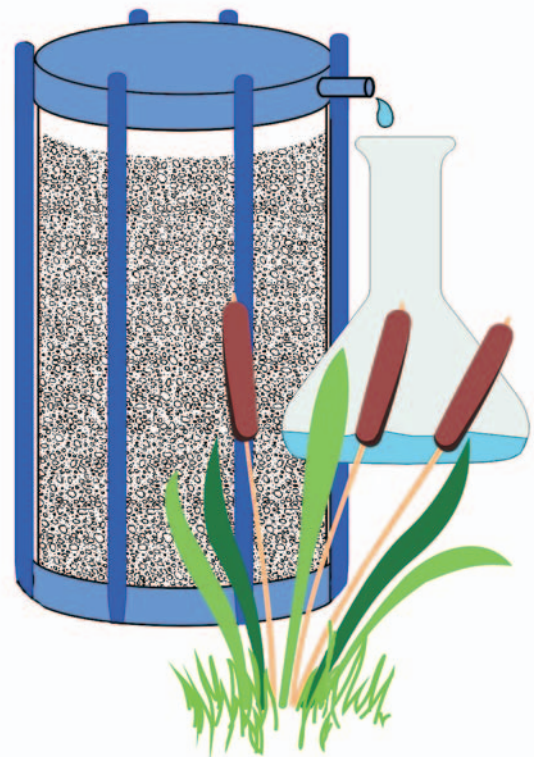


Environmental Sciences Laboratory

Analysis of MSE Cores Tuba City, Arizona, Site

March 2004

Prepared for
U.S. Department of Energy
Grand Junction, Colorado



Work Performed Under DOE Contract No. DE-AC01-02GJ79491 for the U.S. Department of Energy
Approved for public release; distribution is unlimited.

Office of Legacy Management

Analysis of MSE Cores

Tuba City, Arizona, Site

March 2004

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE-AC01-02GJ79491
for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado

Signature Page

Analysis of MSE Cores

Tuba City, Arizona, Site

March 2004

Prepared By: 
Brandon Danforth, Environmental Scientist
Environmental Sciences Laboratory

Reviewed By: 
Stan J. Morrison, Manager
Environmental Sciences Laboratory

End of current text

Contents

Signature Page	iii
Acronym List	vii
Executive Summary	ix
1.0 Introduction.....	1
2.0 Laboratory Methods.....	3
3.0 Results and Discussion	5
4.0 Conclusions.....	7

Tables

Table 1. MSE-1 Analytical Data.....	9
Table 2. MSE-2 Analytical Data.....	10
Table 3. MSE-3 Analytical Data.....	11
Table 4. MSE-4 Analytical Data.....	12
Table 5. MSE-6 Background Analytical Data	13

Figures

Figure 1. MSE Core Uranium Concentrations by Elevation	15
Figure 2. MSE-6 Core Uranium/Iron Regression Line.....	16
Figure 3: Tuba City, Arizona, Site Plan View of EVS-Generated Solid-Phase Uranium Concentration Distribution 25 Ft Below Ground Surface	17
Figure 4: West to East View of North-South Cross-Section Through EVS-Generated Solid-Phase Uranium Plume at the Tuba City, Arizona, Site	18
Figure 5. MSE Core Manganese Concentrations by Elevation	19
Figure 6. MSE Core Calcium Concentrations by Elevation	20
Figure 7. MSE Core Iron Concentrations by Elevation.....	21

Appendices

Appendix A. MSE Soil Core Pictures

End of current text

Acronym List

Ca	calcium
DOE	U.S. Department of Energy
ESL	Environmental Sciences Laboratory
EVS	Environmental Visualization System
Fe	iron
g	gram
HNO ₃	nitric acid
mL	milliliter
Mn	manganese
mg/kg	milligrams per kilogram
Se	selenium
U	uranium

End of current text

Executive Summary

A pump-and-treat system designed for ground water remediation at a former uranium-ore milling facility near Tuba City, Arizona, began operation in March 2002. The distillation system treats ground water from extraction wells installed to the south and east of a uranium mill tailings disposal cell, removing contamination from a ground water contaminant plume moving downgradient of the cell. Currently, ground water is being pumped from wells in which the screens begin between 90 and 100 feet (ft) below ground surface and end at depths around 250 ft below ground surface. Because of the lengths and depths of the screen intervals in the extraction wells, ground water from these wells is probably a mixture of cleaner water from deeper in the aquifer and contaminated water from near the surface. If the contaminant plume does not extend into deeper portions of the aquifer, well screens could be installed at shallower intervals and remove the contaminated ground water more effectively.

In 1997, MSE Technologies, Inc. extracted five 3-inch-diameter cores at the Tuba City site. The 150-ft-deep cores are mostly complete; however, all are missing the top 25 to 50 ft and a few sections within. Four of the MSE cores are from boreholes inside the estimated plume area; three are located to the south (MSE-1, MSE-3, and MSE-4), and one is east of the disposal cell (MSE-2). A fifth MSE core (MSE-6) is from a borehole located to the northwest (upgradient) of the disposal cell and serves as a source for background values.

In August 1998, soil samples were taken from soil core MSE-3 at a number of depths, digested in 20 percent nitric acid, and analyzed for U, Mn, Ca, Se and Fe. High U concentrations near the top of the MSE-3 core that quickly decreased with depth suggested that the bulk of the contamination was shallower than previously thought. In December 2003, the remaining four MSE soil cores were sampled, digested, and analyzed for U, Mn, Ca, and Fe to see if the same abrupt high to low U trend was present at other parts of the site.

Analysis of U concentrations in the remaining three cores within the estimated contaminated area indicated that MSE-1 and MSE-4 follow this trend fairly well, whereas MSE-2 does not follow it as closely. Although the majority of the high U soil concentrations are above 50 ft below ground surface, a few relatively high concentrations were measured deeper, although at sporadic intervals. These higher concentrations at deeper elevations are separated from the main solid-phase contaminant plume by sections of core with low concentrations, suggesting that they may be accumulations of natural background sources rather than deposits from contaminated ground water.

Additional analysis of uranium/iron regression lines for each core showed a high correlation in the background core MSE-6 ($r^2 = 0.86$), but low correlations for the remaining cores. This suggests that uranium in the background ground water has adsorbed onto naturally occurring iron oxide in the soil, and that other soil uptake mechanisms may be active in the contaminated area.

Uranium concentration measurements from the five MSE cores as well as interpolations using Environmental Visualization System software provide evidence that Tuba City extraction wells may be pumping clean water from the aquifer. Extraction well screen depths appear to extend well below the highest of the solid-phase U concentrations. The top of some extraction well screens may also be below the highest concentrations in the ground water. However, further investigation is still needed to better define the spatial extent of the contaminant plume and to determine if remediation of the ground water can be more efficient.

End of current text

1.0 Introduction

A pump-and-treat system designed for ground water remediation at a former uranium-ore milling facility near Tuba City, Arizona, began operation in March 2002. The distillation system treats ground water from extraction wells installed to the south and east of a uranium mill tailings disposal cell, removing contamination from a plume moving downgradient of the cell. Currently, ground water is being pumped from wells in which the screens begin between 90 and 100 feet (ft) below ground surface and end at depths around 250 ft below ground surface. Because of the lengths and depths of the screen intervals in the extraction wells, ground water from these wells is probably a mixture of cleaner water from deeper in the aquifer and contaminated water from near the surface. If the contaminant plume does not extend into deeper portions of the aquifer, well screens could be installed at shallower intervals and remove the contaminated ground water more effectively.

