WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

INTERIM ACTION REPORT
NORTH OMAK ELEMENTARY
OMAK, WASHINGTON

October 9, 2006

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Toxics Cleanup Program
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TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

The purpose of this report is to detail cleanup activities conducted at North Omak Elementary during the summer of 2006.

1.2 AREA-WIDE INTRODUCTION

Area-wide soil contamination is defined as contamination above state cleanup levels that is dispersed over a large geographic area. The soil contamination in this case is a result of central Washington's orchard industry. Much of the region consists of current or former orchard land, where long-term pesticide application has taken its toll. Lead arsenate, a pesticide commonly used between the years of 1905 and 1947 to control the codling moth, has been identified as the primary source of increased lead and arsenic concentrations.

Due to their chemical structure, lead and arsenic tend to bond with soil particles and often remain at or near ground surface level for decades, creating an exposure pathway through inhalation and/or ingestion.

Although lead and arsenic are naturally occurring elements, elevated concentrations have been proven to have a negative impact on human health. Young children are generally more susceptible than adults, which is why Ecology has focused remediation efforts on schools.

Because of the unique nature of area-wide contamination, traditional methods of remediation are not feasible. Therefore, the Area-Wide Soil Contamination Task Force was established in 2002 to identify and pursue effective statewide strategies. Recommendations from the Task Force included soil testing, qualitative evaluations, and protective measures at child-use areas.

In the central Washington region, Okanogan, Chelan, Douglas, and Yakima counties were targeted based on the large volume of apple and pear production during the first half of the 20th century. Ecology's Central Regional Office (CRO) began initial sampling and analysis during the spring of 2002 in the Wenatchee area. This area was chosen based on aerial photography from 1927 and 1947 that showed a high number of school properties located on former orchard land.

Results from the Wenatchee area showed several schools with soil contamination exceeding state cleanup standards. Based on these results, soil testing was implemented in the four priority counties. Over 100 public schools were tested for lead and arsenic during the summer of 2005. Of the schools sampled, Ecology's CRO identified schools with soil contamination exceeding state cleanup standards.

The 35 schools were then prioritized for remedial activities. Remedial activities started during the summer of 2006. Eight schools were chosen, including four schools in Wenatchee, and one each in Omak, Manson, Brewster, and Naches.

2.0 SITE DESCRIPTION

North Omak Elementary School is located at 615 Oak Street in the City of Omak in Okanogan County, Washington. More specifically, the site is located in the SE ¼ of the NE ¼ of Section 26, Township 34 North, Range 26 East, and has GPS coordinates of 48º41'46" and -119º51'69". The site is approximately 1 mile west of State Highway 97 and approximately 100 miles north of the City of Wenatchee (see Vicinity Map located in Appendix A).

Situated on the eastern boundary of the Cascade foothills, this location is approximately 960 feet above sea level on a formation known as the Robinson Flat on topographic maps. Coleman Butte is located less than 2 miles north-northeast of the site and the Okanogan River is located about ¾ miles to the south. Relief is minimal across the site. Ecology well log records suggest depth to groundwater is about 100 feet below ground surface. Groundwater will generally flow south toward the Okanogan River. Average annual precipitation is between 8 and 11 inches.

According to the United States Department of Agriculture (USDA) Soil Survey of Okanogan County Area, Washington, local soils are described as Pogue fine sandy loam and are considered very deep, somewhat excessively drained soils. Pogue-type soils, as well as the rounded hills and U-shaped valleys of the area, were formed primarily by Pleistocene glaciation. Pogue-type soils are a result of glacial till and outwash and can be found on relatively flat terraces as well as steep terrace breaks. Horticultural use is common on Pogue-type soils.

The Soil Survey describes the following soil horizons:

- At 0-6 inches below ground surface (bgs), soil consists of a grayish-brown sandy loam with a weak, platy structure. Soil is soft and considered very friable, slightly sticky, and non-plastic. Soil is well impregnated with many fine roots and pores. Soil has a neutral pH.
- At 6-12 inches bgs, soil is a brown, fine sandy loam with a weak prismatic structure. Soil is soft and considered very friable, slightly sticky, and non-plastic. Soil is well impregnated with many fine roots and pores. Soil has a neutral pH.
- Between 12 and 29 inches bgs, soil becomes more yellowish-brown in color. Soil is a fine gravelly sandy loam with a weak, course prismatic structure. Gravel content is approximately 20 percent. Soil remains soft and friable, non-sticky and non-plastic with fine root intrusion. Soil is still considered moist, soft, and non-sticky but becomes slightly plastic. Soil remains neutral.
- At 29-60 inches bgs, soil becomes multi-colored, very gravelly, single grain sand. Soil is loose and very porous.

Soil at the site was found to substantially similar to the above description. As is common in Pogue-type soils, soil at the site was occasionally found to be very stony within four feet of the surface.

3.0 SITE HISTORY

North Omak Elementary was constructed on historic orchard land in 1955. The Okanogan Health District and Ecology began initial soil analysis to determine the presence of lead arsenate contamination in 2002 and 2003. Analytical results showed arsenic and lead concentrations of up to 212 parts per million (ppm) and 1523 ppm, respectively. Concentrations were in excess of Ecology MTCA Method A cleanup levels, as illustrated in the figure on the next page. Based on these results, the property was added to Ecology's Confirmed and Suspected Contaminated Sites list in May 2003.

Between 2003 and 2005, several interim remedial actions were taken to address contamination hot-spots, including consolidation of playground equipment, installation of a geo-textile barrier beneath a layer of cedar wood chips in playground areas, replacement of soil in garden planters and play areas, and re-vegetation of bare soil areas. A comprehensive turf maintenance plan, including irrigation system upgrades, was also devised to help reduce re-occurrence of bare soil spots.

Following completion of interim remedial actions, additional soil sampling was conducted in 2005 and 2006 to better delineate the nature of lead and arsenic contamination across the property. Review of analytical results demonstrated further remediation was necessary.

Figure 3.1: Pilot Project Samples

4.0 SITE CONTACT INFORMATION

This project was operated by an interagency agreement between Ecology and the Omak School District (School District). All contracts were operated by the School District and invoices were submitted to Ecology for reimbursement. Contractual and planning phases of the project were reviewed by the School District prior to beginning field operations. Ecology maintained contact with administrative and maintenance staff throughout site work to maintain a positive working relationship and exchange of information as needed.

CBA Environmental acted as General Contractor for all work at North Omak Elementary School. Excavation was completed by McMillan Construction Company. Landscaping and irrigation activities were completed by Mountain View Landscaping.

