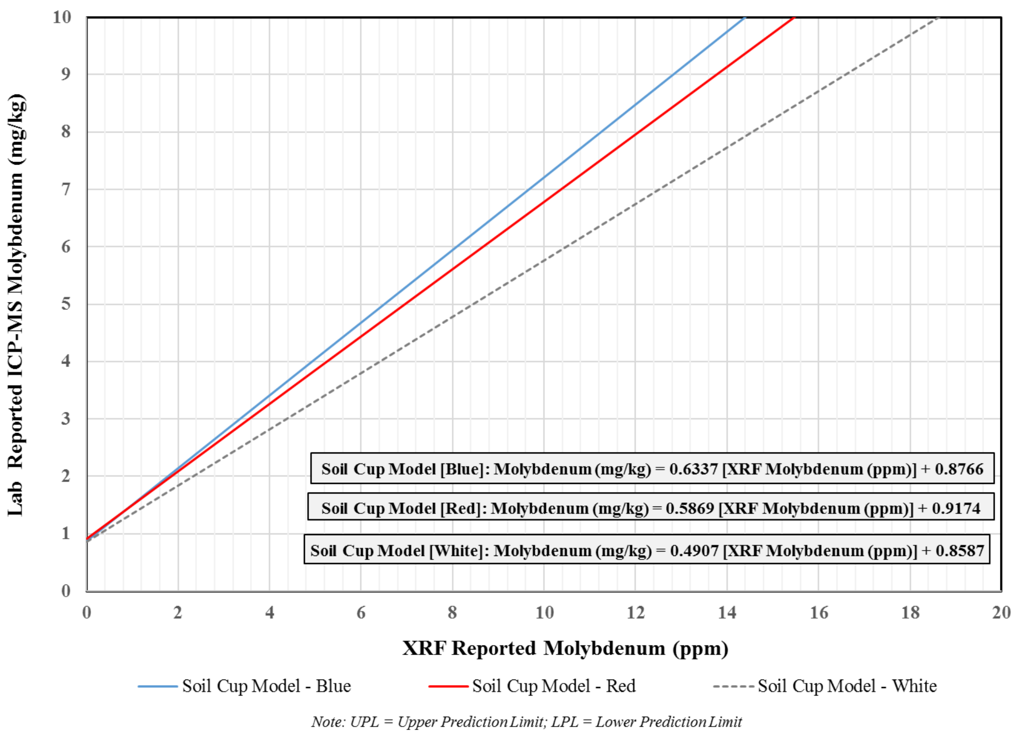


Figure B5-24. Comparison of Soil Cup Regression Models

7.0 THORIUM SOIL CUP SAMPLE REGRESSION

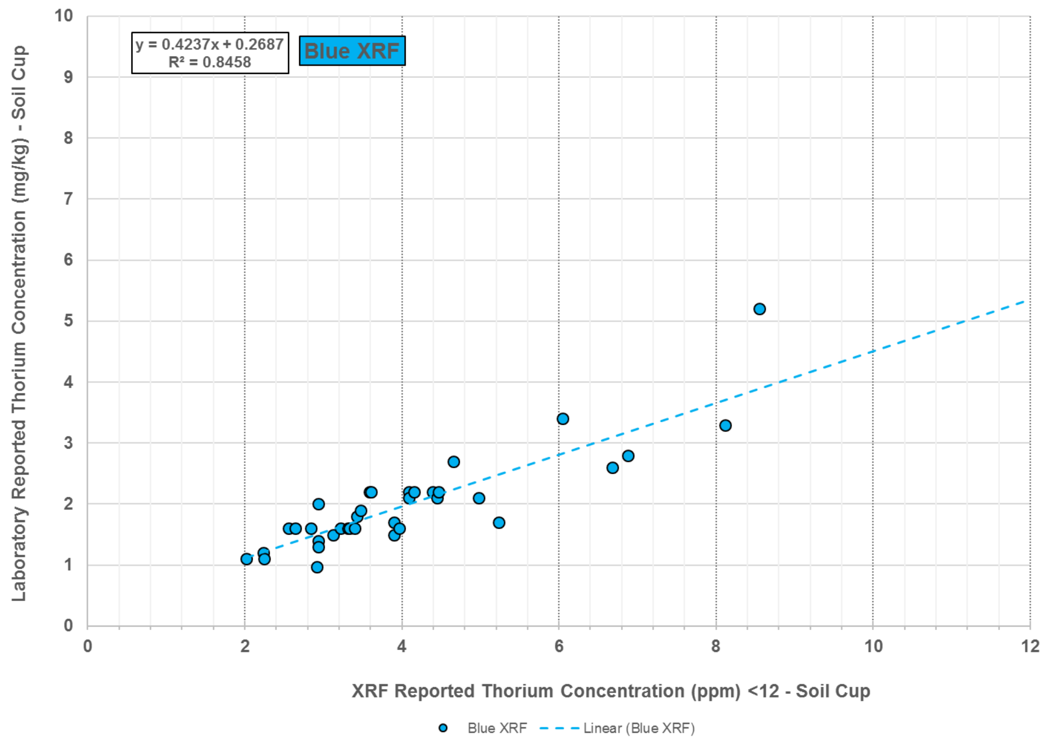


Figure B5-25. Soil Cup Regression Model (<12 ppm) for Thorium (Blue XRF)

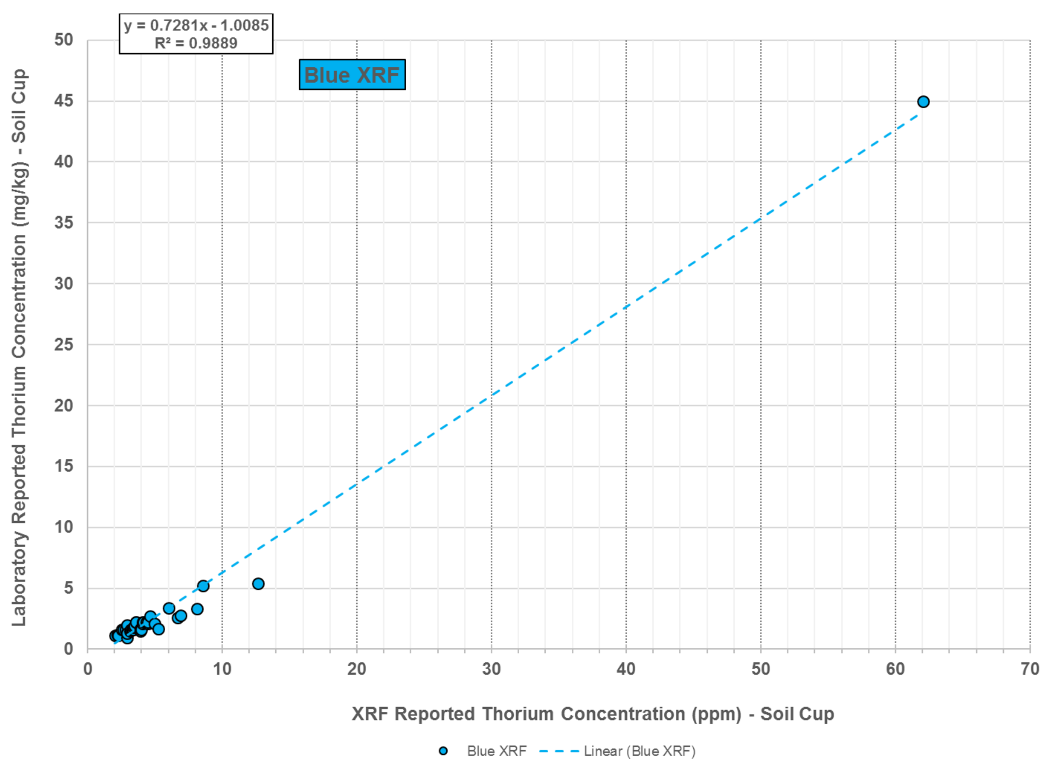


Figure B5-26. Soil Cup Regression Model (All Data) for Thorium (Blue XRF)

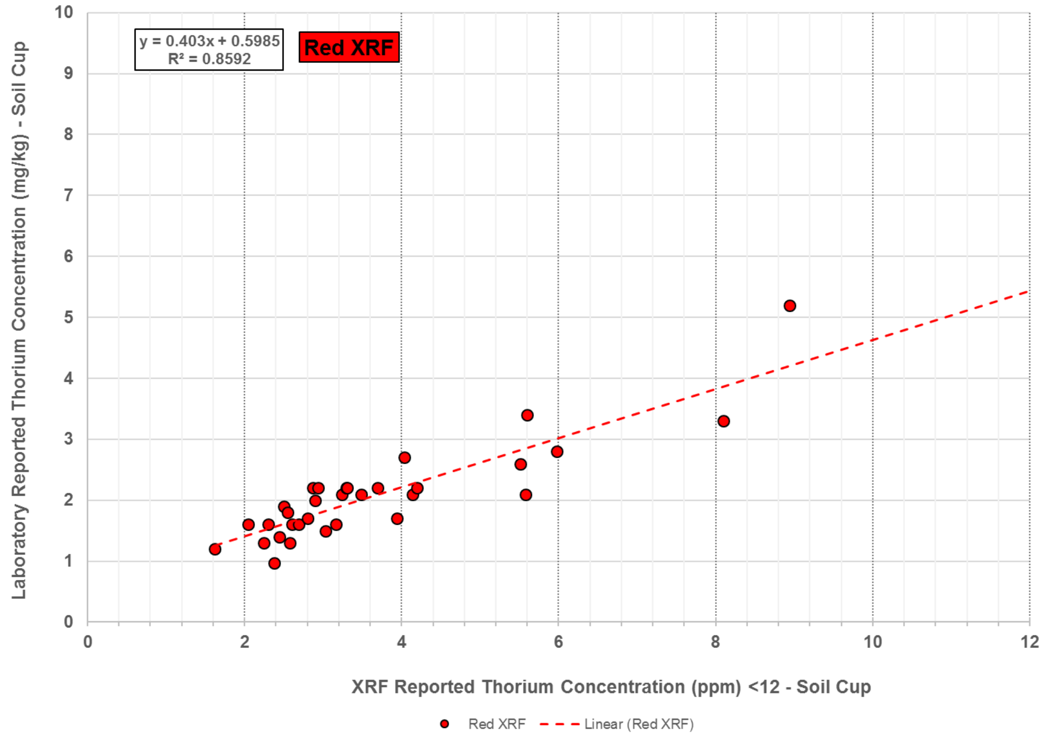


Figure B5-27. Soil Cup Regression Model (<12 ppm) for Thorium (Red XRF)