In 1997, MSE Technologies, Inc. extracted five 3-inch-diameter cores at the Tuba City site as part of an Innovative Technology demonstration. Collection of the mostly complete 150-ft cores began approximately at the water table (25 to 50 ft below ground surface). Four of the MSE cores were taken from inside the estimated plume area; three were collected south of the disposal cell (MSE-1, MSE-3, and MSE-4), and one was collected east of the disposal cell (MSE-2). A fifth core (MSE-6) was collected northwest (upgradient) of the disposal cell and serves as a source for background values.

In August 1998, one of the cores, MSE-3, was logged and analyzed at a number of depths by personnel from the Environmental Sciences Laboratory (ESL) at the U.S. Department of Energy compound in Grand Junction, Colorado. Analysis of U concentrations indicated that concentrations were highest at shallower depths and decreased abruptly with depth. Similar trends were noted for Se and Mn.

In October 2003, ESL personnel proposed an expanded study of the MSE cores to better define the spatial extent of contamination at the Tuba City site. The proposal included logging and analyzing the remaining three MSE cores within the estimated plume area, as well as the background core to the northeast. The study would evaluate whether concentrations in the remaining MSE cores inside the plume area showed trends similar to those in the MSE-3 core in 1998.

End of current text

2.0 Laboratory Methods

Each of the soil cores was treated and analyzed using the methods explained below.

The core (except MSE-3) was laid out in its storage boxes and photographed using a digital camera. Selected sample intervals were then marked along the core. Samples were selected fairly close together near the top of the core and were spread out more at the middle and end. Core MSE-3 was sampled at 20 locations, about half red or yellow shades and half gray or white shades.

Soil samples were leached using a variation of the “Standard Batch Leaching” procedure, CB(BT-1), in the *Environmental Sciences Laboratory Procedures Manual*. Approximately 20 grams (g) of soil were removed at each sample mark, sieved through a No. 10 mesh (<2 millimeter [mm]) opening and logged for consistency and color (see [Tables 1 through 5](#)). 10.0 g of each sample (5.0 g for MSE-3) was weighed and placed into 50 milliliter (mL) plastic centrifuge tubes and filled with 20 percent nitric acid (HNO₃). All tubes were placed on an end-over-end rotating stir bar for 4 hours. The centrifuge tubes were then removed from the stir bar, and the HNO₃ was decanted into a 100 mL volumetric flask. The centrifuge tubes were again filled with 20 percent HNO₃ and placed on the end-over-end stir bar for 30 minutes. The HNO₃ in each tube was decanted again into its respective 100 mL volumetric flask. Each 100 mL volumetric flask was filled to volume with 20 percent HNO₃ and filtered using a vacuum filter.

Each leachate sample was analyzed for U with the ChemChek Kinetic Phosphorescence Analyzer and for Fe, Mn, and Ca by Atomic Absorption Spectrometer. The 1998 analyses of MSE-3 leachates were performed by the Department of Energy’s Analytical Chemistry Laboratory in Grand Junction.

End of current text

3.0 Results and Discussion

The cores were analyzed for U, Mn, Fe, and Ca. Uranium and manganese were analyzed because they are contaminants. Calcium, a constituent of the tailings within the disposal cell, was analyzed to evaluate whether it had moved with the plume and precipitated in appreciable quantities as calcite. Calcite precipitation could fill soil pores and reduce soil porosity, potentially changing the movement of the plume. Iron was chosen for analysis because U has a tendency to adsorb to iron oxide minerals. Iron concentration spikes or dips that correspond to those of U could provide information on potential U sinks.

Uranium Results: As with the U distribution in the August 1998 analysis of core in MSE-3, U concentrations in the remaining three cores within the estimated plume area were expected to be highest at the shallower depths and decrease abruptly with depth. Although MSE-1 and MSE-4 follow this trend fairly well, MSE-2 does not follow it as closely (Figure 1).

The lowest concentrations are closer to the surface in MSE-2; the highest concentrations are about 80 ft below ground surface. The unexpected U concentration trend for MSE-2 may be due to its location to the east of the disposal cell, which may be outside or just on the edge of the contaminant plume area. Also, the top 40.5 ft of the MSE-2 core is missing; only the top 25 ft of the MSE-1 core is missing. Perhaps the uranium concentration in MSE-2 from 42 ft below ground surface (the fourth sample point from the top) and up would increase significantly if an additional 15 ft of core above the top sample were available for analysis.

Uranium concentrations in the background core, MSE-6, were fairly consistently low at each depth, except for one higher value (0.0859 milligrams per kilogram [mg/kg]) about 90 ft below ground surface. Cores MSE-2 and MSE-4 also have higher uranium values between 80 and 100 ft below ground surface. The higher concentrations at these depths could represent a soil layer with naturally high uranium concentrations.

Uranium-Iron Correlations: Uranium-iron regression lines were created for each core to determine if there was any correlation between U and Fe concentrations. Only soil core MSE-6, the background location, showed a good correlation ($r^2 = 0.86$) (Figure 2). MSE-2 showed the next highest correlation ($r^2 = 0.19$); the remaining cores showed little or no correlation ($r^2 < 0.1$).

EVS figures: Environmental Visualization System (EVS) is software capable of krigging soil or ground water concentration data and producing estimated 3-dimensional maps of contaminant plumes. It produces more realistic interpolation when provided with more data. Because of the limited number of locations with soil data (five MSE cores), krigging required large amounts of interpolation and extrapolation, but the results are still useful for visualization. The EVS figures created in this report represent a solid-phase U plume, not a ground water U plume.

Figure 3 shows a plan view of the Tuba City site with the top surface of the krigged U solid-phase contaminant plume at the depth of the shallowest core (MSE-1, 25 ft below ground surface). Figure 3 displays concentrations above 0.05 mg/kg, with the highest concentrations surrounding cores MSE-1 and MSE-4, both of which are directly south and downgradient from the disposal cell. MSE-6, the background core, and MSE-2, east of the disposal cell, are outside of the estimated main plume. Although five sample concentrations from MSE-2 and one from MSE-6 were above 0.05 mg/kg, EVS lacked enough data to connect these hotspots to the main

plume. The black line down the middle of the plume in Figure 3 marks the cross-sectional path of Figure 4.

Figure 4 is a west-to-east view of a north-south cross-section through the middle of the U solid-phase contaminant plume. The cross-section shows only concentrations that are greater than 0.05 mg/kg and are at least 25 ft below ground surface (depth of top of MSE-1 core). By showing only data below 25 ft, unrealistic extrapolation of concentrations from the EVS krigging toward the surface is limited. Figure 4 is a sample cross-section through the middle of the EVS-generated plume; not all cross-sections through the plume would look identical.

The plume in Figure 4 appears to pinch in the center where the cores are located. The flaring of the plume on either side of the center is due to lack of data to the north and south of MSE-1 and MSE-4, which allows the plume to appear deeper in these areas than it most likely is in reality. In the middle of the cross-section, the plume only extends down to about 50 ft below ground level. Marked in pink in Figure 4 is a zone from 100 to 250 ft below ground level depicting the area that extraction well screens are installed. The figure shows that the major portion of the EVS-generated solid-phase contaminant plume is above this zone.