The following table contains contact information for individuals responsible for various roles in the completion of remedial activities.

Table 4-1: Contacts

Name	Organization	Position	Phone Number
R. Robert Risinger	Omak School District	Superintendent	(509) 826-2240
Lloyd Foster	Omak School District	Accounting Officer	(509) 826-7689
Lyle Columbia	Omak School District	Maintenance Director	(509) 826-0320 ext 667
George Williams	CBA Environmental	General Contractor/ Deep Mixing	(570) 682-8742
Mike McMillan	McMillan Construction Co., Inc.	Excavation & Hauling	(509) 476-2770
Mike Stubblefield	Mountain View Landscaping	Landscaping & Irrigation	(509) 663-3168

5.0 REMEDIAL PROCESS

5.1 RISK

The potential exposure pathways for lead and arsenic in soil are inhalation, ingestion, and dermal absorption. It is important to consider that ingestion is not considered as an exposure pathway in the site hazard assessment ranking method. For the purpose of this cleanup, ingestion was considered as a significant exposure pathway. Ingestion of contaminated soil is expected to be the primary route of exposure for metals, particularly with young children. Metals in dust or soil can be ingested accidentally by hand-to-mouth activity. Pica behavior in young children, that is, eating of non-food items, will increase this exposure. Ingestion or inhalation of wind-blown soil or dust are additional pathways of exposure to lead and arsenic. Children are considered a sensitive population because they tend to ingest more soil and dust than adults and because they tend to absorb more of the lead they ingest. Metals are not readily absorbed through the skin, so dermal absorption of metals is not a significant concern at the concentrations found at schools in the area-wide cleanup program.

Evidence of groundwater contamination or the threat of groundwater contamination has not been found relative to area wide lead and arsenic contamination. Extensive soil profile sampling in Central Washington has demonstrated that lead and arsenic contamination does not extend below 30 inches bgs in undisturbed situations. High levels of lead and arsenic contamination (above 50 ppm for arsenic and above 500 ppm for lead) were not found below 12 inches bgs. These results may vary in climates with more precipitation, but in this region, the findings were very consistent. Due to the depth of groundwater found in the vicinity of the school, combined with the distribution of the contamination, the risk of lead and arsenic contamination in groundwater is minimal.

5.2 REMEDIAL PROCESS

5.2.1 SAFETY AND HEALTH

The site was restricted from public access throughout the construction period by a 6-foot high chain link fence. The contractor was required to provide a specific Safety & Health Plan for the site construction activities.

5.2.2 DUST CONTROL PLAN

The contactor was required to control dust and to prepare a dust control plan. Dust control measures, at a minimum, included a water truck.

5.2.3 REMEDIAL ACTIVITIES

The initial remediation plan for North Omak Elementary was based upon sampling conducted across the site to a depth of approximately 8 inches. This data indicated that there were areas with lead and arsenic contamination high enough that some excavation would be required prior to applying deep mixing technology.

The deep mixing technology was supplied by CBA Environmental Inc. (CBA) from Hegins, Pennsylvania. The deep mixer is a piece of heavy equipment manufactured by Vermeer Manufacturing and modified by CBA for the purpose of deep soil mixing. The machine is track mounted and weighs between 50 and 120 tons depending on model. A large rotating drum mounted on the front of the machine is lowered to a maximum depth of 4.5 feet bgs where it rotates and mixes the soil. It travels at average speeds between 4 and 8 feet per minute and typically covers between 1/3 and 1/2 acre per day. Studies conducted by Ecology and CBA have shown a mixing efficiency between 70% and 95% depending on soil types.

Prior to beginning excavation, additional sampling was conducted to create a more detailed delineation of the lead and arsenic concentrations. This sampling data indicated that the majority of the north end of the site containing the soccer fields had arsenic concentrations exceeding 100 ppm between 2 inches and 12 inches bgs. This area would require excavation prior to deep mixing for remediation to be successful. As a general rule, any contamination above 100 ppm cannot be deep mixed without some excavation to remove some of the contaminant load. Concentrations in the 60-99 ppm range may or may not need to be excavated depending on the depth of contamination and the background concentrations found in the clean soil below.

Prior to beginning excavation, a deep mixer was brought onsite to conduct test mixing on the southern portion of the site that had lower lead and arsenic concentrations. The sampling data for this area indicated arsenic concentrations between 50 and 70 ppm near the surface. Two rows approximately 40 feet long were mixed to the machines maximum capable depth of 4' bgs. The results of the mixed soil and unmixed test pits in the immediate vicinity are in the tables below.

Table 5-1: Test Row Concentrations

Sample Depth	Row 1 Mixed Concentrations	Row 2 Mixed Concentrations
Surface	32 ppm	44 ppm
12" bgs	40 ppm	26 ppm
24" bgs	36 ppm	44 ppm

Table 5-2: Test Pit Concentrations

Sample Depth	Row 1 Test Pit Concentrations	Row 2 Test Pit Concentrations
1-4" bgs	116 ppm	73 ppm
6-8" bgs	35 ppm	40 ppm
10-12" bgs	33 ppm	27 ppm
16-18" bgs	29 ppm	24 ppm
20-22" bgs	28 ppm	14 ppm
28-30" bgs	26 ppm	20 ppm

As the test pit data indicates, deep mixing was not successful at the site. Even if the higher surface concentrations were removed, concentrations exist above MTCA cleanup levels deep into the soil profile where clean soil is required for dilution. Profile samples taken across the site confirmed similar conditions throughout.

When it became apparent that deep mixing was not feasible at the site, it was decided to proceed with capping the contamination onsite. The highest concentrations (anything above 75 ppm arsenic or 500 ppm lead) were removed by excavation and the remaining contaminated soils were to be covered with a non-woven permeable geotextile fabric followed by approximately 8" of clean topsoil.

A bulldozer was used for the excavation process. After the bulldozer had excavated an area down to a prescribed depth, X-ray fluorescence (XRF) was used to analyze post-excavation surface concentrations and determine whether more excavation was required. All arsenic contamination in excess of 75 ppm was removed from the site. When post-excavation surface concentrations of 75 ppm were reached, excavation was considered complete for that area. Approximately 6000 cubic yards of soil were excavated from the site. This exceeded the original estimate of approximately 2200 cubic yards by approximately 3800 cubic yards. This excess can be attributed to the fact that deep mixing was not possible at the site. Had deep mixing been possible, much of the contaminated soil would have been blended with clean soils below. A front-end loader was then used to load the stockpiles into trucks for transport to the landfill. Soil excavated from North Omak Elementary was transported to the Okanogan County Landfill located in Okanogan, Washington.