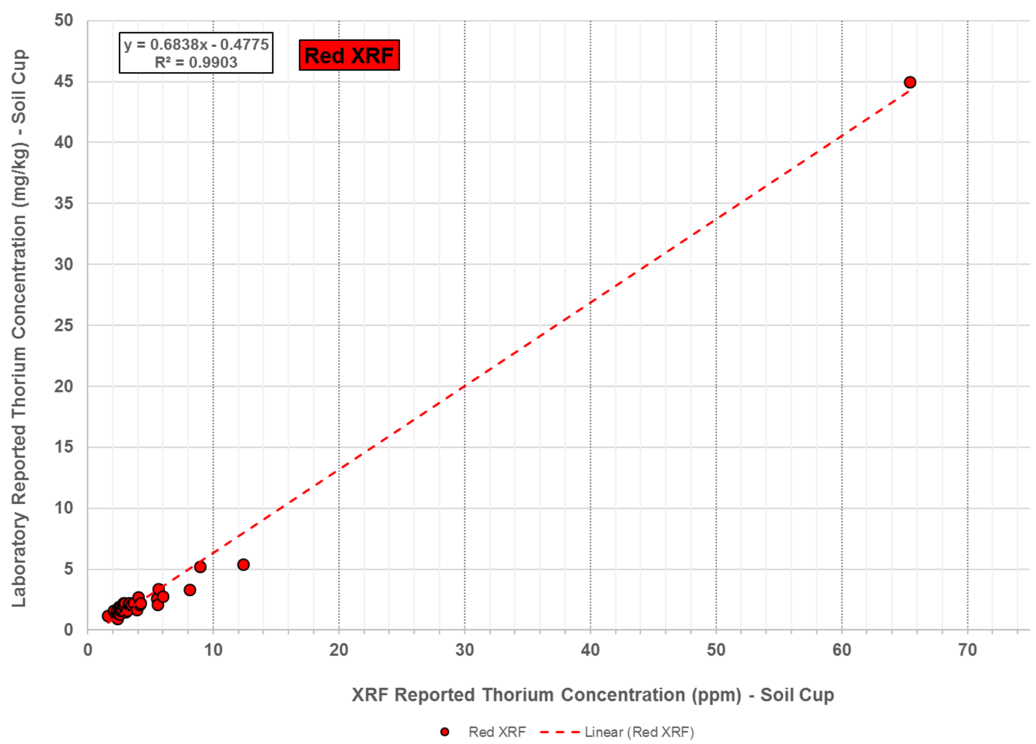


Figure B5-28. Soil Cup Regression Model (All Data) for Thorium (Red XRF)

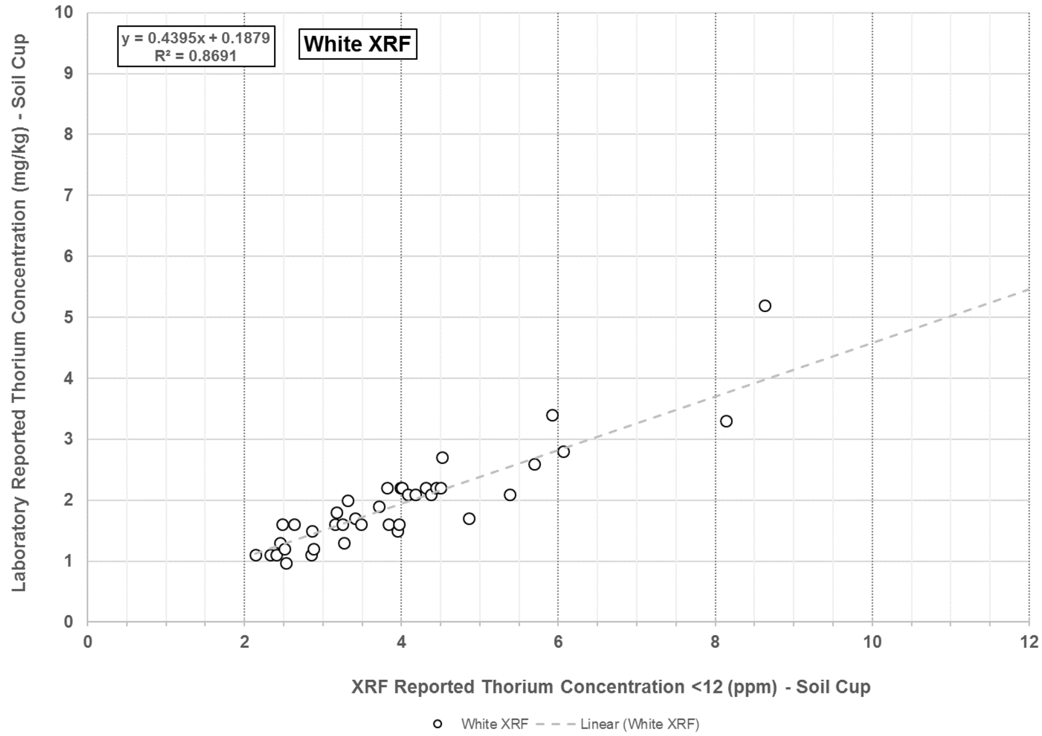


Figure B5-29. Soil Cup Regression Model (<12 ppm) for Thorium (White XRF)

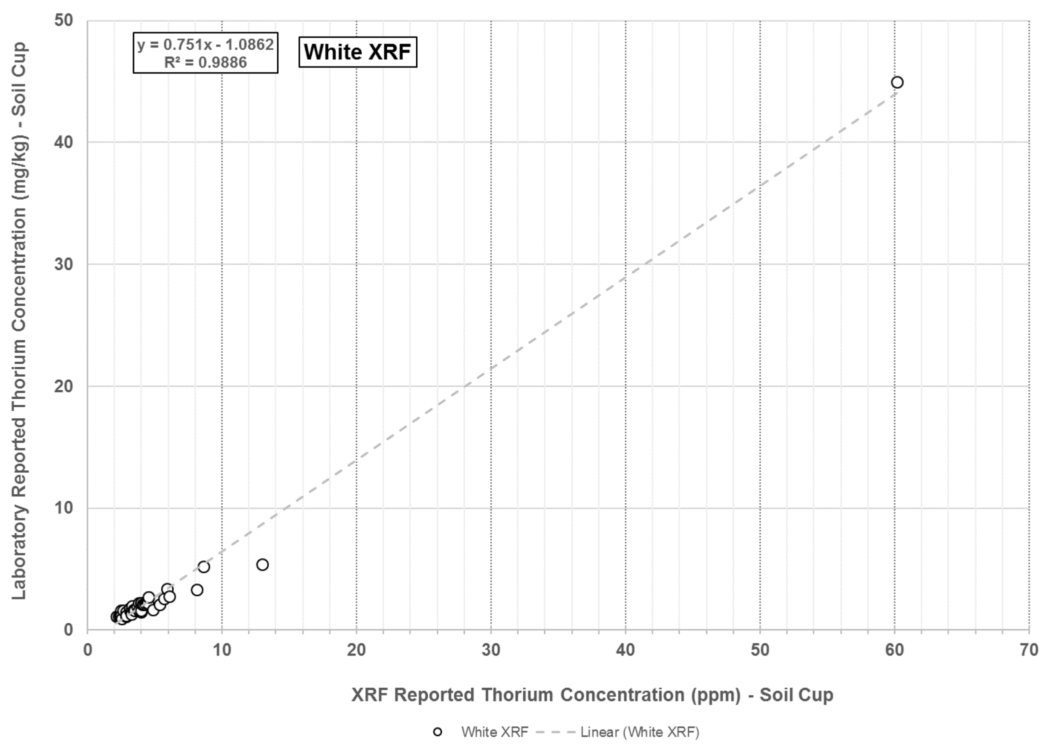
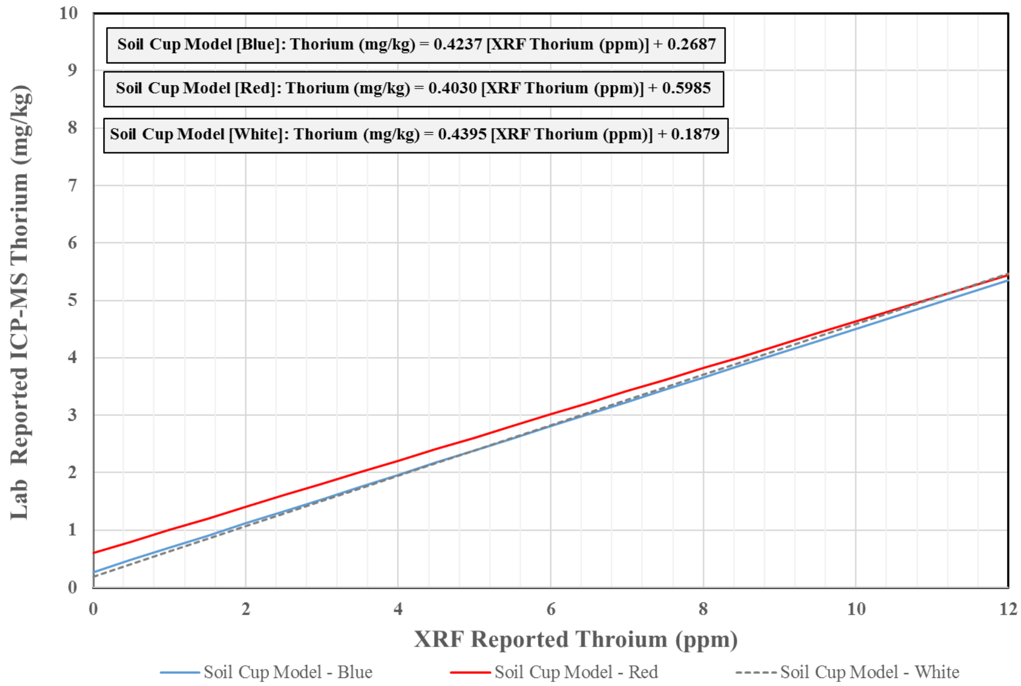


Figure B5-30. Soil Cup Regression Model (All Data) for Thorium (White XRF)



Note: UPL = Upper Prediction Limit; LPL = Lower Prediction Limit

Figure B5-31. Comparison of Soil Cup Regression Models (<12 ppm)

8.0 URANIUM SOIL CUP SAMPLE REGRESSION

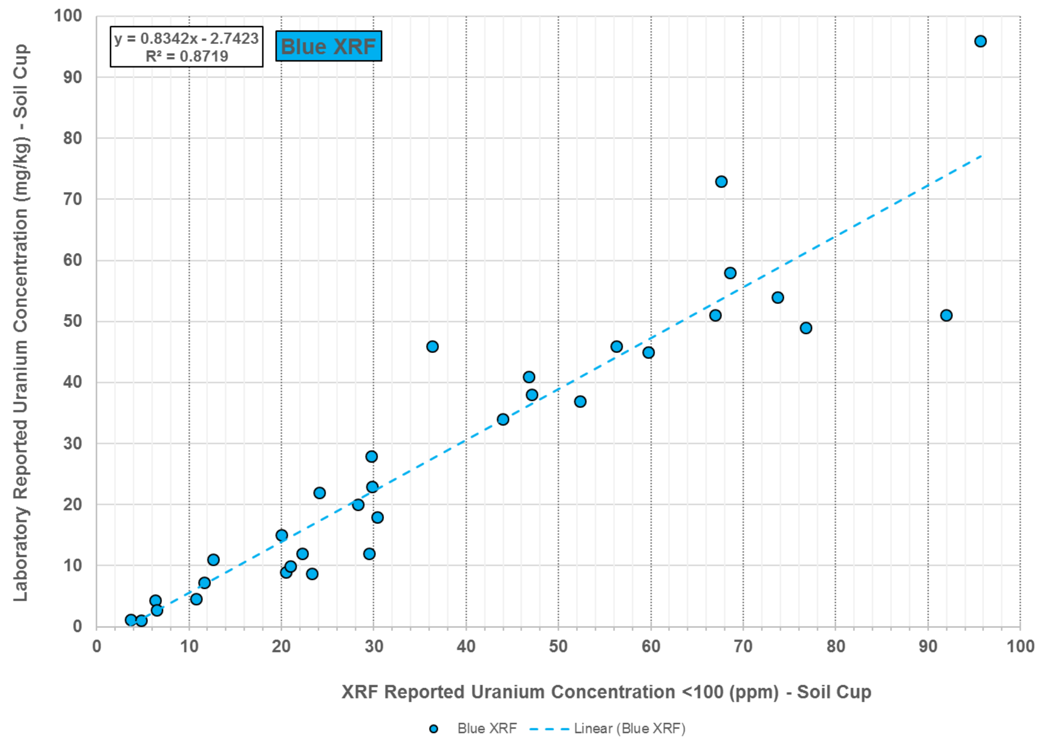


Figure B5-32. Soil Cup Regression Model (<100 ppm) for Uranium (Blue XRF)