Water levels were historically about 20 ft higher than they are today. Pumping by extraction wells has lowered ground water levels significantly. Figure 4 shows the approximate historical and current water levels. More than half the depicted solid-phase U plume (and the highest concentrations) are above the historical ground water level, and almost all of the plume is above the current ground water level. Although other sections of the plume may extend deeper below the current water table, it appears that most of the plume and the highest concentrations are closer to the surface.

A few U soil concentrations above 0.05 mg/kg were found below 50 ft in both the MSE-1 and MSE-4 cores; however, EVS did not have enough data to interpret these values as being connected to the main plume. A cross-section directly through each core would show a small plume around each soil sample where U concentrations were above 0.05 mg/kg. These higher concentrations at greater depths are separated from the main plume by sections of core with low concentrations, suggesting that they may be accumulations of natural background sources rather than deposits from the contaminant plume.

Other analytical results: Manganese soil measurements from the five cores (Figure 5) followed a trend somewhat similar to that of uranium. Soil sample concentrations tended to be higher at shallower depths, possibly suggesting that they were deposited by contaminated ground water. Although the background core (MSE-6) also showed a higher concentration at a shallow depth, these manganese results may still be indicative of a shallow ground water contaminant plume.

Calcium soil measurements (Figure 6) showed no obvious trends that would suggest deposition from a ground water contaminant plume.

Iron soil measurements (Figure 7) were used in the iron-uranium correlations.

4.0 Conclusions

Uranium concentration measurements from the five MSE cores as well as interpolations using EVS provide evidence that Tuba City extraction wells may be pumping clean water from the aquifer. Extraction well screen depths appear to extend well below the highest of the solid-phase U concentrations. The top of some extraction well screens may also be below the highest concentrations in the ground water.

Although this study shows some indication that ground water remediation at the site could become more efficient if extraction well screens were modified, further investigation is needed to better define the spatial extent of the contaminant plume.

End of current text

Table 1. MSE-1 Analytical Data

Sample Number	U mg/kg	Ca mg/kg	Mn mg/kg	Fe mg/kg	Depth (ft)	Elevation (ft above msl)	Descriptions
MSE1-A	3.522	124	5.8	44.4	25	5,038	v. pale brown, mod friable
MSE1-1	2.561	120	6	59.2	25.2	5,037.8	ss, white, mod indurated
MSE1-B	2.079	113	3.2	33.9	27.7	5,035.3	v. pale brown, friable
MSE1-2	0.123	498	15	195	31.2	5,031.8	ss, white, mod indurated
MSE1-C	0.1062	356	5.3	114	32.2	5,030.8	v. pale brown, mod friable
MSE1-3	0.0204	290	5.9	69.2	34	5,029	ss, white, mod indurated
MSE1-4	0.092	310	5.1	59.8	38.3	5,024.7	ss, white, mod indurated
MSE1-5	0.0826	245	5	74.2	44.2	5,018.8	ss, white, friable
MSE1-6	0.0146	330	5	221	48.5	5,014.5	ss, white, mod indurated
MSE1-7	0.015	465	5	126	53.6	5,009.4	ss, reddish yellow, thinly bedded, variegated, mod indurated
MSE1-8	0.024	355	5.1	140	59	5,004	ss, v. pale brown, mod indurated to friable
MSE1-9	0.0085	1198	3.8	126	61.2	5,001.8	ss, v. pale brown, friable
MSE1-10	0.0121	440	9.6	405	64.7	4,998.3	ss, lt. Reddish brown, thinly bedded, friable
MSE1-11	0.0143	435	11.8	151.5	70.2	4,992.8	ss, lt. Reddish brown, thinly bedded, friable
MSE1-12	0.0111	255	1.7	73.5	73.5	4,989.5	ss, pink friable
MSE1-13	0.0068	300	1.7	57.2	85.7	4,977.3	ss, v. pale brown, friable
MSE1-14	0.012	455	1.2	37.3	89.8	4,973.2	ss, v. pale brown, friable
MSE1-15	0.0123	1180	1.8	40.1	94.8	4,968.2	ss, lt. Reddish brown, thinly bedded, friable
MSE1-16	0.0131	605	1	76.5	98.8	4,964.2	ss, lt. Reddish brown, thinly bedded, mod indurated
MSE1-17	0.0089	410	3.9	25.2	105.8	4,957.2	ss, lt reddish brown, cross-bedded, mod indurated
MSE1-18	0.0053	280	1.8	18.6	109.4	4,953.6	ss, lt reddish brown, cross-bedded, friable
MSE1-19	0.0094	440	1.3	147	112.8	4,950.2	ss, reddish brown, friable
MSE1-20	0.0107	390	1.7	180	117.5	4,945.5	ss, lt reddish brown, mod indurated
MSE1-21	0.011	345	1.9	65	123	4,940	ss, reddish yellow, v. friable
MSE1-22	0.0177	735	1.2	92.5	129	4,934	ss, reddish yellow, v. friable
MSE1-23	0.0072	290	1.5	33.6	136	4,927	ss, pink, v. friable
MSE1-24	0.0071	282	1.2	28.4	139.8	4,923.2	ss, reddish yellow, v. friable
MSE1-25	0.0089	380	1.2	32.8	146	4,917	ss, reddish yellow, v. friable

Table 2. MSE-2 Analytical Data

Sample Number	U mg/kg	Ca mg/kg	Mn mg/kg	Fe mg/kg	Depth (ft)	Elevation (ft above msl)	Descriptions
MSE2-A	0.01289	295	4.5	135	40.5	5,024.4	pale yellow, friable
MSE2-1	0.00806	160	10.1	85.6	41.2	5,023.7	pale yellow, friable
MSE2-B	0.00878	121.5	9.6	154.5	42.3	5,022.6	pale yellow, friable
MSE2-2	0.00481	53.5	4.7	122.5	45	5,019.9	pale yellow, mod. friable
MSE2-C	0.00794	112.5	4	130.5	45.5	5,019.4	pale yellow, friable
MSE2-3	0.01097	162	7.3	172.5	47.6	5,017.3	pale yellow, friable
MSE2-4	0.06435	90.2	3.7	109	64.8	5,000.1	pale yellow, friable
MSE2-5	0.05732	163.5	7.4	147	70.5	4,994.4	v. pale brown, friable
MSE2-6	0.05526	622	2.2	93.5	76.2	4,988.7	light gray, friable
MSE2-7	0.02297	1275	1.1	51.5	78.7	4,986.2	light gray, friable
MSE2-8	0.02145	1075	0.8	103	81	4,983.9	light gray, indurated
MSE2-9	0.1963	580	3.5	211.5	84.3	4,980.6	light gray, mod. indurated
MSE2-10	0.01889	1400	1.8	78.5	87.8	4,977.1	light gray, indurated
MSE2-11	0.01531	348	0.7	26.2	92	4,972.9	v. pale brown, friable
MSE2-12	0.01701	602	1.8	128	94.8	4,970.1	light gray, friable
MSE2-13	0.01738	442	2	51	98.6	4,966.3	v. pale brown, friable
MSE2-14	0.01885	490	2	63.8	103.4	4,961.5	v. pale brown, friable
MSE2-15	0.02202	550	5.4	69.2	105	4,959.9	pink, friable
MSE2-16	0.03991	1385	1.6	92.8	108	4,956.9	pink, mod. Indurated
MSE2-17	0.03166	638	2.9	91.6	112.8	4,952.1	reddish yellow, mod. Indurated
MSE2-18	0.0232	662	3.1	100.8	116.4	4,948.5	reddish yellow, mod. Indurated
MSE2-19	0.0158	394	0.6	40.1	119.8	4,945.1	reddish yellow, mod. Indurated
MSE2-20	0.01382	364	1	33.5	126.7	4,938.2	pink w/ light gray streaks, mod friable
MSE2-21	0.01661	426	0.8	93.6	130.5	4,934.4	red, friable
MSE2-22	0.01054	480	0.8	18.1	134.3	4,930.6	v. pale brown, friable
MSE2-23	0.05685	33300	0.7	17	141.5	4,923.4	pink, friable
MSE2-24	0.0167	388	0.6	34.6	144.5	4,920.4	pink, friable
MSE2-25	0.01545	256	0.8	18	147.4	4,917.5	pinkish white, friable