After excavation was complete, a geotextile membrane was placed on the soil surface covered clean topsoil was imported to the site. The topsoil was taken from an undisturbed site and tested for lead and arsenic concentrations. Neither lead nor arsenic were detected above background concentrations in 10 samples taken from the import topsoil. Approximately 5000 yards of topsoil were imported onsite.

5.3 SAMPLE RESULTS

Remedial activities at North Omak Elementary were intended to remove soil containing high concentrations of lead and arsenic and cap the remaining soil that contained lower levels of lead and arsenic that still exceeded MTCA cleanup levels. With these goals in mind, remediation was successful at North Omak Elementary.

Initial sampling between the surface and 8 inches bgs found average arsenic concentrations of 90 ppm with a maximum concentration of 690 ppm. Initial lead concentrations averaged 890 ppm with a maximum concentration of 3181 ppm. Excavation continued until surface concentrations did not exceed 75 ppm arsenic and 500 ppm lead. Post-excavation arsenic samples indicated an average concentration of 43 ppm and a maximum concentration of 72. Post-excavation lead samples indicated an average concentration of 142 ppm and a maximum concentration of 475 ppm. Sample data can be viewed in the tables below.

MTCA Method A Soil Cleanup Levels

As- 20ppm

Pb-250ppm

Table 5-3: Pre-Excavation Samples

Date	As	Pb	Sample ID	School
27-Jun-06	97	574	OT-1 1-4"	North Omak
27-Jun-06	89	331	OT-1 5-8"	North Omak
27-Jun-06	30	229	OT-2 1-4"	North Omak
27-Jun-06	77	433	OT-2 5-8"	North Omak
27-Jun-06	81	644	OT-3 1-4"	North Omak
27-Jun-06	84	549	OT-3 5-8"	North Omak
27-Jun-06	45	301	OT-4 1-4"	North Omak
27-Jun-06	89	407	OT-4 5-8"	North Omak
27-Jun-06	13	16	OT-5 1-4"	North Omak
27-Jun-06	75	213	OT-5 5-8"	North Omak
27-Jun-06	17	14	OT-6 1-4"	North Omak
27-Jun-06	50	237	OT-6 5-8"	North Omak
27-Jun-06	30	278	OT-7 1-4"	North Omak
27-Jun-06	178	995	OT-7 5-8"	North Omak
27-Jun-06	177	1443	OT-9 1-4"	North Omak
27-Jun-06	691	3181	OT-9 5-8"	North Omak
27-Jun-06	24	95	OT-10 1-4"	North Omak
27-Jun-06	20	15	OT-10 5-8"	North Omak
27-Jun-06	63	784	OT-11 1-4"	North Omak
27-Jun-06	114	927	OT-11 5-8"	North Omak
27-Jun-06	76	674	OT-12 1-4"	North Omak
27-Jun-06	177	828	OT-12 5-8"	North Omak
27-Jun-06	56	758	OT-13 1-4"	North Omak
27-Jun-06	115	735	OT-13 5-8"	North Omak
27-Jun-06	121	900	OT-14 1-4"	North Omak
27-Jun-06	91	298	OT-14 5-8"	North Omak
27-Jun-06	107	1046	OT-15 1-4"	North Omak
27-Jun-06	169	1346	OT-15 5-8"	North Omak
27-Jun-06	130	935	OT-16 1-4"	North Omak
27-Jun-06	109	226	OT-16 5-8"	North Omak
27-Jun-06	89	939	OT-17 1-4	North Omak
27-Jun-06	137	1764	OT-17 5-8"	North Omak
27-Jun-06	63	406	OT-18 1-4"	North Omak
27-Jun-06	137	245	OT-18 5-8"	North Omak
27-Jun-06	66	617	OT-19 1-4"	North Omak
27-Jun-06	72	96	OT-19 5-8"	North Omak
27-Jun-06	56	202	OT-20 1-4"	North Omak
27-Jun-06	39	19	OT-20 5-8"	North Omak
27-Jun-06	63	711	OT-21 1-4"	North Omak
27-Jun-06	97	1020	OT-21 5-8"	North Omak
27-Jun-06	72	776	OT-22 1-4"	North Omak
27-Jun-06	175	1107	OT-22 5-8"	North Omak
27-Jun-06	136	1377	OT-23 1-4"	North Omak
27-Jun-06	121	430	OT-23 5-8"	North Omak
27-Jun-06	98	940	OT-24 1-4"	North Omak
27-Jun-06	62	58	OT-24 5-8	North Omak
27-Jun-06	162	1287	OT-25 1-4"	North Omak

Date	As	Pb	Sample ID	School
27-Jun-06	124	339	OT-25 5-8"	North Omak
27-Jun-06	101	1095	OT-26 1-4"	North Omak
27-Jun-06	186	1050	OT-26 5-8"	North Omak
27-Jun-06	141	1003	OT-27 1-4	North Omak
27-Jun-06	215	1304	OT-27 5-8"	North Omak
27-Jun-06	69	607	OT-28 1-4"	North Omak
27-Jun-06	72	196	OT-28 5-8"	North Omak
27-Jun-06	115	977	OT-29 1-4"	North Omak
27-Jun-06	80	321	OT-29 5-8"	North Omak
27-Jun-06	79	721	OT-30 1-4"	North Omak
27-Jun-06	36	281	OT-30 5-8"	North Omak
27-Jun-06	93	907	OT-31 1-4"	North Omak
27-Jun-06	96	246	OT-31 5-8"	North Omak
27-Jun-06	77	637	OT-32 1-4"	North Omak
27-Jun-06	32	220	OT-32 5-8"	North Omak
28-Jun-06	97	922	OT-33 1-4"	North Omak
28-Jun-06	115	1086	OT-33 5-8"	North Omak
28-Jun-06	94	961	OT-34 1-4"	North Omak
28-Jun-06	55	189	OT-34 5-8"	North Omak
28-Jun-06	74	549	OT-35 1-4"	North Omak
28-Jun-06	48	37	OT-35 5-8"	North Omak
28-Jun-06	50	690	OT-36 1-4"	North Omak
28-Jun-06	43	184	OT-36 5-8"	North Omak
28-Jun-06	165	1302	OT-37 1-4"	North Omak
28-Jun-06	139	433	OT-37 5-8"	North Omak
28-Jun-06	61	550	OT-38 1-4"	North Omak
28-Jun-06	28	41	OT-38 5-8"	North Omak
28-Jun-06	20	36	OT-38a 5-8"	North Omak
28-Jun-06	134	1373	OT-39 1-4"	North Omak
28-Jun-06	114	298	OT-39 5-8	North Omak
28-Jun-06	120	733	OT-40 1-4"	North Omak
28-Jun-06	33	43	OT-41 1-4"	North Omak
28-Jun-06	43	11	OT-40 5-8"	North Omak
28-Jun-06	45	39	OT-42 1-4"	North Omak
28-Jun-06	37	85	OT-43 1-4"	North Omak
28-Jun-06	<LOD	34	OT-44 1-4"	North Omak
28-Jun-06	82	780	OT-45 1-4"	North Omak
28-Jun-06	27	16	OT-45 5-8"	North Omak
28-Jun-06	14	66	OT-46 1-4"	North Omak
28-Jun-06	25	400	OT-47 1-4"	North Omak
28-Jun-06	45	167	OT-47 5-8"	North Omak
28-Jun-06	63	397	OT-48 1-4"	North Omak
28-Jun-06	35	15	OT-48 5-8"	North Omak
28-Jun-06	69	706	OT-49 1-4"	North Omak
28-Jun-06	132	1015	OT-50-1-4"	North Omak
28-Jun-06	82	801	OT-50 1-4"	North Omak
28-Jun-06	88	527	OT-50 5-8"	North Omak
28-Jun-06	<LOD	658	OT-51 1-4"	North Omak
28-Jun-06	115	825	OT-51 5-8"	North Omak