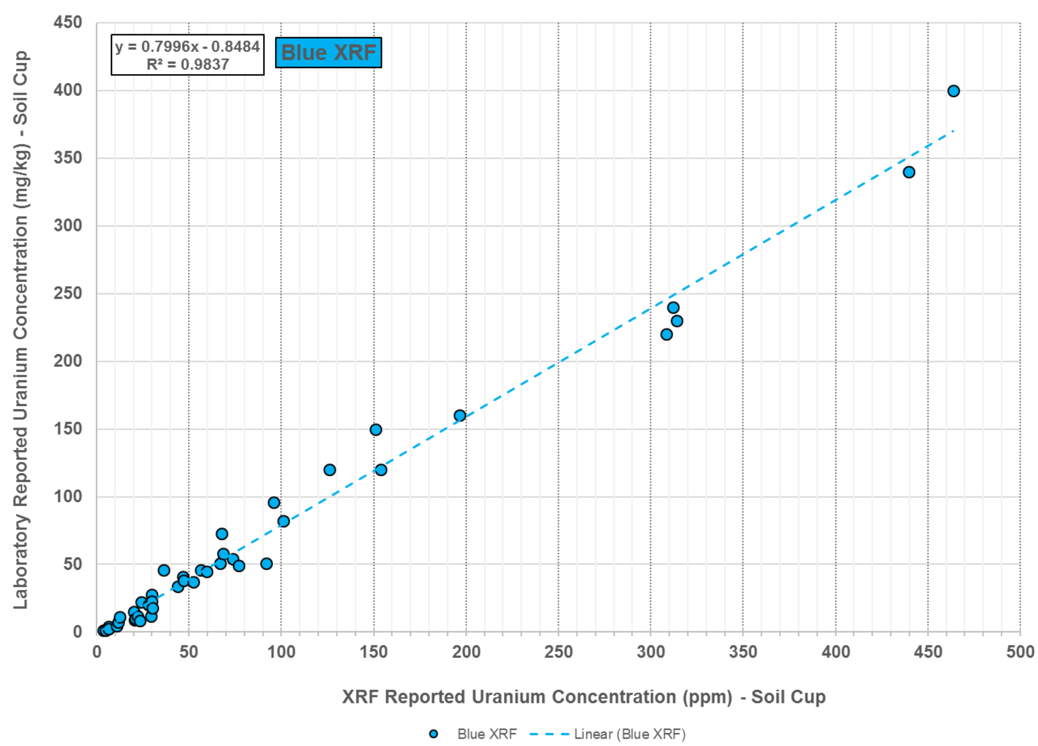


Figure B5-33. Soil Cup Regression Model (All Data) for Uranium (Blue XRF)

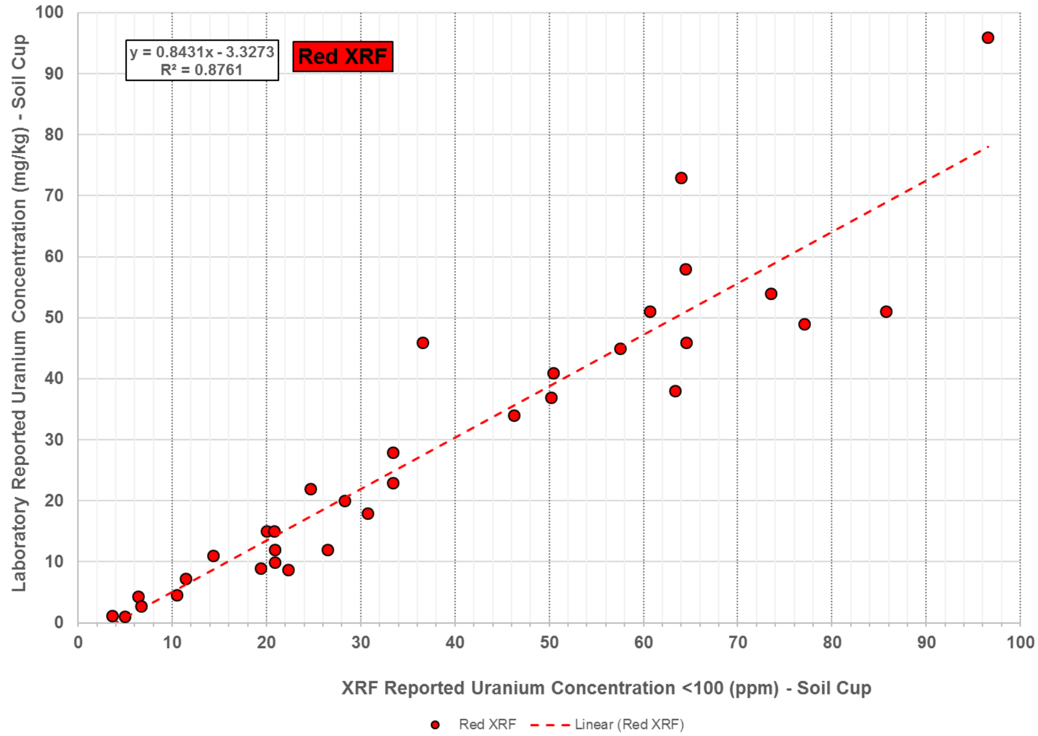


Figure B5-34. Soil Cup Regression Model (<100 ppm) for Uranium (Red XRF)

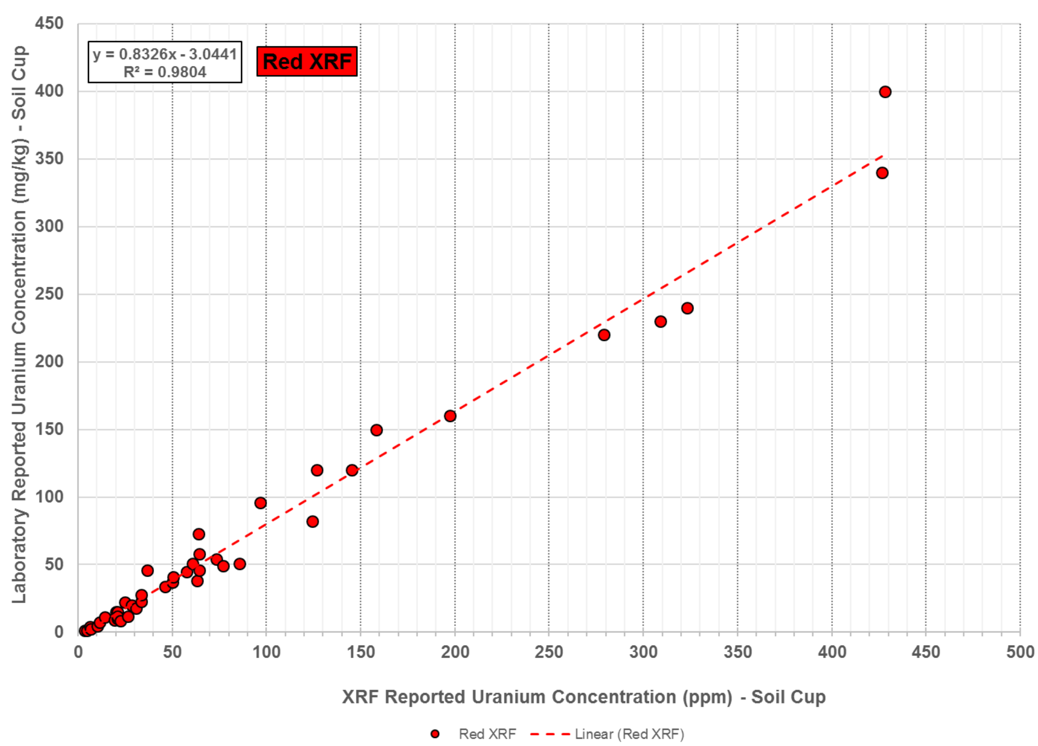


Figure B5-35. Soil Cup Regression Model (All Data) for Uranium (Red XRF)

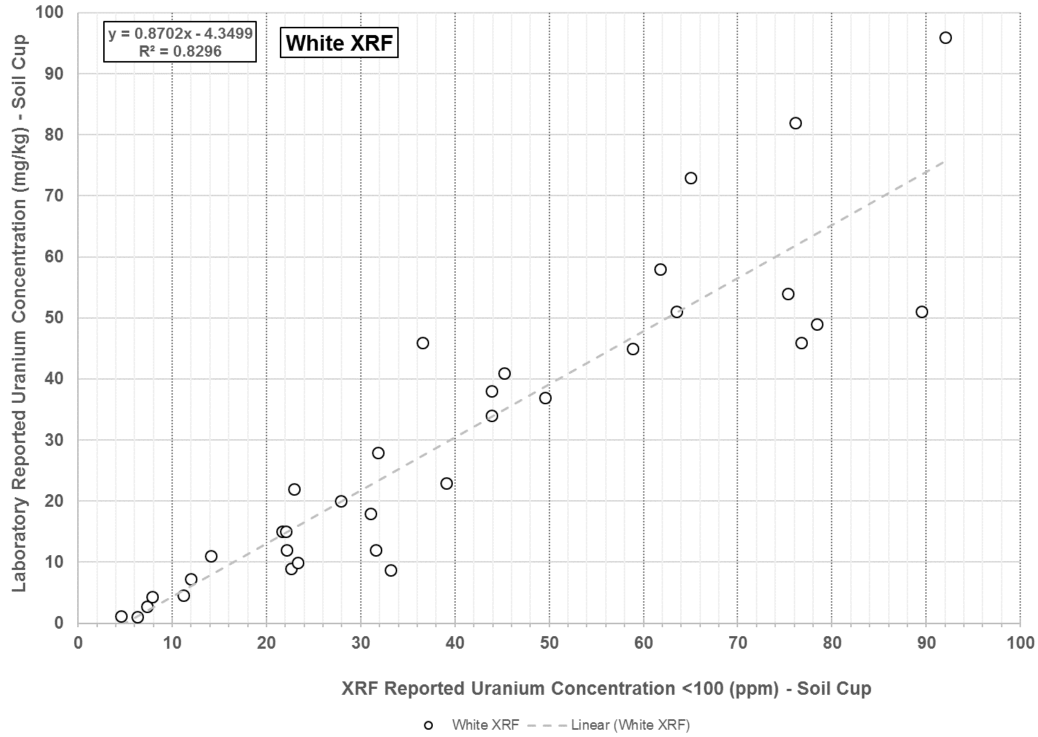


Figure B5-36. Soil Cup Regression Model (<100 ppm) for Uranium (White XRF)

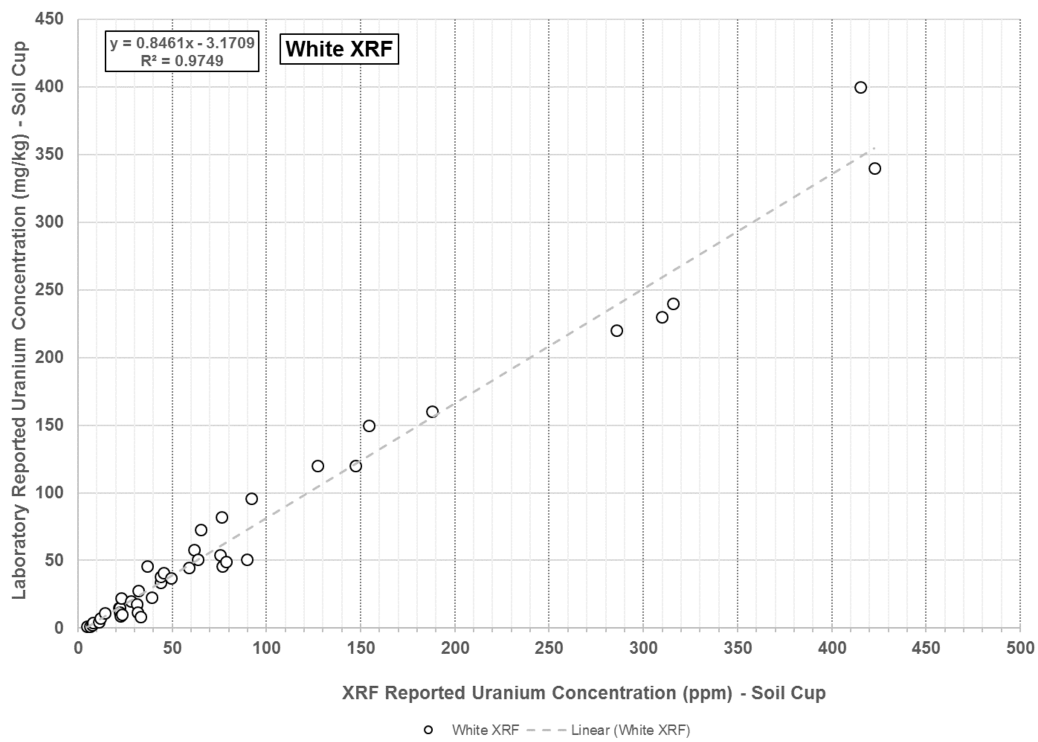


Figure B5-37. Soil Cup Regression Model (All Data) for Uranium (White XRF)