Table 3. MSE-3 Analytical Data

Sample Number	U mg/kg	Ca mg/kg	Mn mg/kg	Fe mg/kg	Se mg/kg	Depth (ft)	Elevation (ft above msl)	Descriptions
MSE3-40	0.15	178	23.6	257	0.06	40	5,022.9	Gray ss. Top of core. Friable.
MSE3-44	0.14	184	14.6	316	0.04	44	5,018.9	Gray sand. Friable. v. soft, like beach sand.
MSE3-48.5	0.1		20.6	181	0.04	48.5	5,014.4	Gray ss. Friable.
MSE3-53	0.1	19300	62.8	128	0.04	53	5,009.9	Tan, beige sand from around carbonate stringer.
MSE3-56	0.11		17	124	0.04	56	5,006.9	Beige to tan ss. Friable.
MSE3-57	0.1	182	18.9	162	0.04	57	5,005.9	Beige ss. Friable
MSE3-65	0.08	382	17.6	124	0.04	65	4,997.9	Beige sand. Friable. Dry.
MSE3-67	0.06	128	8.9	128	0.04	67	4,995.9	Red brown. Friable.
MSE3-72	0.03	466	4	241	0.04	72	4,990.9	Red br. sand. Friable.
MSE3-74	0.02	238	4.2	190	0.04	74	4,988.9	Tan sand.
MSE3-77	0.02	326	5.9	157	0.04	77	4,985.9	Light tan ss. Consolidated.
MSE3-80	0.02	326	4.5	357	0.04	80	4,982.9	Red br. sand. Friable.
MSE3-88	0.02	290	1.5	136	0.04	88	4,974.9	Red brown ss. Friable.
MSE3-96	0.03	290	3.3	164	0.04	96	4,966.9	Red brown sand. Friable.
MSE3-103	0.02	160	3.4	189	0.04	103	4,959.9	Red brown sand. Friable.
MSE3-115	0.02	184	4.6	197	0.04	115	4,947.9	Red brown sand. Friable.
MSE3-123	0.02	272	3.1	66.2	0.04	123	4,939.9	Red brown sand. Friable.
MSE3-137	0.02	266	2.5	72.1	0.04	137	4,925.9	Red brown sand. Friable.
MSE3-144	0.02	132	14.6	628	0.04	144	4,918.9	Deep red br sand. Friable.
MSE3-150	0.02	200	8.1	533	0.04	150	4,912.9	Red br sand. Friable.

Table 4. MSE-4 Analytical Data

Sample Number	U mg/kg	Ca mg/kg	Mn mg/kg	Fe mg/kg	Depth (ft)	Elevation (ft above msl)	Descriptions
MSE4-A	0.7506	3260	6.2	72.2	38.5	5,022.4	ss, light gray, friable
MSE4-1	1.157	1045	1.3	90	39.3	5,021.6	ss, v. pale brown, friable
MSE4-B	0.7244	1135	1.4	78	40.1	5,020.8	ss, v. pale brown, friable
MSE4-C	0.0755	600	0.4	49.7	41.9	5,019	ss, pink, friable
MSE4-2	0.01819	272	1.4	78	43.8	5,017.1	ss, light gray, friable
MSE4-4	0.07448	323	1	21.1	50.1	5,010.8	ss, light gray, friable
MSE4-5	0.03007	288	1.3	33	55.7	5,005.2	ss, v. pale brown, friable
MSE4-6	0.01587	190	1.4	52	57.2	5,003.7	ss, v. pale brown, friable
MSE4-7	0.10358	218	2.3	75.5	62.5	4,998.4	ss, v. pale brown, friable
MSE4-8	0.02333	257	2.3	67.5	65.8	4,995.1	ss, reddish yellow, mod. friable
MSE4-9	0.00654	237	4.8	171	70.7	4,990.2	ss, pink, friable
MSE4-10	0.01588	409	1.4	171	75.5	4,985.4	ss, pink, mod. Indurated
MSE4-11	0.08839	177	1.3	85	81.7	4,979.2	ss, v. pale brown, friable
MSE4-12	0.01971	428	1.4	93	87.8	4,973.1	ss, pink mod. friable
MSE4-13	0.00786	323	1.3	35.1	90.8	4,970.1	ss, pink, friable
MSE4-14	0.20038	478	2.4	91	96.5	4,964.4	ss, pink, friable
MSE4-15	0.1313	2690	2.4	52.3	99.5	4,961.4	ss, pinkish gray, mod. friable
MSE4-16	0.01794	2710	2.2	57.1	104.6	4,956.3	ss, pink, friable
MSE4-17	0.01061	2490	0.7	45.2	107.5	4,953.4	ss, pink, friable
MSE4-18	0.01498	4270	1.2	55.2	112.7	4,948.2	ss, light brown, mod. friable
MSE4-19	0.01281	2660	2.3	52.2	131.7	4,929.2	ss, light brown, friable
MSE4-20	0.0158	3420	1.1	75	134.4	4,926.5	ss, light brown, mod. friable
MSE4-21	0.01075	1860	1.3	39.5	140.5	4,920.4	ss, light brown, friable
MSE4-22	0.01211	2590	2.3	85.5	145.3	4,915.6	ss, reddish brown, friable