Date	As	Pb	Sample ID	School
28-Jun-06	76	700	OT-52 1-4"	North Omak
28-Jun-06	55	26	OT-52 5-8"	North Omak
28-Jun-06	<LOD	417	OT-53 1-4"	North Omak
28-Jun-06	80	534	OT-53 5-8"	North Omak
28-Jun-06	67	1087	OT-54 1-4"	North Omak
28-Jun-06	43	88	OT-54 5-8"	North Omak
28-Jun-06	75	800	OT-55 1-4"	North Omak
28-Jun-06	146	576	OT-55 5-8"	North Omak
28-Jun-06	124	1309	OT-56 1-4"	North Omak
28-Jun-06	213	906	OT-56 5-8"	North Omak
28-Jun-06	73	660	OT-57 1-4"	North Omak
28-Jun-06	138	1023	OT-57 5-8"	North Omak
28-Jun-06	27	115	OT-58 1-4"	North Omak
28-Jun-06	40	253	OT-58 5-8	North Omak
28-Jun-06	43	563	OT-59 1-4"	North Omak
28-Jun-06	45	115	OT-59 5-8"	North Omak
8-Aug-06	36	382	OET-90	North Omak
8-Aug-06	82	598	OET-91	North Omak
8-Aug-06	81	656	OET-92	North Omak
8-Aug-06	44	346	OET-93	North Omak
Average	90	590		
Maximum	691	3181		

Table 5-4: Post-Excavation Samples

Date	As	Pb	Sample ID	School
28-Jul-06	37	24	OET-1	North Omak
28-Jul-06	65	203	OET-2	North Omak
28-Jul-06	34	27	OET-3	North Omak
28-Jul-06	25	15	OET-4	North Omak
28-Jul-06	29	11	OET-5	North Omak
28-Jul-06	31	18	OET-6	North Omak
28-Jul-06	26	23	OET-7	North Omak
28-Jul-06	29	13	OET-9	North Omak
28-Jul-06	28	<LOD	OET-10	North Omak
28-Jul-06	<LOD	<LOD	OET-11	North Omak
28-Jul-06	35	11	OET-12	North Omak
28-Jul-06	25	<LOD	OET-13	North Omak
28-Jul-06	52	48	OET-14	North Omak
28-Jul-06	71	214	OET-15	North Omak
28-Jul-06	47	55	OET-16	North Omak
28-Jul-06	62	191	OET-17	North Omak
28-Jul-06	45	30	OET-18	North Omak
28-Jul-06	45	53	OET-19	North Omak
28-Jul-06	70	140	OET-20	North Omak
28-Jul-06	41	98	OET-21	North Omak

Date	As	Pb	Sample ID	School
28-Jul-06	28	11	OET-22	North Omak
28-Jul-06	60	70	OET-23	North Omak
31-Jul-06	32	13	OET-25	North Omak
31-Jul-06	38	34	OET-26	North Omak
31-Jul-06	30	15	OET-27	North Omak
31-Jul-06	28	14	OET-30	North Omak
1-Aug-06	51	159	OET-32	North Omak
1-Aug-06	34	25	OET-33	North Omak
2-Aug-06	47	88	OET-40	North Omak
2-Aug-06	32	21	OET-41	North Omak
2-Aug-06	34	<LOD	OET-42	North Omak
2-Aug-06	66	213	OET-43	North Omak
2-Aug-06	40	<LOD	OET-46	North Omak
2-Aug-06	31	<LOD	OET-48	North Omak
2-Aug-06	38	<LOD	OET-49	North Omak
2-Aug-06	20	<LOD	OET-50	North Omak
2-Aug-06	31	25	OET-53	North Omak
2-Aug-06	43	<LOD	OET-55	North Omak
2-Aug-06	49	27	OET-56	North Omak
2-Aug-06	23	<LOD	OET-57	North Omak
2-Aug-06	45	24	OET-58	North Omak
3-Aug-06	42	174	OET-60	North Omak
3-Aug-06	56	21	OET-61	North Omak
3-Aug-06	67	264	OET-64	North Omak
3-Aug-06	53	159	OET-65	North Omak
3-Aug-06	32	23	OET-66	North Omak
3-Aug-06	33	32	OET-68	North Omak
3-Aug-06	51	<LOD	OET-69	North Omak
3-Aug-06	23	<LOD	OET-70	North Omak
3-Aug-06	49	464	OET-72	North Omak
3-Aug-06	54	250	OET-73	North Omak
3-Aug-06	65	133	OET-75	North Omak
3-Aug-06	31	<LOD	OET-76a	North Omak
3-Aug-06	23	<LOD	OET-76	North Omak
3-Aug-06	<LOD	307	OET-78	North Omak
3-Aug-06	<LOD	<LOD	OET-82	North Omak
3-Aug-06	<LOD	37	OET-83	North Omak
3-Aug-06	53	374	OET-84	North Omak
3-Aug-06	61	406	OET-87	North Omak
3-Aug-06	61	<LOD	OET-88	North Omak
3-Aug-06	40	42	OET-89	North Omak
3-Aug-06	54	315	OET-90	North Omak
3-Aug-06	46	27	OET-91	North Omak
3-Aug-06	32	<LOD	OET-93	North Omak
9-Aug-06	58	189	OTS-97	North Omak