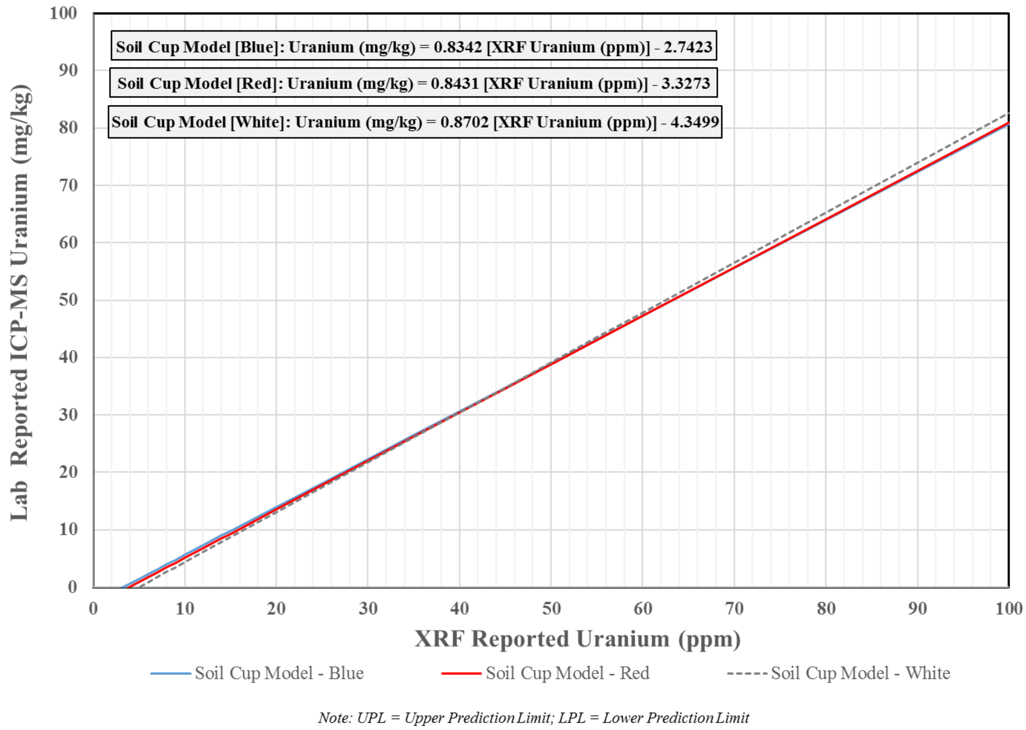


Figure B5-38. Comparison of Soil Cup Regression Models (<100 ppm)

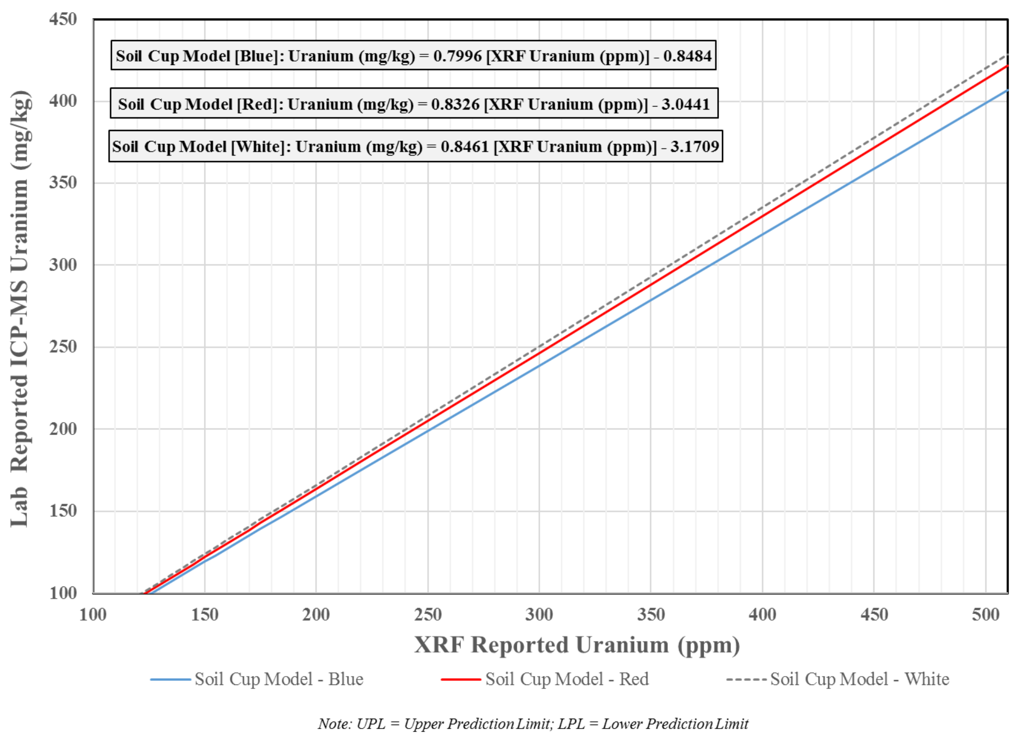


Figure B5-39. Comparison of Soil Cup Regression Models (All Data)

9.0 VANADIUM SOIL CUP SAMPLE REGRESSION

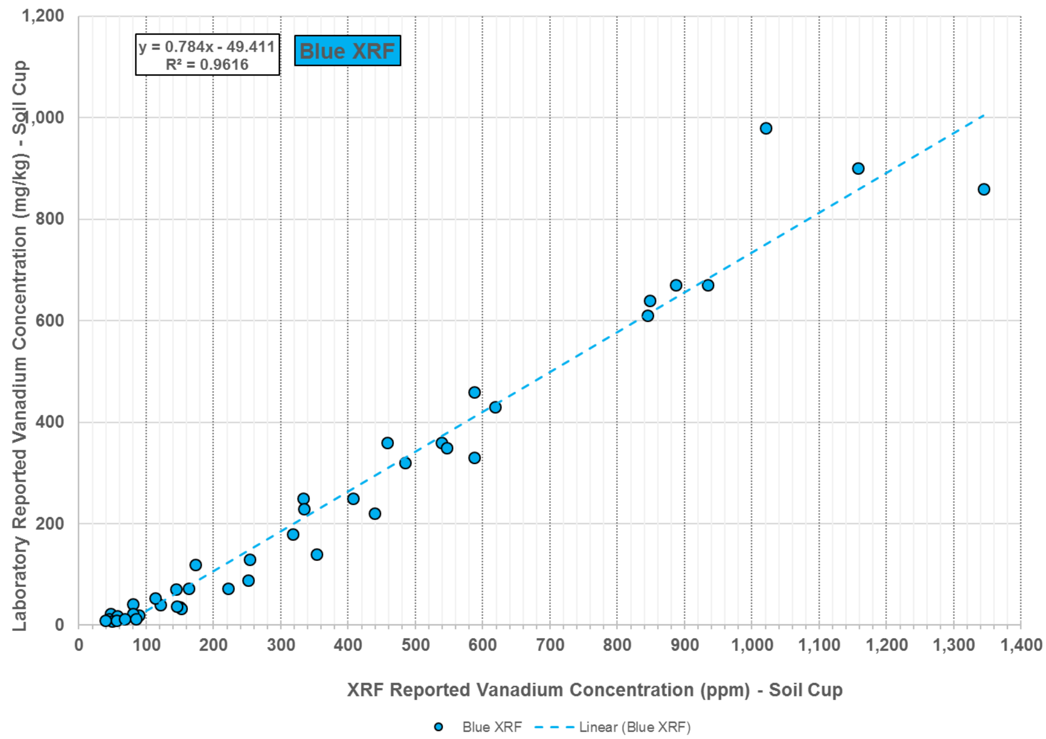


Figure B5-40. Soil Cup Regression Model for Vanadium (Blue XRF)

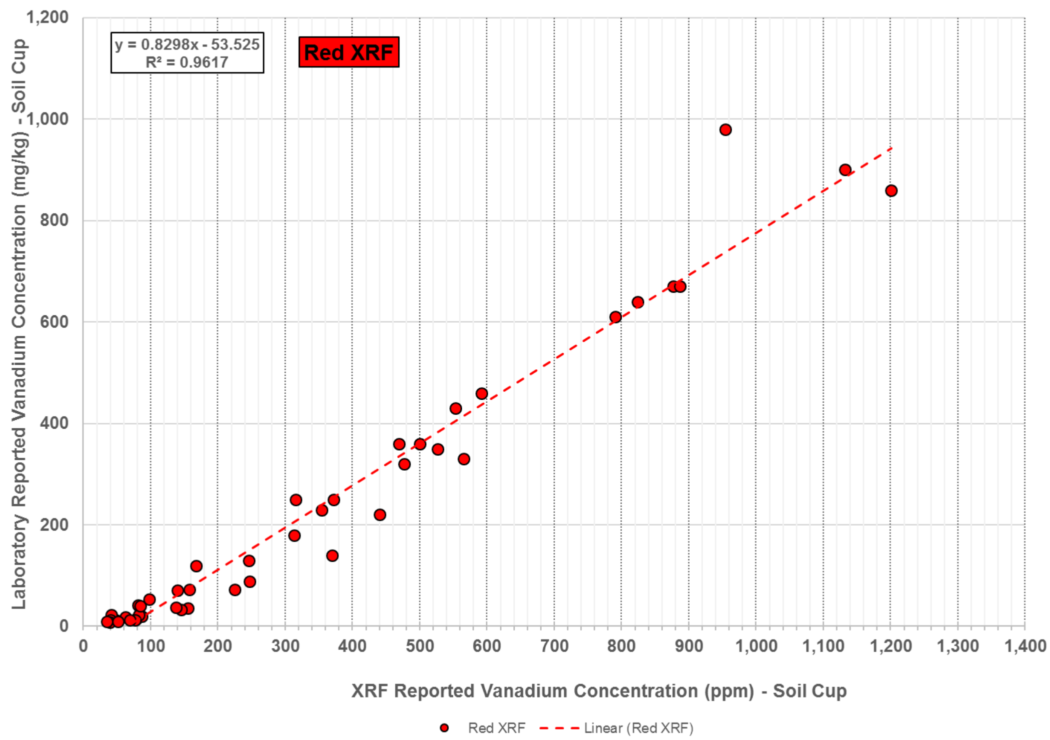


Figure B5-41. Soil Cup Regression Model for Vanadium (Red XRF)