Table 5. MSE-6 Background Analytical Data

Sample Number	U mg/kg	Ca mg/kg	Mn mg/kg	Fe mg/kg	Depth (ft)	Elevation (ft above msl)	Descriptions
MSE6-1	0.02112	250	5.1	149.5	51.8	5.085.5	pale yellow, friable
MSE6-2	0.02587	385	13	179	58.2	5.079.1	v. pale brown, mod. friable
MSE6-3	0.03351	374	2.8	129.5	64.8	5.072.5	light gray, mod. friable
MSE6-4	0.03287	250	4.1	152.5	70.1	5.067.2	v. pale brown, mod. friable
MSE6-5	0.03819	346	4.4	101.5	76.4	5.060.9	v. pale brown, mod. friable
MSE6-6	0.02813	268	5.6	66.2	81.9	5.055.4	v. pale brown, friable
MSE6-7	0.08586	1375	6	519	87.1	5.050.2	light yellowish brown, mod. friable
MSE6-8	0.01619	295	3.4	100.5	95.7	5.041.6	v. pale brown, mod. friable
MSE6-9	0.00903	257	1.9	45.8	101.7	5.035.6	v. pale brown, mod. friable
MSE6-10	0.01033	332	3	70.6	104.5	5.032.8	light gray w/ rust specs, friable
MSE6-11	0.01095	255	2.9	81	107.6	5.029.7	v. pale brown, mod. friable
MSE6-12	0.01218	284	1.2	35.7	114.1	5.023.2	v. pale brown, friable
MSE6-13	0.01608	366	0.8	45.5	118.2	5.019.1	v. pale brown, friable
MSE6-14	0.01296	379	1.8	69.5	122.2	5.015.1	pinkish white, friable
MSE6-15	0.01113	352	1.5	43.8	126.5	5.010.8	white, friable
MSE6-16	0.01239	352	1.5	65	131.7	5.005.6	pinkish white, friable
MSE6-17	0.00972	330	1.7	32.5	134.7	5.002.6	pinkish white, friable
MSE6-18	0.01204	331	1.5	37.2	137.3	5.000	pinkish white, friable
MSE6-19	0.01034	387	2.1	76.5	141.7	4.995.6	v. pale brown w/ rust stain, friable
MSE6-20	0.01417	345	1.7	33	145.3	4.992	pinkish white, friable