Date	As	Pb	Sample ID	School
9-Aug-06	39	294	OTS-98	North Omak
9-Aug-06	39	460	OTS-99	North Omak
9-Aug-06	31	192	OTS-100	North Omak
9-Aug-06	20	<LOD	OTS-102	North Omak
9-Aug-06	15	<LOD	OTS-103	North Omak
9-Aug-06	27	<LOD	OTS-104	North Omak
9-Aug-06	23	<LOD	OTS-106	North Omak
9-Aug-06	41	<LOD	OTS-107	North Omak
10-Aug-06	33	49	OTS-108	North Omak
10-Aug-06	27	<LOD	OTS-109	North Omak
10-Aug-06	35	31	OTS-110	North Omak
10-Aug-06	26	27	OTS-113	North Omak
10-Aug-06	54	423	OTS-114	North Omak
10-Aug-06	28	<LOD	OTS-115	North Omak
10-Aug-06	43	58	OTS-117	North Omak
10-Aug-06	<LOD	<LOD	OTS-118	North Omak
10-Aug-06	72	348	OTS-120	North Omak
10-Aug-06	69	423	OTS-121 1-4"	North Omak
10-Aug-06	59	195	OTS-121 5-8"	North Omak
10-Aug-06	53	95	OTS-122 5-8"	North Omak
10-Aug-06	40	42	OTS-128 5-8"	North Omak
10-Aug-06	63	307	OTS-127 5-8"	North Omak
10-Aug-06	41	130	OTS-123 5-8"	North Omak
10-Aug-06	57	382	OTS-124 5-8"	North Omak
10-Aug-06	59	358	OTS-130 1-4"	North Omak
10-Aug-06	63	251	OTS-130 5-8"	North Omak
15-Aug-06	42	74	OET-131	North Omak
15-Aug-06	35	<LOD	OET-132	North Omak
15-Aug-06	<LOD	103	OET-133	North Omak
15-Aug-06	70	299	OET-134	North Omak
15-Aug-06	61	475	OET-135	North Omak
15-Aug-06	57	49	OET-137	North Omak
15-Aug-06	32	<LOD	OET-143	North Omak
15-Aug-06	28	37	OET-144	North Omak
Average	43	142		
Maximum	72	475		

* <LOD represents that the value is below the level of detection

5.4 CONFIRMATIONAL SAMPLING

Though confirmation samples were analyzed by XRF continuously during the remedial process, it was decided that a significant number of samples should also be collected for certified lab analysis. Certified lab analysis serves two purposes: it provides additional third party data to validate remedial activities, and it provides additional data to correlate the relationship between XRF and wet chemistry.

Samples collected for laboratory analysis were collected after all remediation was complete. A clean soil probe was used to collect a sample from 1-8 inches bgs. This sample was thoroughly mixed in a clean stainless steel bowl to homogenize the sample. The sample was then split into two portions. One portion was placed in a new, clean, sealed plastic bag and analyzed with the XRF. The other portion was placed in a clean, laboratory supplied, glass jar for laboratory analysis. The samples collected for laboratory analysis were then sent under sealed chain-of-custody to CCI Analytical Laboratory in Everett, Washington for lead and arsenic analysis.

The analysis found a correlation coefficient (r2 value) between Innov-X XRF field measurements and Inductively-Couples Plasma (ICP) of 0.779 for arsenic and 0.893 for lead. It should be noted that two of the data points were actually method detection limits for samples in which lead or arsenic was not detected. When those non-detect data points are removed, the analysis found that the Innov-X XRF had a correlation coefficient (r2 value) between field and Inductively-Coupled Plasma (ICP) laboratory analysis of 0.838 for arsenic and 0.879 for lead. The samples specific to North Omak Elementary School are available in the table on the next page.

Table 5-5: XRF-Lab Split Samples

Date	As Lab	As XRF	Pb Lab	Pb XRF	Sample ID	School
20-Sep-06	2	7.97*	2	10.45*	O-Lab-1-import	North Omak
20-Sep-06	2	7.65*	2	10.17*	O-Lab-2-import	North Omak
20-Sep-06	29	46	150	195	O-Lab-3	North Omak
20-Sep-06	35	47	170	233	O-Lab-4	North Omak
20-Sep-06	40	42	180	190	O-Lab-5	North Omak
20-Sep-06	42	52	200	251	O-Lab-6	North Omak
20-Sep-06	48	51	230	227	O-Lab-7	North Omak
20-Sep-06	21	25	100	123	O-Lab-8	North Omak
20-Sep-06	67	74	280	325	O-Lab-9	North Omak
20-Sep-06	47	50	180	253	O-Lab-10	North Omak

* These XRF values represent the detection limit of a non-detect sample. They are not actual values.

6.0 PROJECT SUMMARY

Soil samples collected at North Omak Elementary School (site) during sampling events in 2002 and 2003 indicated lead and arsenic contamination existed in surface soils at concentrations above MTCA cleanup levels. Deep mixing was initially considered as a remediation technique. After digging test pits, it was discovered that the contamination existed at levels deeper than previously thought. Even if the surface concentrations were removed, the remaining contaminants in the soil would still contain concentrations exceeding MTCA cleanup levels. Therefore, the field was capped. Excavation was used to remove the top 6" of contaminated soil from the site, and dispose of the material in a properly permitted landfill meeting the requirements of RCRA Subtitle D. A non-woven permeable geotextile fabric was placed on top of the contaminated soil, followed by new topsoil and turf/hydroseed to restore the site to the original condition. As a result, the remaining lead and arsenic concentrations were contained within the site, and a restrictive covenant was issued to restrict future improvements or redevelopment of the site.