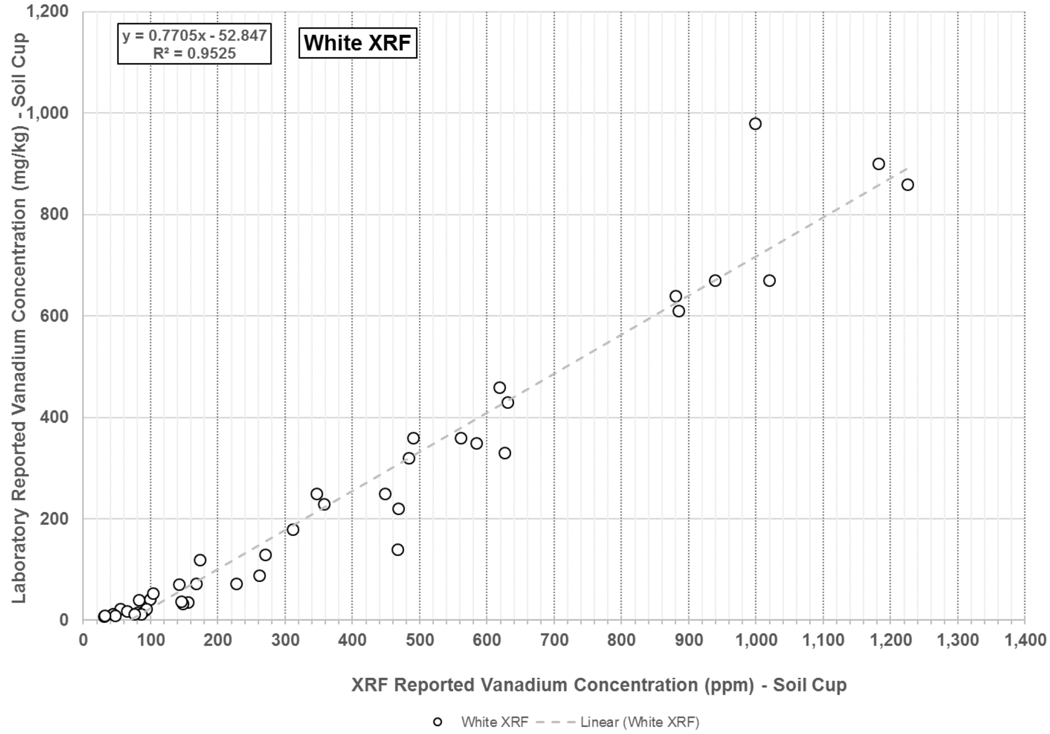
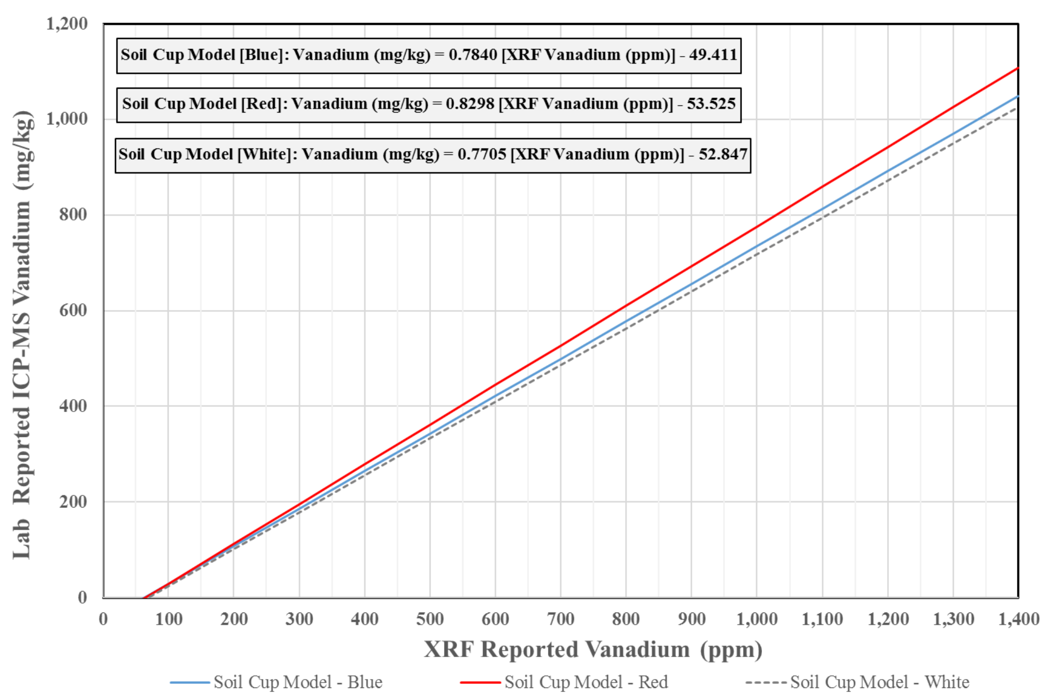


Figure B5-42. Soil Cup Regression Model for Vanadium (White XRF)



Note: UPL = Upper Prediction Limit; LPL = Lower Prediction Limit

Figure B5-43. Comparison of Soil Cup Regression Models

10.0 ZINC SOIL CUP SAMPLE REGRESSION

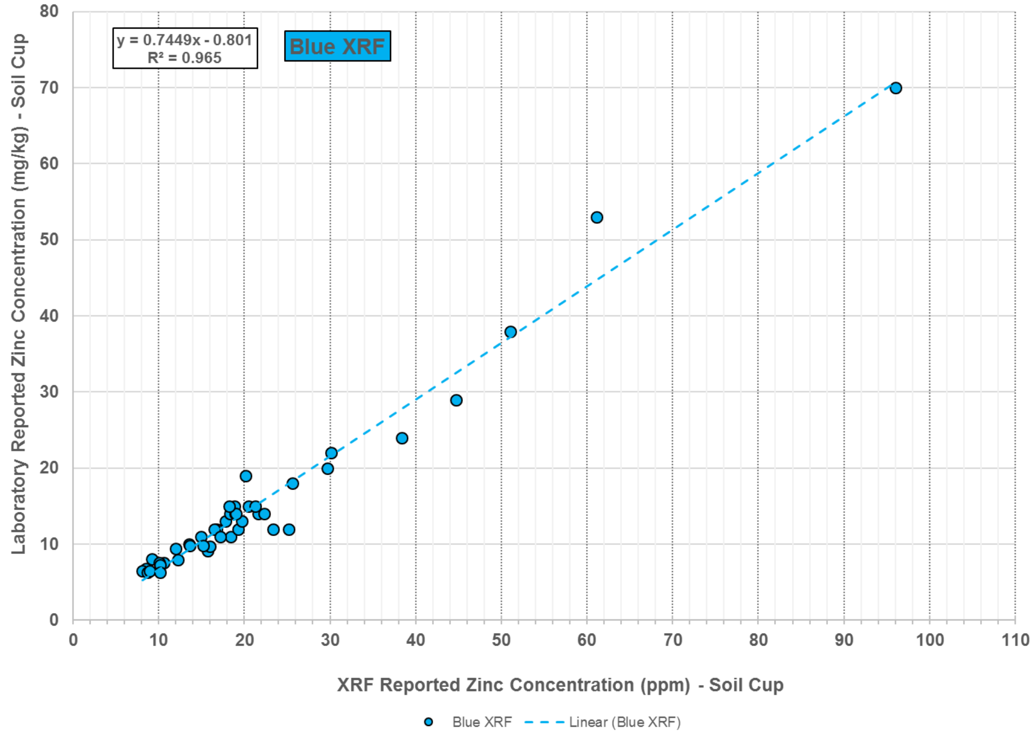


Figure B5-44. Soil Cup Regression Model for Zinc (Blue XRF)

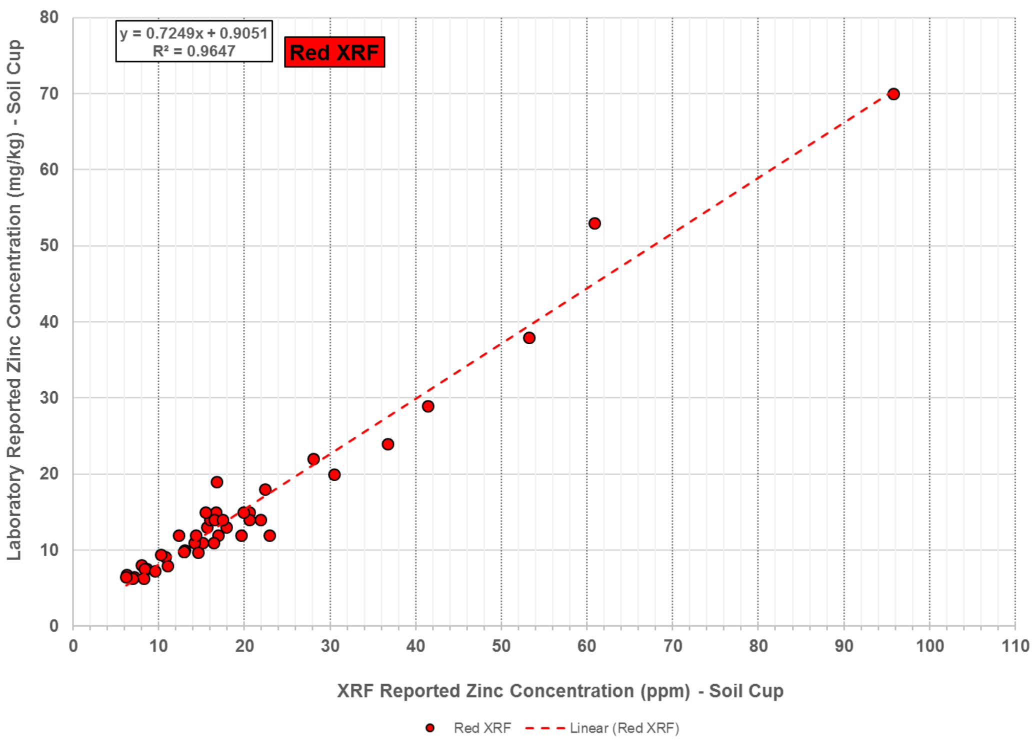


Figure B5-45. Soil Cup Regression Model for Zinc (Red XRF)