End of current text

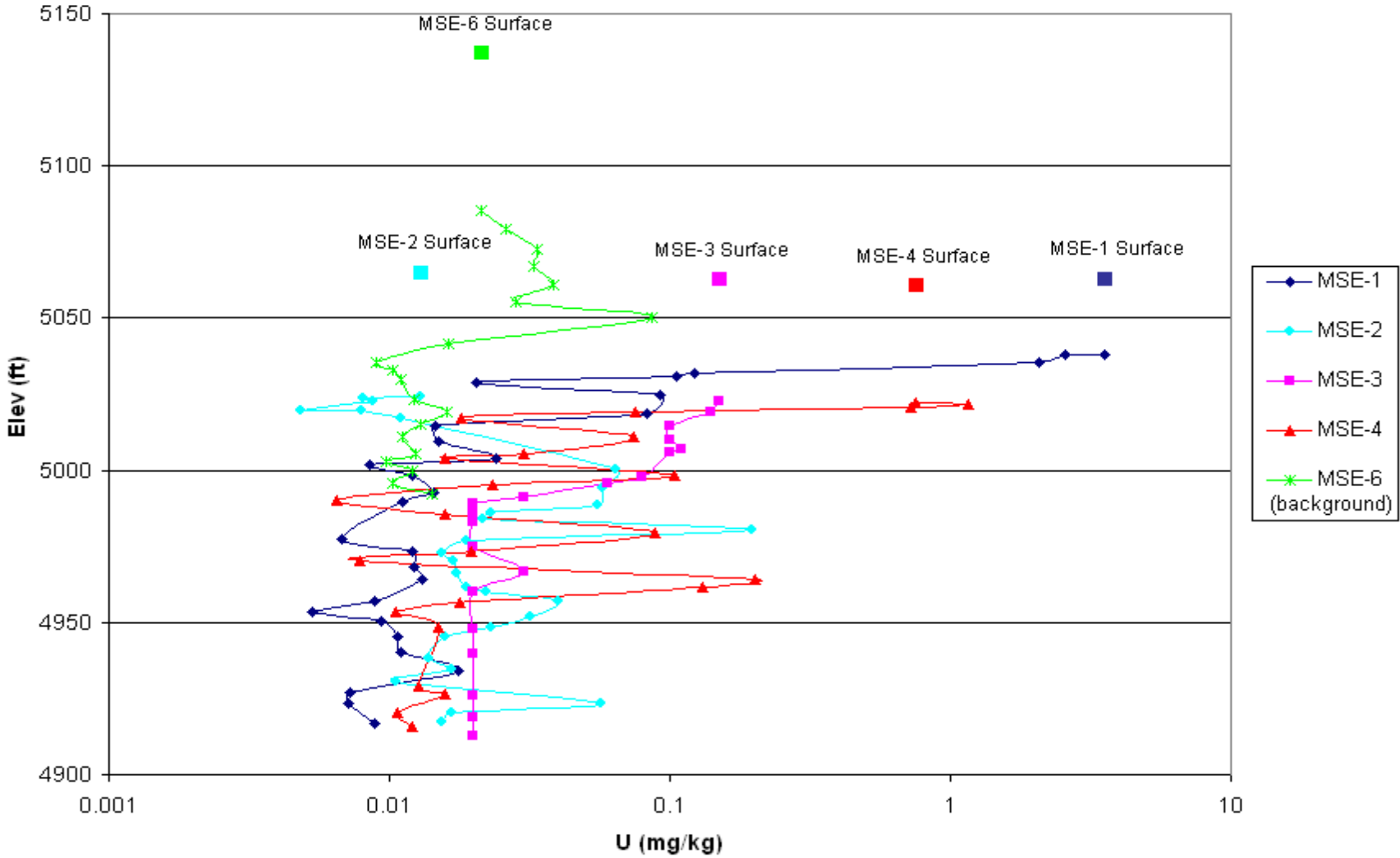


Figure 1. MSE Core Uranium Concentrations by Elevation

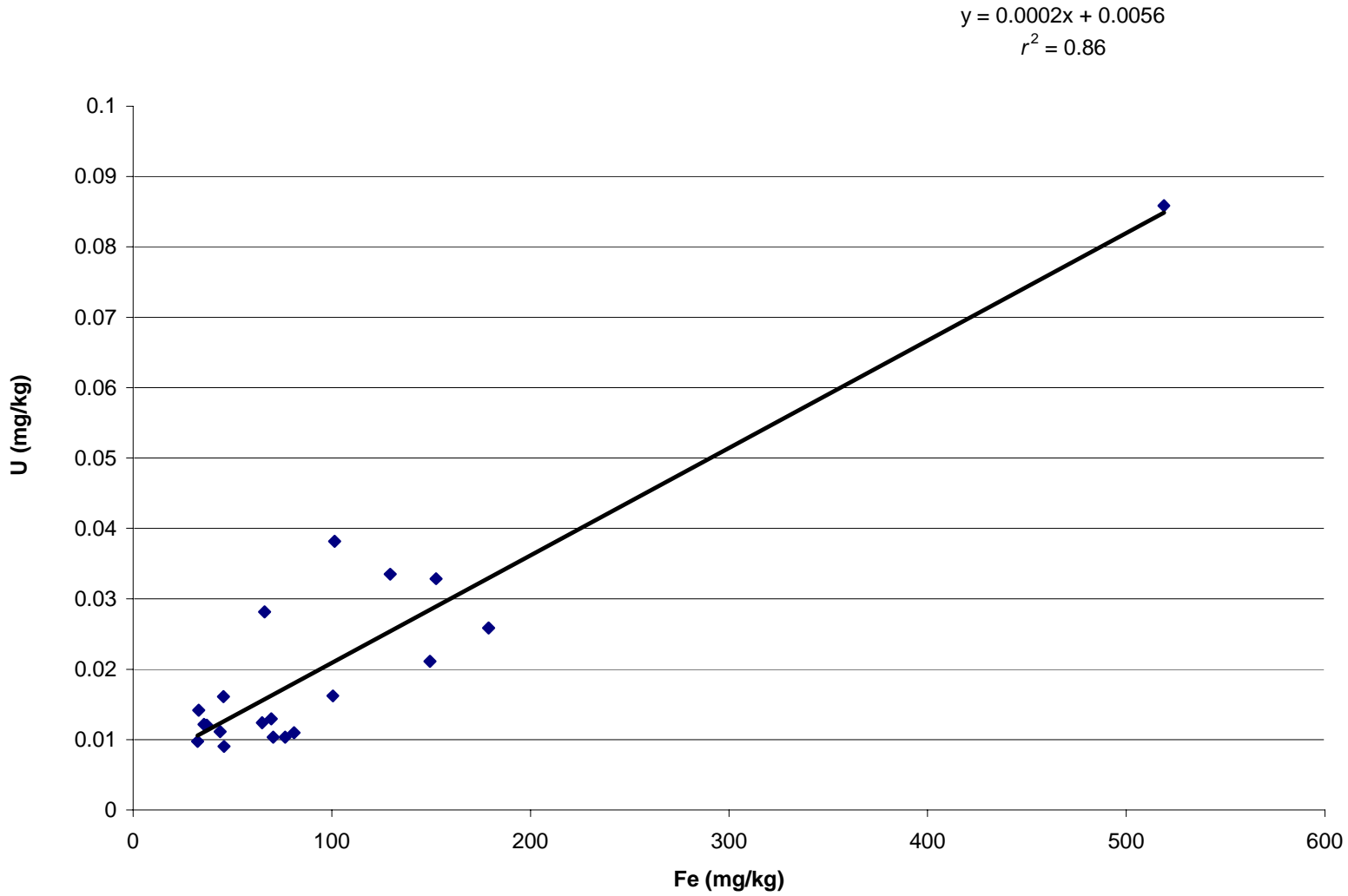


Figure 2. MSE-6 Core Uranium/Iron Regression Line

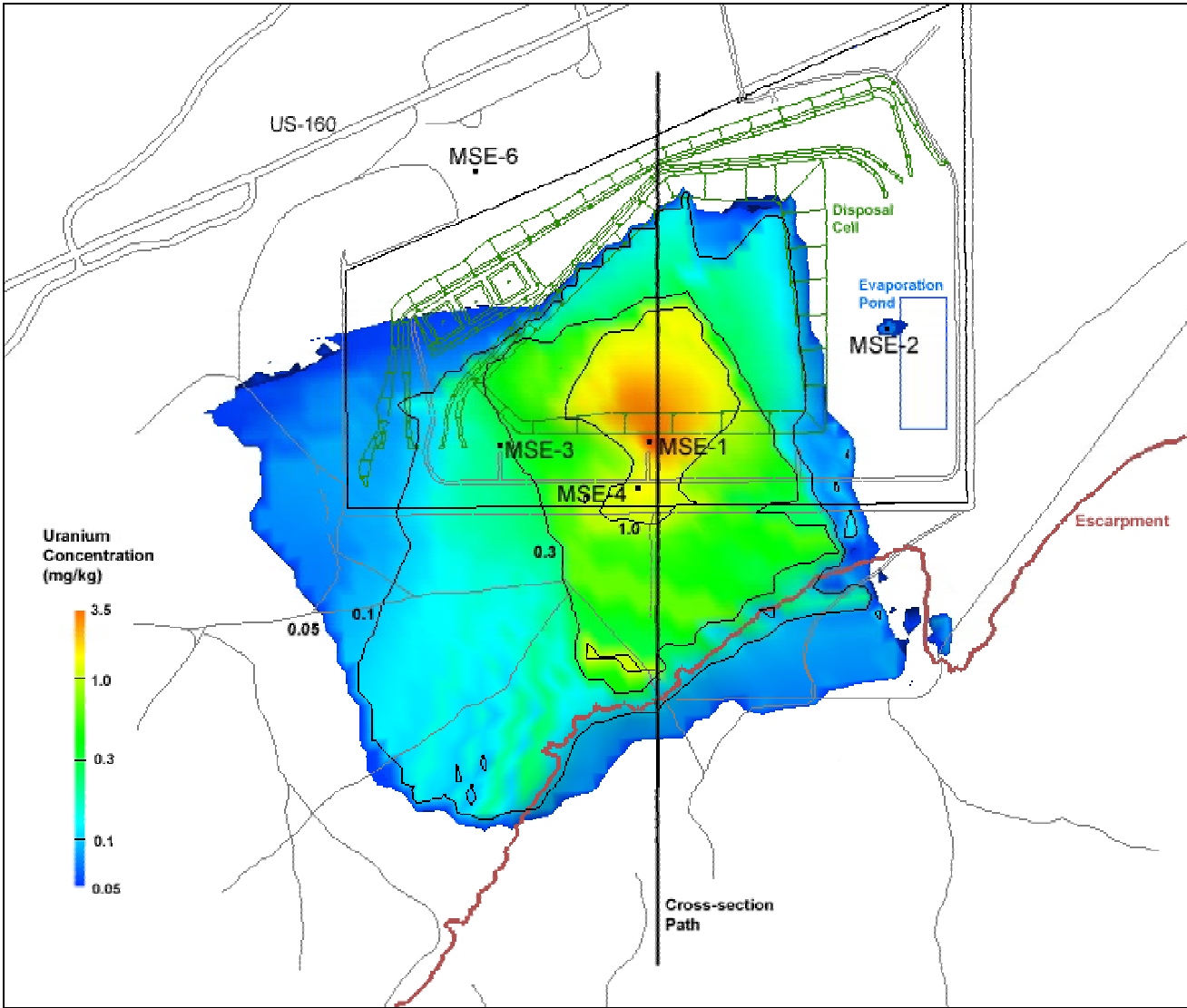


Figure 3: Tuba City, Arizona, Site Plan View of EVS-Generated Solid-Phase Uranium Concentration Distribution 25 Ft Below Ground Surface
Black line through the middle shows the cross-section path of Figure 3.