7.0 APPENDICES

Appendix A: FIGURES

Figure A-1: Vicinity Map

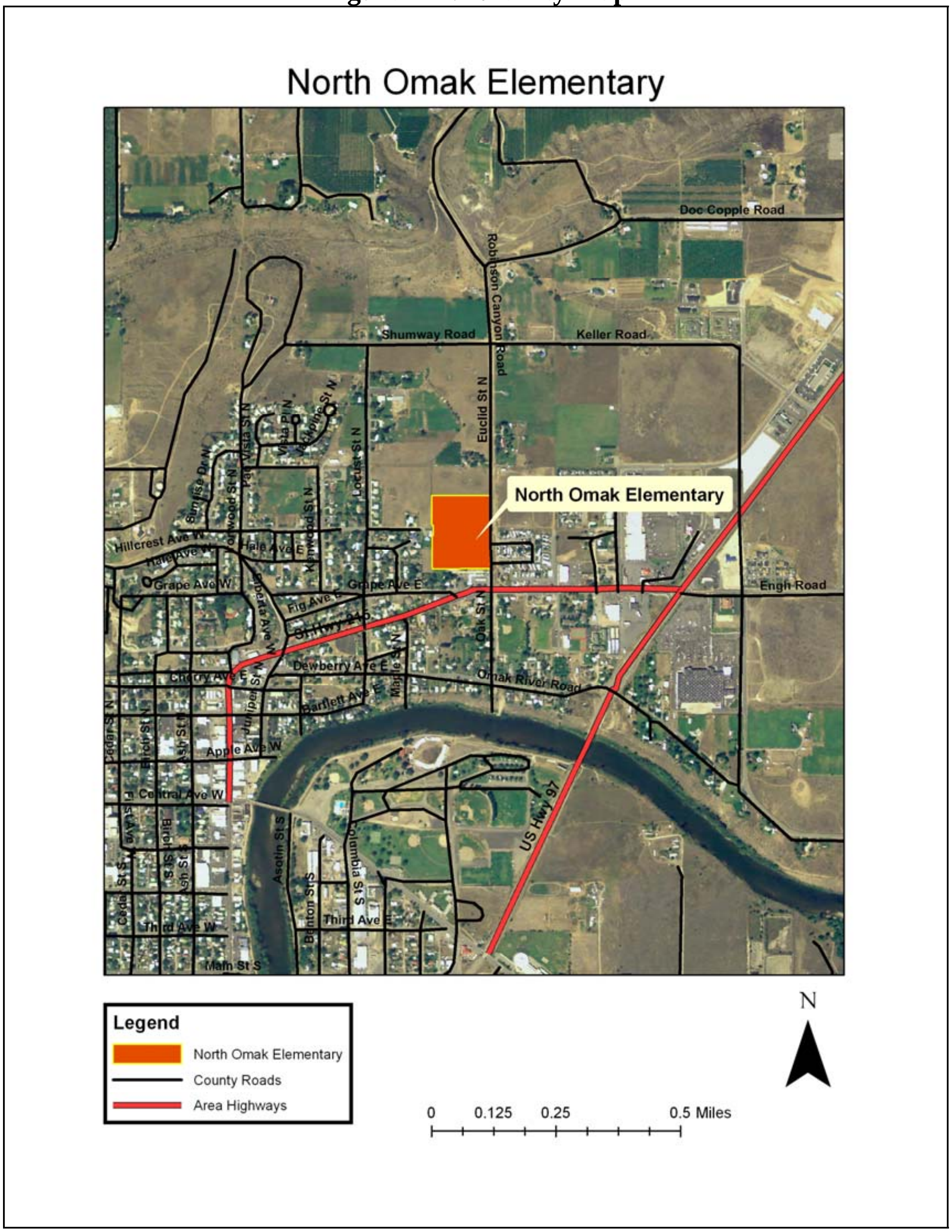
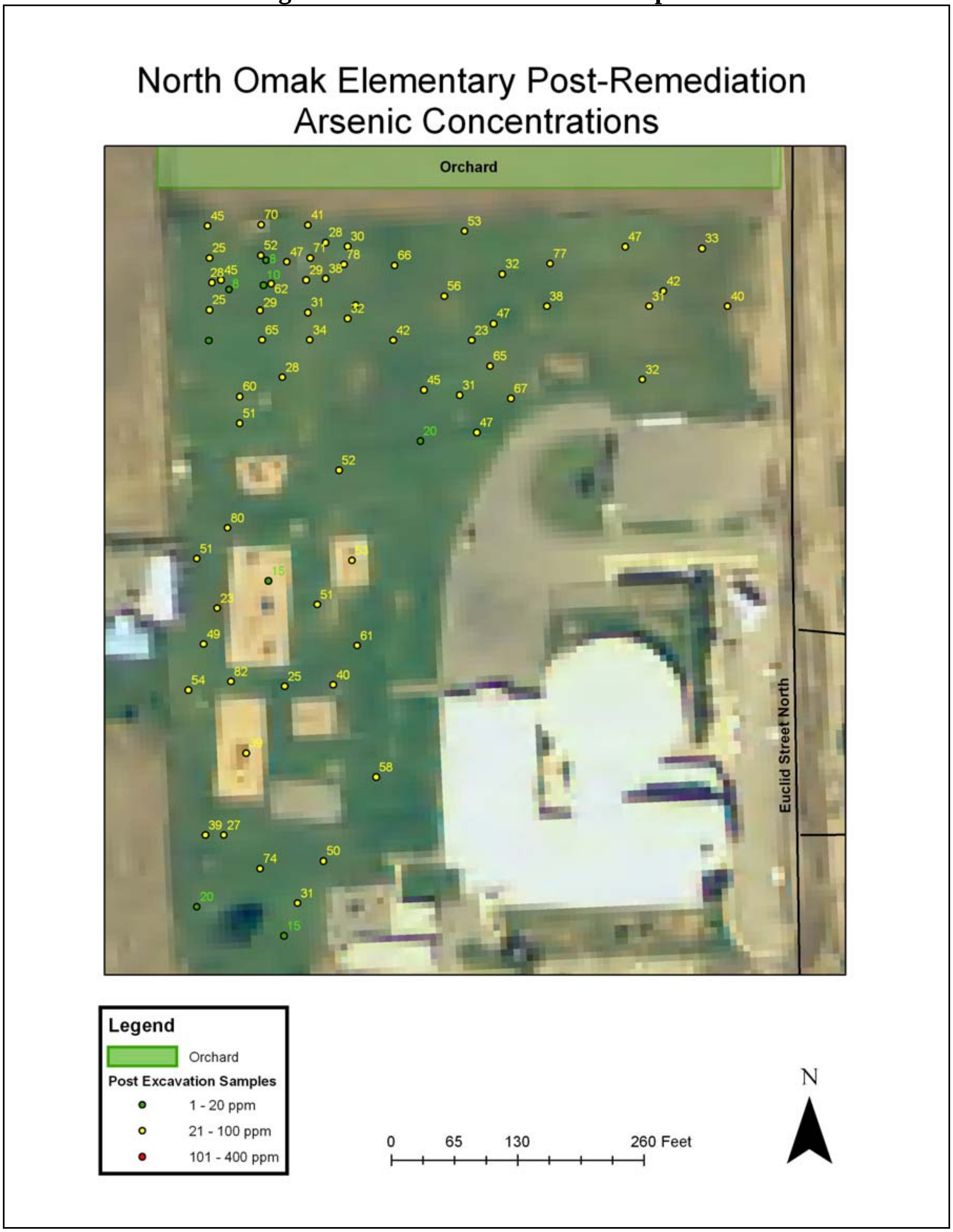