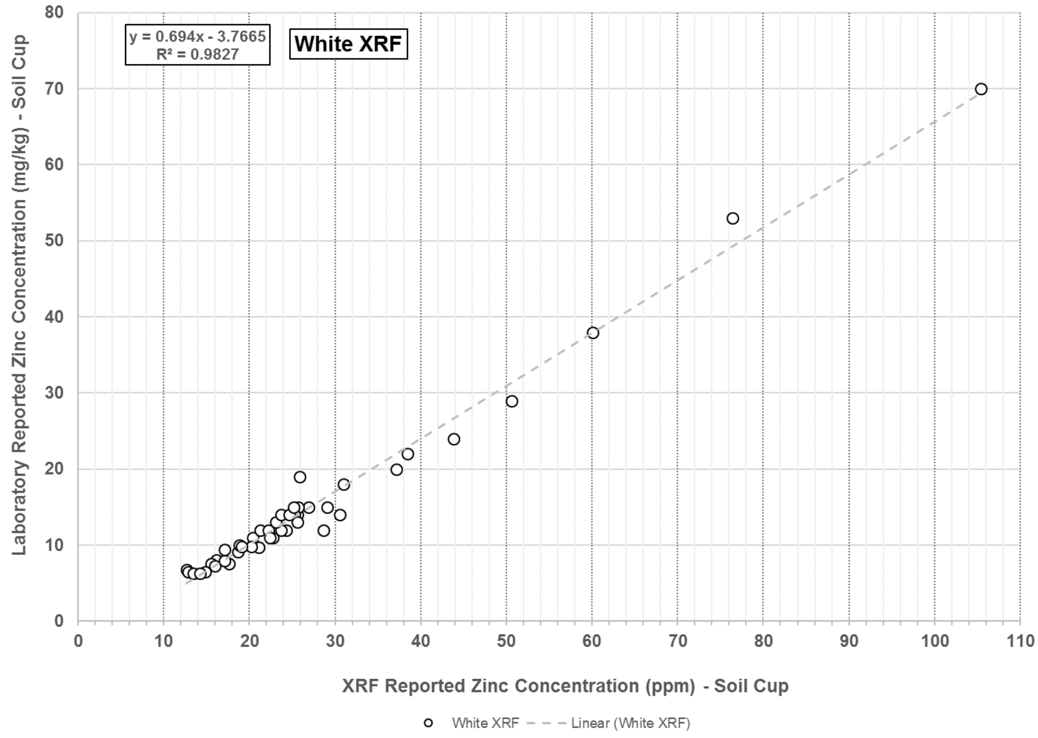
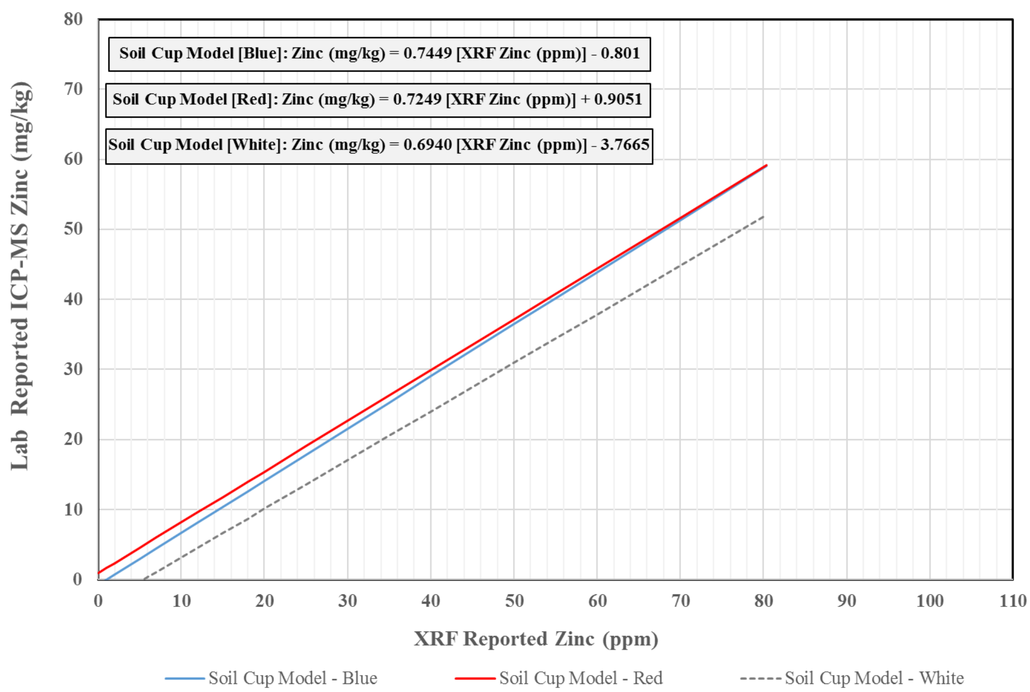


Figure B5-46. Soil Cup Regression Model for Zinc (White XRF)



Note: UPL = Upper Prediction Limit; LPL = Lower Prediction Limit

Figure B5-47. Comparison of Soil Cup Regression Models

ATTACHMENT B6

PROUCL OUTPUT FOR POPULATION TESTS

ARSENIC PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 3:14:39 PM
From File	T1 T6 Arsenic.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: XRF Corrected

Sample 2 Data: Lab Arsenic

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	131	131
Number of Distinct Observations	131	77
Minimum	1.151	1.5
Maximum	54.32	74
Mean	8.49	8.49
Median	4.796	4.9
SD	10.15	10.49
SE of Mean	0.887	0.917

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	260	0.000	-2.595	2.595	1.000
Welch-Satterthwaite (Unequal Varian	259.7	0.000	-2.595	2.595	1.000

Pooled SD: 10.322

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	103
Variance of Sample 2	110.1

Numerator DF	Denominator DF	F-Test Value	P-Value
130	130	1.069	0.704

Conclusion with Alpha = 0.01

Two variances appear to be equal

	A	B	C	D	E	F	G	H	I	J	K	L
1	t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.15/6/2019 4:40:22 PM								
5	From File			T1T6_Arsenic_Uncorrected.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			99%								
8	Substantial Difference (S)			0.000								
9	Selected Null Hypothesis			Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)								
10	Alternative Hypothesis			Sample 1 Mean <> Sample 2 Mean								
11												
12												
13	Sample 1 Data: C0											
14	Sample 2 Data: C1											
15												
16												
17	Raw Statistics											
18					Sample 1	Sample 2						
19	Number of Valid Observations				131	131						
20	Number of Missing Observations				3	3						
21	Number of Distinct Observations				131	77						
22	Minimum				1.634	1.5						
23	Maximum				52.73	74						
24	Mean				8.686	8.49						
25	Median				5.137	4.9						
26	SD				9.752	10.49						
27	SE of Mean				0.852	0.917						
28												
29	Sample 1 vs Sample 2 Two-Sample t-Test											
30												
31	H0: Mean of Sample 1 = Mean of Sample 2											
32					t-Test	Lower C.Val	Upper C.Val					
33	Method			DF	Value	t (0.005)	t (0.995)	P-Value				
34	Pooled (Equal Variance)			260	0.157	-2.595	2.595	0.876				
35	Welch-Satterthwaite (Unequal Varian			258.6	0.157	-2.595	2.595	0.876				
36	Pooled SD: 10.129											
37	Conclusion with Alpha = 0.010											
38	Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2											
39	Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2											
40												
41	Test of Equality of Variances											
42												
43	Variance of Sample 1				95.1							
44	Variance of Sample 2				110.1							
45												
46	Numerator DF		Denominator DF		F-Test Value		P-Value					
47	130		130		1.158		0.405					
48	Conclusion with Alpha = 0.01											
49	Two variances appear to be equal											
50												

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/6/2019 4:50:42 PM
From File	T7 T9 Arsenic.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: T7-T9 XRF Arsenic Corrected

Sample 2 Data: T7-T9 Arsenic Lab

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	86	86
Number of Distinct Observations	86	62
Minimum	1.511	1.4
Maximum	57.63	58
Mean	7.985	8.551
Median	4.159	4.85
SD	10.43	10.72
SE of Mean	1.125	1.156

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	170	-0.351	-2.605	2.605	0.726
Welch-Satterthwaite (Unequal Varian	169.9	-0.351	-2.605	2.605	0.726

Pooled SD: 10.577

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	108.9
Variance of Sample 2	114.9

Numerator DF	Denominator DF	F-Test Value	P-Value
85	85	1.056	0.803

Conclusion with Alpha = 0.01

Two variances appear to be equal

	A	B	C	D	E	F	G	H	I	J	K	L
1	t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.15/6/2019 4:49:51 PM								
5	From File			T7 T9 Arsenic.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			99%								
8	Substantial Difference (S)			0.000								
9	Selected Null Hypothesis			Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)								
10	Alternative Hypothesis			Sample 1 Mean <> Sample 2 Mean								
11												
12												
13	Sample 1 Data: T7-T9 XRF Arsenic UnCorrected											
14	Sample 2 Data: T7-T9 Arsenic Lab											
15												
16												
17	Raw Statistics											
18					Sample 1	Sample 2						
19	Number of Valid Observations				86	86						
20	Number of Distinct Observations				86	62						
21	Minimum				1.979	1.4						
22	Maximum				55.9	58						
23	Mean				8.201	8.551						
24	Median				4.524	4.85						
25	SD				10.03	10.72						
26	SE of Mean				1.081	1.156						
27												
28	Sample 1 vs Sample 2 Two-Sample t-Test											
29												
30	H0: Mean of Sample 1 = Mean of Sample 2											
31					t-Test	Lower C.Val	Upper C.Val					
32	Method			DF	Value	t (0.005)	t (0.995)	P-Value				
33	Pooled (Equal Variance)			170	-0.221	-2.605	2.605	0.825				
34	Welch-Satterthwaite (Unequal Varian			169.2	-0.221	-2.605	2.605	0.825				
35	Pooled SD: 10.378											
36	Conclusion with Alpha = 0.010											
37	Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2											
38	Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2											
39												
40	Test of Equality of Variances											
41												
42	Variance of Sample 1				100.5							
43	Variance of Sample 2				114.9							
44												
45	Numerator DF		Denominator DF		F-Test Value		P-Value					
46	85		85		1.143		0.538					
47	Conclusion with Alpha = 0.01											
48	Two variances appear to be equal											
49												

IRON PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 8:27:13 AM
From File	T1 T6 Iron.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: XRF Iron Corrected

Sample 2 Data: Lab Iron

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	256	256
Number of Distinct Observations	256	73
Minimum	1754	1700
Maximum	20975	24000
Mean	5929	5929
Median	5299	5300
SD	2776	3059
SE of Mean	173.5	191.2

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	510	-0.002	-2.586	2.586	0.999
Welch-Satterthwaite (Unequal Varian	505.3	-0.002	-2.586	2.586	0.999

Pooled SD: 2921.340

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	7708336
Variance of Sample 2	9360119

Numerator DF	Denominator DF	F-Test Value	P-Value
255	255	1.214	0.122

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 8:25:39 AM
From File	T1 T6 Iron.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: XRF Iron Uncorrected

Sample 2 Data: Lab Iron

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	256	256
Number of Distinct Observations	256	73
Minimum	2839	1700
Maximum	39954	24000
Mean	10901	5929
Median	9684	5300
SD	5361	3059
SE of Mean	335.1	191.2

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	510	12.887	-2.586	2.586	0.000
Welch-Satterthwaite (Unequal Varian	405.2	12.887	-2.588	2.588	0.000

Pooled SD: 4364.569

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	28738812
Variance of Sample 2	9360119

Numerator DF	Denominator DF	F-Test Value	P-Value
255	255	3.070	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 11:37:32 AM
From File	T7 T9 Iron.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Iron Corrected

Sample 2 Data: Iron Lab Result

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	269	269
Number of Distinct Observations	269	76
Minimum	1939	1700
Maximum	17468	16000
Mean	5356	5609
Median	5012	5200
SD	1995	2107
SE of Mean	121.6	128.4

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	536	-1.434	-2.585	2.585	0.152
Welch-Satterthwaite (Unequal Varian	534.4	-1.434	-2.585	2.585	0.152

Pooled SD: 2051.538

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	3979307
Variance of Sample 2	4438309

Numerator DF	Denominator DF	F-Test Value	P-Value
268	268	1.115	0.372

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 1:54:12 PM
From File	T7 T9 Iron.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Iron Uncorrected

Sample 2 Data: Iron Lab Result

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	269	269
Number of Distinct Observations	269	76
Minimum	3197	1700
Maximum	33181	16000
Mean	9794	5609
Median	9130	5200
SD	3852	2107
SE of Mean	234.8	128.4

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	536	15.633	-2.585	2.585	0.000
Welch-Satterthwaite (Unequal Varian	415.2	15.633	-2.588	2.588	0.000

Pooled SD: 3104.373

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	14835958
Variance of Sample 2	4438309

Numerator DF	Denominator DF	F-Test Value	P-Value
268	268	3.343	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

LEAD PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 10:49:22 AM
From File	T1 T6 lead.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Lead XRF Corrected

Sample 2 Data: Lab Lead

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	597657	255
Number of Missing Observations	2343	0
Number of Distinct Observations	255	83
Minimum	1.117	1.9
Maximum	118.2	120
Mean	7.26	7.267
Median	6.268	5.9
SD	7.742	8.049
SE of Mean	0.01	0.504

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	597910	-0.015	-2.576	2.576	0.988
Welch-Satterthwaite (Unequal Varian	254.2	-0.014	-2.595	2.595	0.989

Pooled SD: 7.742

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	59.93
Variance of Sample 2	64.79