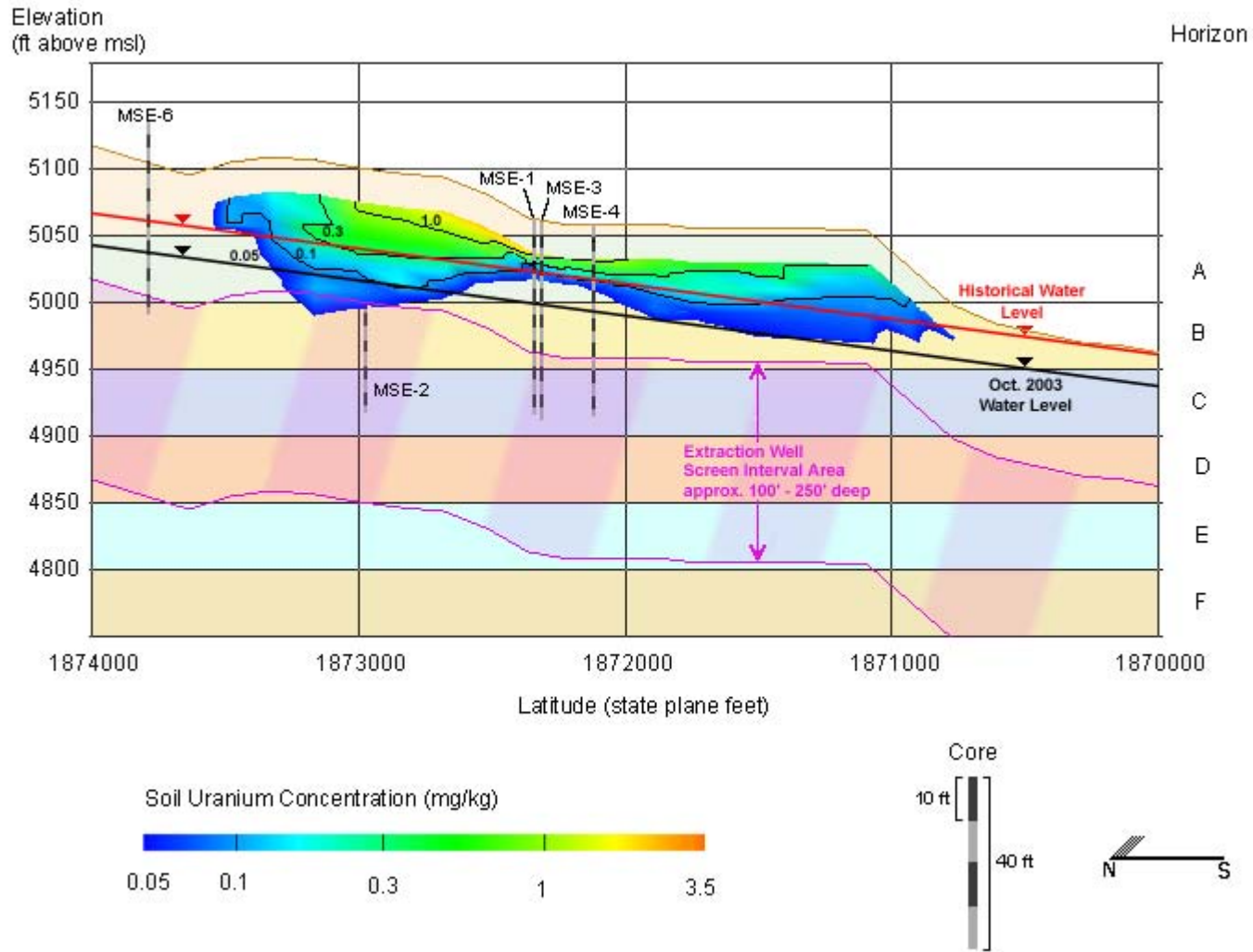


Figure 4: West to East View of North-South Cross-Section Through EVS-Generated Solid-Phase Uranium Plume at the Tuba City, Arizona, Site