Figure A-2: Pre-Remediation Samples

Figure A-3: Post-Remediation Samples



Appendix B: XRF USE

The summer 2006 area-wide contamination clean-up projects involved the collection and analysis of a vast number of soil samples. Concentrations of lead and arsenic in these soil samples provided information as to whether or not an area was contaminated, and this information was used to determine how the remedial activities would proceed. Therefore project staff needed a way to quickly and reliably evaluate soil arsenic and lead concentrations. This was achieved through the use of two portable X-Ray Fluorescence (XRF) Analyzers manufactured by Innov-x Systems.

The instruments use x-ray technology to excite elemental electrons in a soil sample and cause these elements to emit characteristic x-rays. The intensity of these elemental x-rays is then measured to determine the amount of a particular element present in the sample. The entire analysis is performed in approximately one minute and the data is stored in a removable Hewlett-Packard (HP) iPAQ personal data assistant which can transmit the information to a laptop.

The use of portable XRF units for the determination of soil elemental concentrations has been described by EPA Method 6200 and has been found to provide, "a rapid field screening procedure" for site characterization [US EPA]. Results from the study conducted by Ecology in 2002 (as shown in the graphs below) found that a portable Niton XRF had a correlation coefficient (r2 value) between field and Inductively-Coupled Plasma (ICP) laboratory analyses of 0.8057 for lead and 0.933 for arsenic. In addition, a verification study conducted by the EPA Superfund Innovative Technology Evaluation (SITE) Monitoring and Measurement Technology (MMT) Program provides additional support for the use of this technology. The investigation compared an Innov-x XRF model, similar to the one used by Ecology, with reference laboratory data and showed a correlation coefficient of 0.8762 for arsenic and 0.91 for lead [US EPA]. All of this data shows that an XRF can be an effective tool for characterizing large contamination sites.

Figure B-1: 2002 Arsenic Comparison

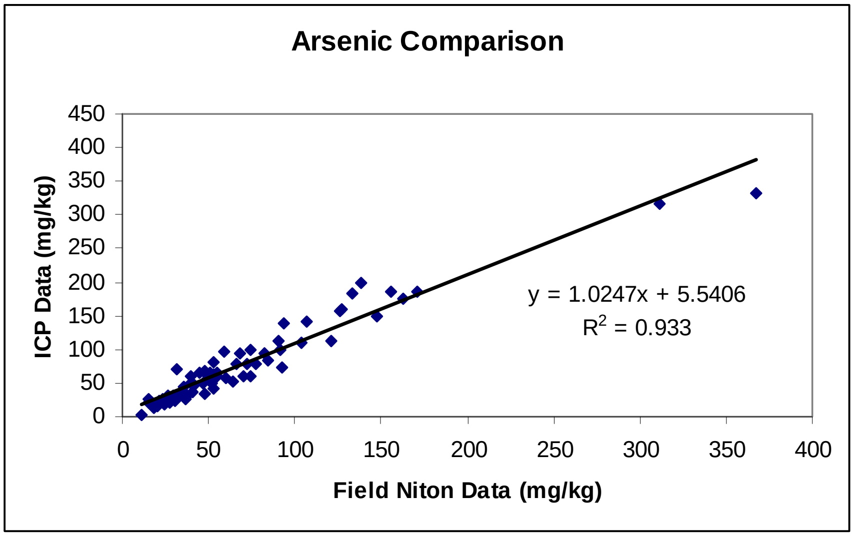
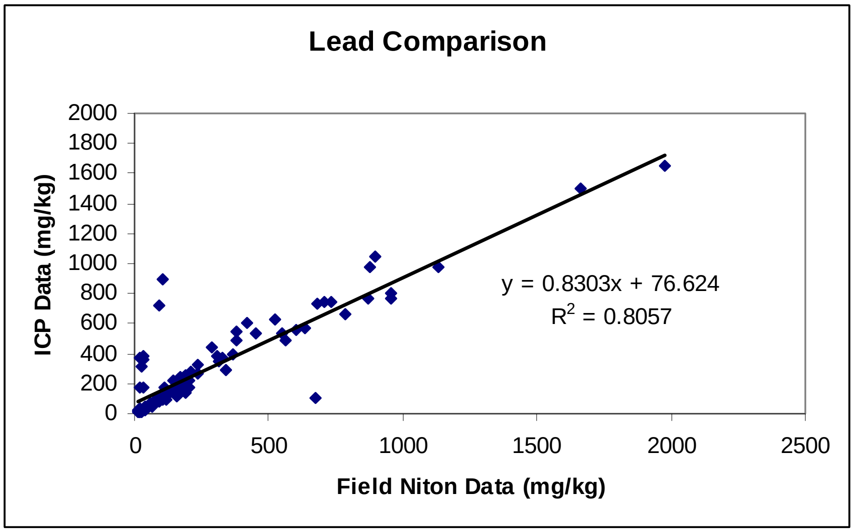


Figure B-2: 2002 Lead Comparison



During the summer 2006 projects, soil samples were collected and analyzed with the XRF instruments from a variety of locations. These locations included: undisturbed portions of the school playfields, sections of the playfields where initial soil excavations had occurred, and areas that had been processed by the deep mixer. As timely decision making was often required to keep the projects on schedule, the ability to assess the effectiveness of remediation activities with on-site soil analysis was invaluable to the overall success of the project. The XRF could determine concentrations of lead and arsenic in minutes. Sending samples for laboratory analysis at standard rates takes 2-3 weeks and would have drastically reduced the efficiency of remedial activities. Real-time results from these field analyses enabled project staff to make decisions such as whether the removal of additional soil was necessary or whether the barrel of the deep mixer should be raised to mix less soil or lowered to mix more.