Numerator DF	Denominator DF	F-Test Value	P-Value
254	597656	1.081	0.358

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 8:57:06 AM
From File	T1 T6 lead.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Lead XRF Uncorreced

Sample 2 Data: Lab Lead

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	255	255
Number of Distinct Observations	255	83
Minimum	2.724	1.9
Maximum	118.8	120
Mean	9.151	7.267
Median	8.135	5.9
SD	7.761	8.049
SE of Mean	0.486	0.504

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	508	2.690	-2.586	2.586	0.007
Welch-Satterthwaite (Unequal Varian	507.3	2.690	-2.586	2.586	0.007

Pooled SD: 7.906

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	60.23
Variance of Sample 2	64.79

Numerator DF	Denominator DF	F-Test Value	P-Value
254	254	1.076	0.561

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 2:08:52 PM
From File	T7 T9 Lead.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Lead (T7-T9)

Sample 2 Data: Lab Reported Lead (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	266	266
Number of Distinct Observations	266	75
Minimum	1.731	1.7
Maximum	19.32	22
Mean	6.496	6.197
Median	6.179	5.7
SD	2.49	2.804
SE of Mean	0.153	0.172

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	530	1.301	-2.585	2.585	0.194
Welch-Satterthwaite (Unequal Varian	522.7	1.301	-2.585	2.585	0.194

Pooled SD: 2.652

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	6.201
Variance of Sample 2	7.862

Numerator DF	Denominator DF	F-Test Value	P-Value
265	265	1.268	0.054

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 2:07:04 PM
From File	T7 T9 Lead.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Lead (T7-T9)

Sample 2 Data: Lab Reported Lead (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	266	266
Number of Distinct Observations	266	75
Minimum	3.681	1.7
Maximum	21.06	22
Mean	8.389	6.197
Median	8.076	5.7
SD	2.461	2.804
SE of Mean	0.151	0.172

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	530	9.584	-2.585	2.585	0.000
Welch-Satterthwaite (Unequal Varian	521.2	9.584	-2.585	2.585	0.000

Pooled SD: 2.638

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	6.054
Variance of Sample 2	7.862

Numerator DF	Denominator DF	F-Test Value	P-Value
265	265	1.299	0.034

Conclusion with Alpha = 0.01

Two variances appear to be equal

MANGANESE PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 10:13:48 AM
From File	T1 T6 Manganese.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Manganese (T1-T6)

Sample 2 Data: Lab Manganese

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	251	251
Number of Distinct Observations	251	48
Minimum	90.2	63
Maximum	466.8	540
Mean	197.8	197.8
Median	179.9	180
SD	74.88	86.84
SE of Mean	4.726	5.481

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.005)	Upper C.Val t (0.995)	P-Value
Pooled (Equal Variance)	500	0.000	-2.586	2.586	1.000
Welch-Satterthwaite (Unequal Varian	489.4	0.000	-2.586	2.586	1.000

Pooled SD: 81.080

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	5607
Variance of Sample 2	7541

Numerator DF	Denominator DF	F-Test Value	P-Value
250	250	1.345	0.020

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 10:11:12 AM
From File	T1 T6 Manganese.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Manganese (T1-T6)

Sample 2 Data: Lab Manganese

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	251	251
Number of Distinct Observations	251	48
Minimum	31.33	63
Maximum	454	540
Mean	152.1	197.8
Median	132	180
SD	84.02	86.84
SE of Mean	5.303	5.481

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	500	-5.996	-2.586	2.586	0.000
Welch-Satterthwaite (Unequal Varian	499.5	-5.996	-2.586	2.586	0.000

Pooled SD: 85.442

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	7060
Variance of Sample 2	7541

Numerator DF	Denominator DF	F-Test Value	P-Value
250	250	1.068	0.603

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 1:38:48 PM
From File	T7 T9 Manganese.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Manganese (T7-T9)

Sample 2 Data: Lab Reported Manganese (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	257	257
Number of Distinct Observations	257	48
Minimum	100.6	70
Maximum	1012	1500
Mean	207.1	201.5
Median	191.7	180
SD	79.57	111.7
SE of Mean	4.963	6.967

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.005)	Upper C.Val t (0.995)	P-Value
Pooled (Equal Variance)	512	0.656	-2.585	2.585	0.512
Welch-Satterthwaite (Unequal Varian	462.6	0.656	-2.586	2.586	0.512

Pooled SD: 96.969

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	6331
Variance of Sample 2	12474

Numerator DF	Denominator DF	F-Test Value	P-Value
256	256	1.970	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 1:33:59 PM
From File	T7 T9 Manganese.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Manganese (T7-T9)

Sample 2 Data: Lab Reported Manganese (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	257	257
Number of Distinct Observations	257	48
Minimum	43.04	70
Maximum	1066	1500
Mean	162.5	201.5
Median	145.2	180
SD	89.28	111.7
SE of Mean	5.569	6.967

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	512	-4.370	-2.585	2.585	0.000
Welch-Satterthwaite (Unequal Varian	488.3	-4.370	-2.586	2.586	0.000

Pooled SD: 101.109

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	7972
Variance of Sample 2	12474

Numerator DF	Denominator DF	F-Test Value	P-Value
256	256	1.565	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

MOLYBDENUM PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 11:11:03 AM
From File	T1 T6 Molybdenum.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF

Sample 2 Data: Lab Molybdenum_negatives removed

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	116	116
Number of Missing Observations	30	30
Number of Distinct Observations	116	79
Minimum	0.0161	0.04
Maximum	58.77	60
Mean	2.371	2.272
Median	0.57	0.47
SD	6.109	6.19
SE of Mean	0.567	0.575

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	230	0.122	-2.597	2.597	0.903
Welch-Satterthwaite (Unequal Varian	230.0	0.122	-2.597	2.597	0.903

Pooled SD: 6.149

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	37.32
Variance of Sample 2	38.31

Numerator DF	Denominator DF	F-Test Value	P-Value
115	115	1.027	0.888

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 10:07:10 AM
From File	T1 T6 Molybdenum.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF

Sample 2 Data: Lab Molybdenum

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	146	146
Number of Distinct Observations	146	86
Minimum	1.625	0.04
Maximum	75.91	60
Mean	4.432	1.847
Median	2.589	0.3
SD	6.953	5.576
SE of Mean	0.575	0.461

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	290	3.505	-2.593	2.593	0.001
Welch-Satterthwaite (Unequal Varian	276.9	3.505	-2.594	2.594	0.001

Pooled SD: 6.302

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	48.35
Variance of Sample 2	31.09

Numerator DF	Denominator DF	F-Test Value	P-Value
145	145	1.555	0.008

Conclusion with Alpha = 0.01

Two variances are not equal

	A	B	C	D	E	F	G	H	I	J	K	L
1	t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.15/7/2019 2:25:16 PM								
5	From File			T7 T9 Molybdenum.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			99%								
8	Substantial Difference (S)			0.000								
9	Selected Null Hypothesis			Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)								
10	Alternative Hypothesis			Sample 1 Mean <> Sample 2 Mean								
11												
12												
13	Sample 1 Data: Corrected XRF Molybdenum (T7-T9)											
14	Sample 2 Data: Lab Reported Molybdenum (T7-T9)											
15												
16												
17	Raw Statistics											
18					Sample 1	Sample 2						
19	Number of Valid Observations				28	28						
20	Number of Distinct Observations				28	24						
21	Minimum				-0.238	0.051						
22	Maximum				56.13	50						
23	Mean				38.74	4.782						
24	Median				51.53	0.36						
25	SD				22.34	12.38						
26	SE of Mean				4.222	2.339						
27												
28	Sample 1 vs Sample 2 Two-Sample t-Test											
29												
30	H0: Mean of Sample 1 = Mean of Sample 2											
31					t-Test	Lower C.Val	Upper C.Val					
32	Method			DF	Value	t (0.005)	t (0.995)	P-Value				
33	Pooled (Equal Variance)			54	7.036	-2.670	2.670	0.000				
34	Welch-Satterthwaite (Unequal Varian			42.1	7.036	-2.698	2.698	0.000				
35	Pooled SD: 18.059											
36	Conclusion with Alpha = 0.010											
37	Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2											
38	Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2											
39												
40	Test of Equality of Variances											
41												
42	Variance of Sample 1				499.1							
43	Variance of Sample 2				153.2							
44												
45	Numerator DF		Denominator DF		F-Test Value		P-Value					
46	27		27		3.257		0.003					
47	Conclusion with Alpha = 0.01											
48	Two variances are not equal											
49												

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 2:23:21 PM
From File	T7 T9 Molybdenum.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Molybdenum (T7-T9)

Sample 2 Data: Lab Reported Molybdenum (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	28	28
Number of Distinct Observations	28	24
Minimum	1.815	0.051
Maximum	72.59	50
Mean	50.76	4.782
Median	66.81	0.36
SD	28.05	12.38
SE of Mean	5.301	2.339

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.005)	Upper C.Val t (0.995)	P-Value
Pooled (Equal Variance)	54	7.935	-2.670	2.670	0.000
Welch-Satterthwaite (Unequal Varian	37.1	7.935	-2.715	2.715	0.000

Pooled SD: 21.680

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	786.8
Variance of Sample 2	153.2

Numerator DF	Denominator DF	F-Test Value	P-Value
27	27	5.136	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

THORIUM PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 9:54:18 AM
From File	T1 T6 Thorium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Thorium (T1-T6)

Sample 2 Data: Lab Thorium

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	256	256
Number of Distinct Observations	255	43
Minimum	0.989	1
Maximum	37.37	38
Mean	2.645	2.654
Median	2.239	2.3
SD	3.151	3.286
SE of Mean	0.197	0.205

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	510	-0.030	-2.586	2.586	0.976
Welch-Satterthwaite (Unequal Varian	509.1	-0.030	-2.586	2.586	0.976

Pooled SD: 3.219

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	9.928
Variance of Sample 2	10.8

Numerator DF	Denominator DF	F-Test Value	P-Value
255	255	1.088	0.502

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 9:51:51 AM
From File	T1 T6 Thorium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Thorium (T1-T6)

Sample 2 Data: Lab Thorium

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	256	256
Number of Distinct Observations	255	43
Minimum	1.97	1
Maximum	54.94	38
Mean	5.03	2.654
Median	4.379	2.3
SD	4.646	3.286
SE of Mean	0.29	0.205

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.005)	Upper C.Val t (0.995)	P-Value
Pooled (Equal Variance)	510	6.681	-2.586	2.586	0.000
Welch-Satterthwaite (Unequal Varian	459.1	6.681	-2.587	2.587	0.000

Pooled SD: 4.024

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	21.59
Variance of Sample 2	10.8

Numerator DF	Denominator DF	F-Test Value	P-Value
255	255	1.999	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 12:50:30 PM
From File	T7 T9 Thorium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Thorium (T7-T9)

Sample 2 Data: Lab Reported Thorium (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	248	248
Number of Distinct Observations	248	41
Minimum	0.842	1.3
Maximum	8.052	7.6
Mean	2.42	2.595
Median	2.151	2.35
SD	1.107	0.997
SE of Mean	0.0703	0.0633

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	494	-1.845	-2.586	2.586	0.066
Welch-Satterthwaite (Unequal Varian	488.7	-1.845	-2.586	2.586	0.066

Pooled SD: 1.053

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	1.225
Variance of Sample 2	0.993

Numerator DF	Denominator DF	F-Test Value	P-Value
247	247	1.233	0.100

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 12:48:12 PM
From File	T7 T9 Thorium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Thorium (T7-T9)

Sample 2 Data: Lab Reported Thorium (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	248	248
Number of Distinct Observations	248	41
Minimum	1.687	1.3
Maximum	15.58	7.6
Mean	4.728	2.595
Median	4.209	2.35
SD	2.133	0.997
SE of Mean	0.135	0.0633