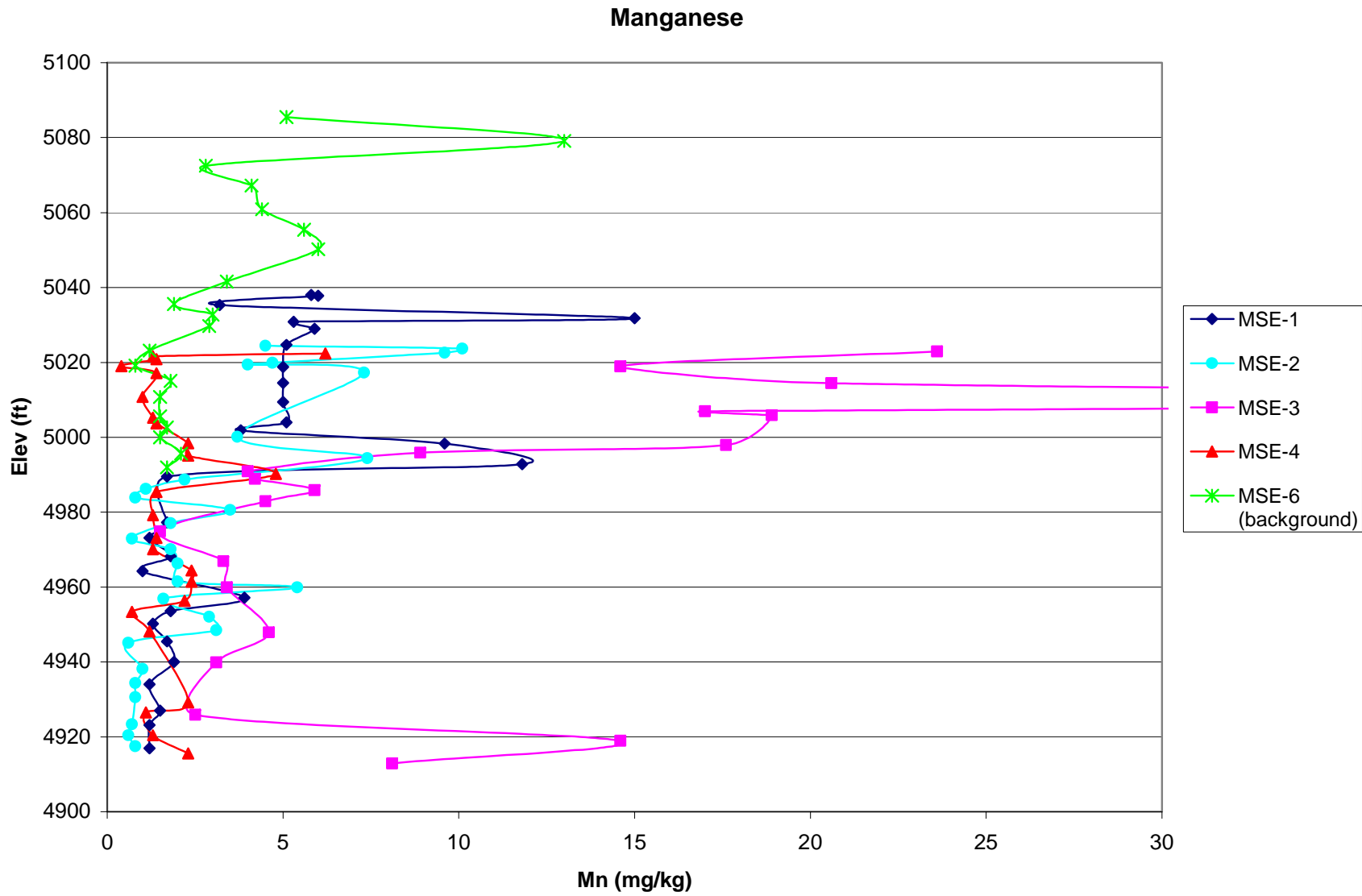


Figure 5. MSE Core Manganese Concentrations by Elevation

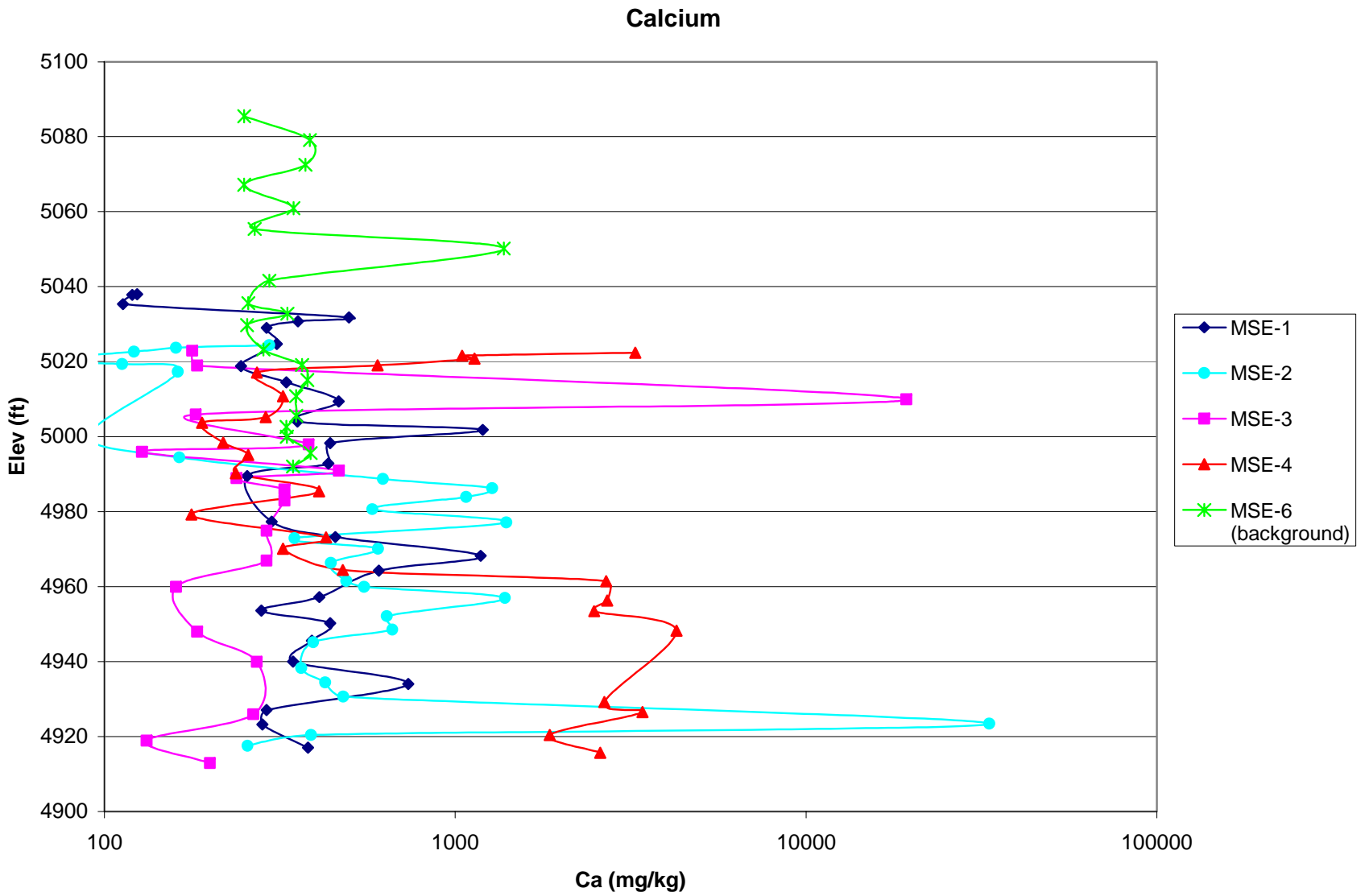


Figure 6. MSE Core Calcium Concentrations by Elevation

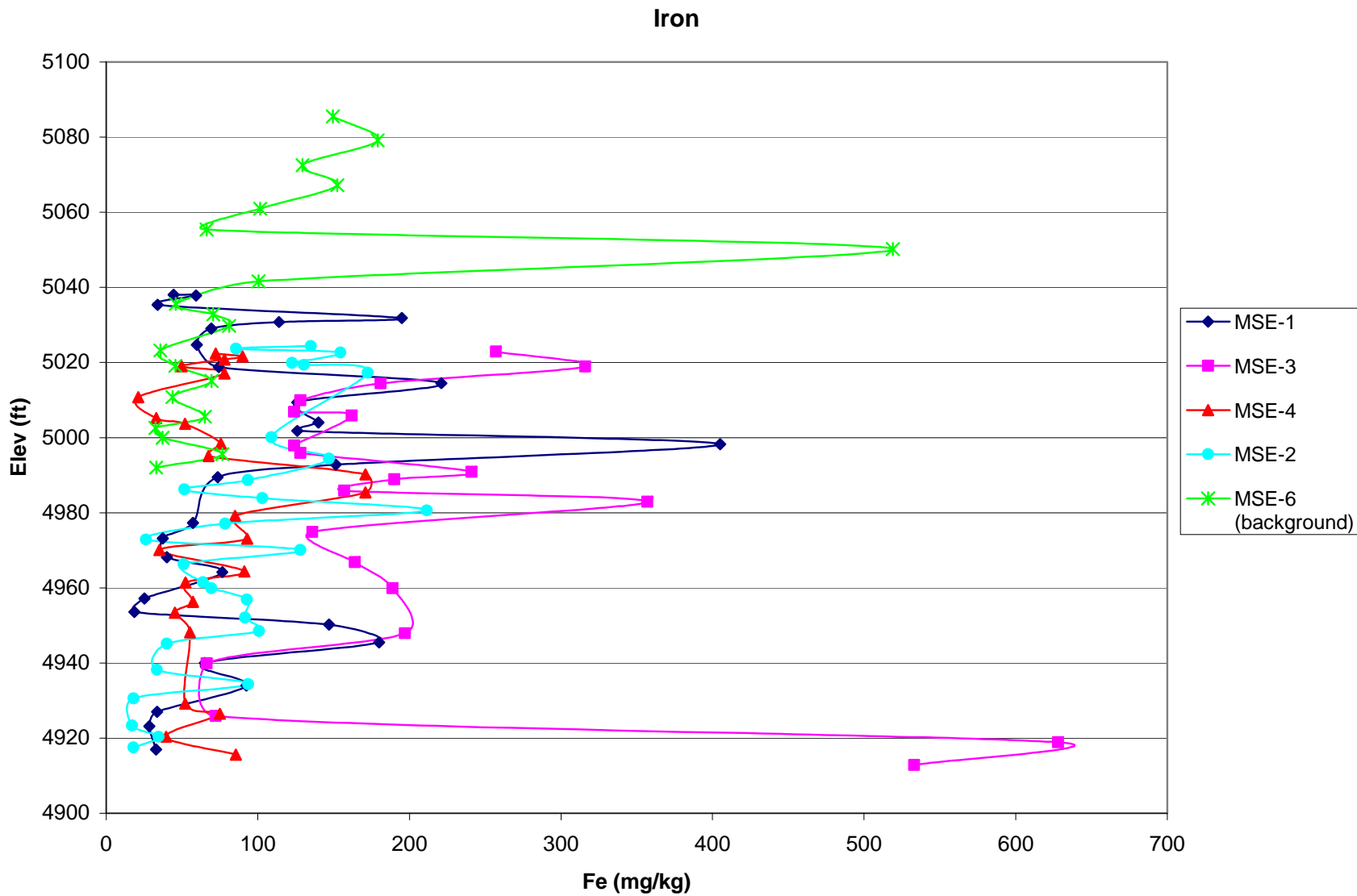


Figure 7. MSE Core Iron Concentrations by Elevation

End of current text

Appendix A
MSE Soil Core Pictures

















TCMSE2
82.5-93'



TCMSE2
93-104'

MSE2 ~~95.0-96.0~~
TO DBSA LAB

