Following the completion of the remediation projects conducted in 2006, additional samples were collected for comparison between XRF and Lab ICP methods. A total of 95 additional samples were collected and analyzed by both methods. These samples were analyzed by XRF prior to packaging in clean sealed jar. The analysis (as shown in the graphs below) found that the Innov-X XRF had a correlation coefficient (r2 value) between field and Inductively-Coupled Plasma (ICP) laboratory analyses of 0.779 for arsenic and 0.893 for lead. It should be noted that many of the data points were actually detection limits of both analysis methods for samples where lead or arsenic was not detected. When those non-detect data points are removed, the analysis found that the Innov-X XRF had a correlation coefficient (r2 value) between field and Inductively-Coupled Plasma (ICP) laboratory analyses of 0.838 for arsenic and 0.879 for lead.

Figure B-3: 2006 Arsenic Comparison

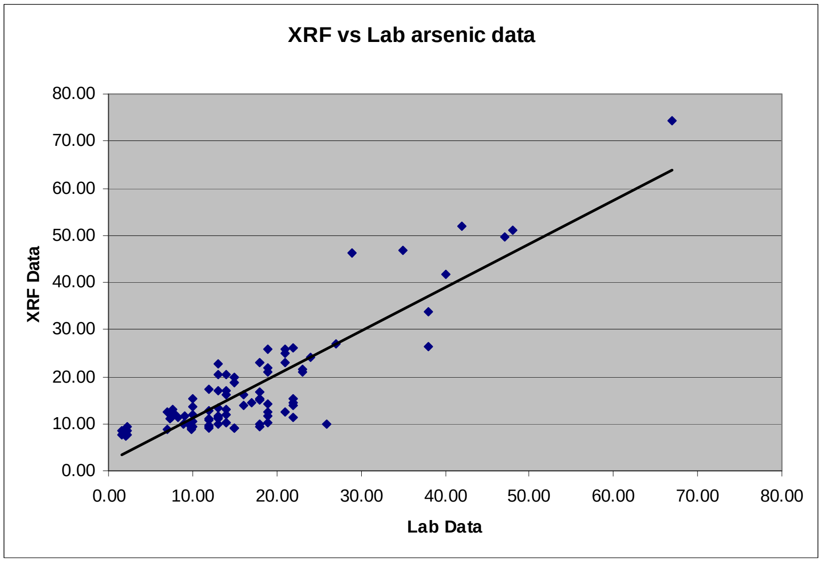
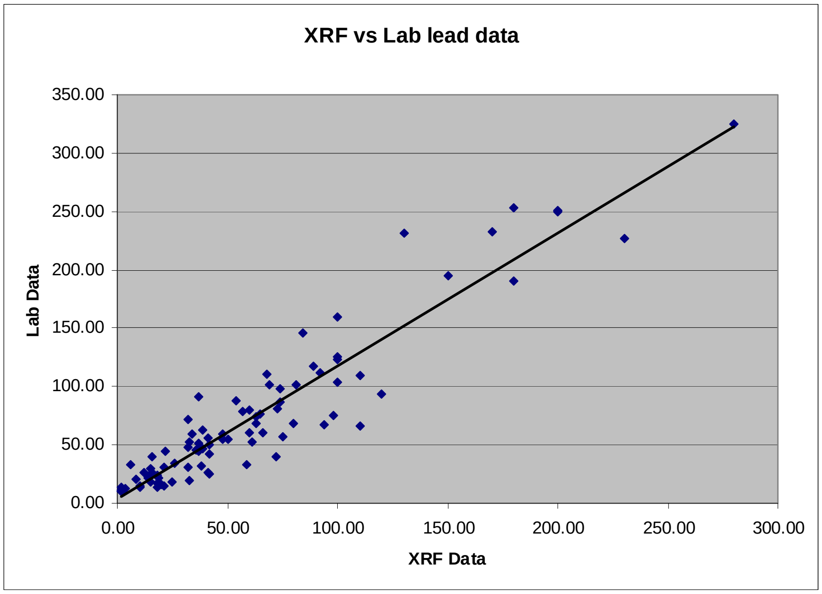


Figure B-4: 2006 Lead Comparison



Project staff followed all safety protocols for use of the XRF instruments including completion of mandatory information and safety trainings before sampling analysis began. In order to reduce health risks associated with radiation exposure, the instruments were operated while in a docking station and careful attention was paid to eliminate direct x-ray exposure. Actual amounts of radiation exposure as regulated by OSHA were monitored with the use of dosimeters which were carried by all sampling personnel.

Finally, in addition to the time saving benefits of the XRF instruments, their use proved to be a cost effective option for sample analysis. Due to the area (total acreage) covered during the school remediation projects, a large number of samples were required to characterize site progress. Use of the instruments resulted in a significant reduction in the number of soil samples sent off for laboratory analysis at a cost of $62-$66 per sample. Therefore, instead of project money being spent on one time analyses, it was invested in a second XRF instrument which enabled remediation work to occur simultaneously in several locations. Not only has the instrument paid for itself over the course of a single summer, but it will now be available for use in many future projects.

Appendix C: COSTS

Remediation costs were higher than anticipated due to higher arsenic concentrations than expected, therefore eliminating deep mixing as a feasible remediation technique.

North Omak Elementary Remediation Costs

Mobilization	
Soil Transportation	$44,055
Equipment Mobilization	$3,300
Demobilization of Equipment	$7,500
Waste Container and disposal	$1,357
Labor and Truck Rental	$1,245
Excavation Costs	
Soil Excavation	$34,131
Landscaping	
Wood Chips	$2,433
Drainage Fabric	$13,110
Import/Spread Topsoil	$51,150
Sod and Installation	$15,510
Hydroseeding	$26,218
Sod Purchase	$323
Irrigation	
Irrigation System	$61,600
Miscellaneous	
Removal of Playground Equipment	$10,758
Debris Disposal	$722
Install Playground Equipment	$11,000
Area Prep	$39,850
Misc. Charges	$13,700
Total	$363,529
Acres remediated	6.40
Cost per acre	$56,801
Square feet remediated	278,784
Cost per square foot	$1.30

Appendix D: PHOTO LOG

Photo D-1: North Omak Elementary playground pre-remediation

Photo D-2: North Omak Elementary playground post-remediation

Photo D-3: North Omak Elementary during excavation and grading

Photo D-4: North Omak Elementary fenced play area after remediation

Appendix E: BIBLIOGRAPHY

US EPA. Method 6200. “Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment”. January 1998.

US EPA. “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 2006.