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	494	14.271	-2.586	2.586	0.000
Welch-Satterthwaite (Unequal Varian	350.0	14.271	-2.590	2.590	0.000

Pooled SD: 1.665

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	4.55
Variance of Sample 2	0.993

Numerator DF	Denominator DF	F-Test Value	P-Value
247	247	4.580	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

URANIUM PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 9:21:33 AM
From File	T1 T6 Uranium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Uranium (T1-T6)

Sample 2 Data: Lab Uranium

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	207	207
Number of Distinct Observations	207	121
Minimum	0.135	0.46
Maximum	390.7	370
Mean	30.72	31.99
Median	10.27	9.5
SD	61.37	63.37
SE of Mean	4.265	4.405

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	412	-0.206	-2.588	2.588	0.837
Welch-Satterthwaite (Unequal Varian	411.6	-0.206	-2.588	2.588	0.837

Pooled SD: 62.379

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	3766
Variance of Sample 2	4016

Numerator DF	Denominator DF	F-Test Value	P-Value
206	206	1.067	0.644

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 9:16:11 AM
From File	T1 T6 Uranium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Uranium (T1-T6)
Sample 2 Data: Lab Uranium

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	207	207
Number of Distinct Observations	207	121
Minimum	2.989	0.46
Maximum	509.1	370
Mean	41.8	31.99
Median	15.61	9.5
SD	79.17	63.37
SE of Mean	5.502	4.405

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	412	1.392	-2.588	2.588	0.165
Welch-Satterthwaite (Unequal Varian	393.2	1.392	-2.588	2.588	0.165

Pooled SD: 71.707

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	6267
Variance of Sample 2	4016

Numerator DF	Denominator DF	F-Test Value	P-Value
206	206	1.560	0.001

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 12:10:40 PM
From File	T7 T9 Uranium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Uranium (T7-T9)

Sample 2 Data: Lab Reported Uranium (T7-T9)_negatives removed

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	219	219
Number of Missing Observations	7	7
Number of Distinct Observations	219	124
Minimum	0.169	0.49
Maximum	639.7	660
Mean	24.82	23.75
Median	7.112	4
SD	60.29	63.15
SE of Mean	4.074	4.267

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	436	0.182	-2.587	2.587	0.856
Welch-Satterthwaite (Unequal Varian	435.1	0.182	-2.587	2.587	0.856

Pooled SD: 61.737

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	3635
Variance of Sample 2	3988

Numerator DF	Denominator DF	F-Test Value	P-Value
218	218	1.097	0.495

Conclusion with Alpha = 0.01

Two variances appear to be equal

	A	B	C	D	E	F	G	H	I	J	K	L
1	t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.15/7/2019 12:08:50 PM								
5	From File			T7 T9 Uranium.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			99%								
8	Substantial Difference (S)			0.000								
9	Selected Null Hypothesis			Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)								
10	Alternative Hypothesis			Sample 1 Mean <> Sample 2 Mean								
11												
12												
13	Sample 1 Data: Uncorrected XRF Uranium (T7-T9)											
14	Sample 2 Data: Lab Reported Uranium (T7-T9)											
15												
16												
17				Raw Statistics								
18					Sample 1	Sample 2						
19	Number of Valid Observations				226	226						
20	Number of Distinct Observations				226	125						
21	Minimum				2.027	0.28						
22	Maximum				799.4	660						
23	Mean				32.76	23.04						
24	Median				10.95	3.8						
25	SD				74.1	62.28						
26	SE of Mean				4.929	4.143						
27												
28				Sample 1 vs Sample 2 Two-Sample t-Test								
29												
30	H0: Mean of Sample 1 = Mean of Sample 2											
31					t-Test	Lower C.Val	Upper C.Val					
32	Method			DF	Value	t (0.005)	t (0.995)	P-Value				
33	Pooled (Equal Variance)			450	1.509	-2.587	2.587	0.132				
34	Welch-Satterthwaite (Unequal Varian			437.1	1.509	-2.587	2.587	0.132				
35	Pooled SD: 68.446											
36	Conclusion with Alpha = 0.010											
37	Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2											
38	Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2											
39												
40				Test of Equality of Variances								
41												
42	Variance of Sample 1				5491							
43	Variance of Sample 2				3879							
44												
45	Numerator DF		Denominator DF		F-Test Value		P-Value					
46	225		225		1.415		0.009					
47	Conclusion with Alpha = 0.01											
48	Two variances are not equal											
49												

VANADIUM PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 11:17:01 AM
From File	T1 T6 Vanadium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Vanadium (T1-T6)

Sample 2 Data: Lab Vanadium_negatives removed

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	248	248
Number of Missing Observations	4	4
Number of Distinct Observations	248	122
Minimum	0.308	4.7
Maximum	1015	980
Mean	99.67	99.53
Median	30.17	22.5
SD	170.1	178.2
SE of Mean	10.8	11.32

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	494	0.009	-2.586	2.586	0.992
Welch-Satterthwaite (Unequal Varian	492.9	0.009	-2.586	2.586	0.992

Pooled SD: 174.188

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	28929
Variance of Sample 2	31754

Numerator DF	Denominator DF	F-Test Value	P-Value
247	247	1.098	0.465

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 8:30:30 AM
From File	T1 T6 Vanadium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Vanadium (T1-T6)

Sample 2 Data: Lab Vanadium

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	252	252
Number of Distinct Observations	252	124
Minimum	14.3	4.6
Maximum	1298	980
Mean	146.1	98.04
Median	59.33	21.5
SD	212.5	177.2
SE of Mean	13.39	11.16

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	502	2.760	-2.586	2.586	0.006
Welch-Satterthwaite (Unequal Varian	486.3	2.760	-2.586	2.586	0.006

Pooled SD: 195.631

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	45157
Variance of Sample 2	31386

Numerator DF	Denominator DF	F-Test Value	P-Value
251	251	1.439	0.004

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 11:50:50 AM
From File	T7 T9 Vanadium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Vanadium (T7-T9)

Sample 2 Data: Lab Reported Vanadium (T7-T9)_negatives removed

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	252	252
Number of Missing Observations	13	13
Number of Distinct Observations	252	118
Minimum	0.0204	4.7
Maximum	689.5	1100
Mean	59.74	66.38
Median	23.35	19
SD	102.6	132.9
SE of Mean	6.463	8.372

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.005)	Upper C.Val t (0.995)	P-Value
Pooled (Equal Variance)	502	-0.628	-2.586	2.586	0.530
Welch-Satterthwaite (Unequal Varian	471.8	-0.628	-2.586	2.586	0.530

Pooled SD: 118.717

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	10526
Variance of Sample 2	17661

Numerator DF	Denominator DF	F-Test Value	P-Value
251	251	1.678	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/7/2019 11:48:18 AM
From File	T7 T9 Vanadium.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Vanadium (T7-T9)

Sample 2 Data: Lab Reported Vanadium (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	265	265
Number of Distinct Observations	265	123
Minimum	13.71	4.6
Maximum	888.9	1100
Mean	94.18	63.6
Median	50.25	18
SD	126.8	130.2
SE of Mean	7.788	7.996

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	528	2.740	-2.585	2.585	0.006
Welch-Satterthwaite (Unequal Varian	527.6	2.740	-2.585	2.585	0.006

Pooled SD: 128.485

Conclusion with Alpha = 0.010

Student t (Pooled): Reject H0, Conclude Sample 1 <> Sample 2

Welch-Satterthwaite: Reject H0, Conclude Sample 1 <> Sample 2

Test of Equality of Variances

Variance of Sample 1	16073
Variance of Sample 2	16944

Numerator DF	Denominator DF	F-Test Value	P-Value
264	264	1.054	0.668

Conclusion with Alpha = 0.01

Two variances appear to be equal

ZINC PROUCL OUTPUT FILES

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/6/2019 8:07:56 PM
From File	T1 T6 Zinc.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Zinc (T1-T6)

Sample 2 Data: Lab Zinc

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	243	243
Number of Distinct Observations	243	50
Minimum	7.886	6.3
Maximum	59.9	68
Mean	16.95	16.94
Median	14.95	15
SD	7.578	8.37
SE of Mean	0.486	0.537

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	484	0.000	-2.586	2.586	1.000
Welch-Satterthwaite (Unequal Varian	479.3	0.000	-2.586	2.586	1.000

Pooled SD: 7.984

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	57.43
Variance of Sample 2	70.05

Numerator DF	Denominator DF	F-Test Value	P-Value
242	242	1.220	0.123

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/6/2019 8:06:13 PM
From File	T1 T6 Zinc.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Zinc (T1-T6)

Sample 2 Data: Lab Zinc

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	243	243
Number of Distinct Observations	243	50
Minimum	5.242	6.3
Maximum	80.42	68
Mean	18.33	16.94
Median	15.46	15
SD	10.95	8.37
SE of Mean	0.703	0.537

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	484	1.572	-2.586	2.586	0.117
Welch-Satterthwaite (Unequal Varian	452.8	1.572	-2.587	2.587	0.117

Pooled SD: 9.747

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	120
Variance of Sample 2	70.05

Numerator DF	Denominator DF	F-Test Value	P-Value
242	242	1.712	0.000

Conclusion with Alpha = 0.01

Two variances are not equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/6/2019 8:12:34 PM
From File	T7 T9 Zinc_a.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Corrected XRF Zinc (T7 - T9)

Sample 2 Data: Lab Reported Zinc (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	244	244
Number of Distinct Observations	244	52
Minimum	6.589	4.9
Maximum	51.96	67
Mean	15.25	15.42
Median	13.78	14
SD	6.284	7.337
SE of Mean	0.402	0.47

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

		t-Test	Lower C.Val	Upper C.Val	
Method	DF	Value	t (0.005)	t (0.995)	P-Value
Pooled (Equal Variance)	486	-0.272	-2.586	2.586	0.785
Welch-Satterthwaite (Unequal Varian	474.8	-0.272	-2.586	2.586	0.785

Pooled SD: 6.831

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	39.49
Variance of Sample 2	53.84

Numerator DF	Denominator DF	F-Test Value	P-Value
243	243	1.363	0.016

Conclusion with Alpha = 0.01

Two variances appear to be equal

t-Test Sample 1 vs Sample 2 Comparison for Uncensored Full Data Sets without NDs

User Selected Options	
Date/Time of Computation	ProUCL 5.15/6/2019 8:10:44 PM
From File	T7 T9 Zinc_a.xls
Full Precision	OFF
Confidence Coefficient	99%
Substantial Difference (S)	0.000
Selected Null Hypothesis	Sample 1 Mean = Sample 2 Mean (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean <> Sample 2 Mean

Sample 1 Data: Uncorrected XRF Zinc (T7 - T9)

Sample 2 Data: Lab Reported Zinc (T7-T9)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Observations	244	244
Number of Distinct Observations	244	52
Minimum	3.368	4.9
Maximum	68.94	67
Mean	15.88	15.42
Median	13.76	14
SD	9.083	7.337
SE of Mean	0.581	0.47

Sample 1 vs Sample 2 Two-Sample t-Test

H0: Mean of Sample 1 = Mean of Sample 2

Method	DF	t-Test Value	Lower C.Val t (0.005)	Upper C.Val t (0.995)	P-Value
Pooled (Equal Variance)	486	0.622	-2.586	2.586	0.534
Welch-Satterthwaite (Unequal Varian	465.4	0.622	-2.586	2.586	0.534

Pooled SD: 8.256

Conclusion with Alpha = 0.010

Student t (Pooled): Do Not Reject H0, Conclude Sample 1 = Sample 2

Welch-Satterthwaite: Do Not Reject H0, Conclude Sample 1 = Sample 2

Test of Equality of Variances

Variance of Sample 1	82.49
Variance of Sample 2	53.84

Numerator DF	Denominator DF	F-Test Value	P-Value
243	243	1.532	0.001

Conclusion with Alpha = 0.01

Two variances are not equal