Appendix N

Statistical Evaluation of Surface Soils
Asarco El Paso Smelter, Remedial Investigation Phase III

Investigation Area	Sample Code	Sample Date	Sample Top Depth (feet)	Sample Bottom Depth (feet)	Arsenic (mg/kg) *DL = 10 mg/kg	Cadmium (mg/kg) *DL = 10 mg/kg	Chromium (mg/kg) *DL = 80 mg/kg	Copper (mg/kg) *DL = 20 mg/kg	Iron (mg/kg) *DL = 20 mg/kg	Lead (mg/kg) *DL = 10 mg/kg	Selenium (mg/kg) *DL = 10 mg/kg	Zinc (mg/kg) *DL = 10 mg/kg
IA-17	BH17-19A	06-Mar-01	0	1	86	36	100	240	7600	220	20	150
IA-17	BH17-8A	02-Mar-01	1	2	290	66	100	1200	14000	1200	20	5000
Count					**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Maximum					**290**	**66**	**100**	**1200**	**14000**	**1200**	**20**	**5000**
Mean					**188**	**51**	**100**	**720**	**10800**	**710**	**20**	**2575**
Std Deviation					**144**	**21**	**0**	**679**	**4525**	**693**	**0**	**3429**
95% Confidence					**200**	**29**	**NA**	**941**	**6272**	**960**	**NA**	**4753**

*** DL = Most commonly used reporting detection limit. All values reported as less than detection limit were divided by 2.**

Appendix N

Statistical Evaluation of Surface Soils
Asarco El Paso Smelter, Remedial Investigation Phase III

Investigation Area	Sample Code	Sample Date	Sample Top Depth (feet)	Sample Bottom Depth (feet)	Arsenic (mg/kg) *DL = 10 mg/kg	Cadmium (mg/kg) *DL = 10 mg/kg	Chromium (mg/kg) *DL = 80 mg/kg	Copper (mg/kg) *DL = 20 mg/kg	Iron (mg/kg) *DL = 20 mg/kg	Lead (mg/kg) *DL = 10 mg/kg	Selenium (mg/kg) *DL = 10 mg/kg	Zinc (mg/kg) *DL = 10 mg/kg
IA-18	BH18-1A	06-Mar-01	0	1	240	18	300	1200	44000	610	20	2200
IA-18	BH18-1B	06-Mar-01	1	2	44	5	100	32	15000	51	20	57
IA-18	BH18-1C	06-Mar-01	2	3	64	5	100	160	14000	90	20	83
IA-18	BH18-2A	06-Mar-01	1	2	93	5	100	100	14000	80	20	71
IA-18	BH18-2B	06-Mar-01	2	3	78	5	100	10	19000	51	20	46
IA-18	BH18-3A	06-Mar-01	0.2	1	51	5	100	100	13000	100	20	67
IA-18	BH18-3B	06-Mar-01	1	2	49	5	100	47	13000	50	20	80
IA-18	BH18-3C	06-Mar-01	2	3	98	5	100	110	15000	69	20	73
IA-18	BH18-4A1	06-Mar-01	0.1	1	44	11	100	230	13000	200	20	120
IA-18	BH18-4B	06-Mar-01	1	2	68	11	100	410	14000	450	20	380
IA-18	BH18-4C	06-Mar-01	2	3	62	5	100	62	12000	74	20	68
IA-18	BH18-5A	06-Mar-01	0.2	1	260	5	100	820	15000	160	20	100
IA-18	BH18-5B	06-Mar-01	1	2	67	5	100	23	17000	43	20	56
IA-18	BH18-5C	06-Mar-01	2	3	70	5	100	120	11000	69	20	58
Count					**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**
Maximum					**260**	**18**	**300**	**1200**	**44000**	**610**	**20**	**2200**
Mean					**92**	**7**	**114**	**245**	**16357**	**150**	**20**	**247**
Std Deviation					**69**	**4**	**53**	**348**	**8205**	**170**	**0**	**568**
95% Confidence					**36**	**2**	**28**	**182**	**4298**	**89**	**NA**	**298**

*** DL = Most commonly used reporting detection limit. All values reported as less than detection limit were divided by 2.**

Appendix N

Statistical Evaluation of Surface Soils
Asarco El Paso Smelter, Remedial Investigation Phase III

Investigation Area	Sample Code	Sample Date	Sample Top Depth (feet)	Sample Bottom Depth (feet)	Arsenic (mg/kg) *DL = 10 mg/kg	Cadmium (mg/kg) *DL = 10 mg/kg	Chromium (mg/kg) *DL = 80 mg/kg	Copper (mg/kg) *DL = 20 mg/kg	Iron (mg/kg) *DL = 20 mg/kg	Lead (mg/kg) *DL = 10 mg/kg	Selenium (mg/kg) *DL = 10 mg/kg	Zinc (mg/kg) *DL = 10 mg/kg
IA-19	BL25A	26-Jun-01	0	0.17	56	18	40	381	12000	349	10	229
IA-19	BL25B	26-Jun-01	0.17	0.33	64	14	40	354	9600	403	10	238
IA-19	BL25C	13-Aug-01	1	2	50	5	40	130	13000	140	10	53
IA-19	BL26A	26-Jun-01	0	0.17	30	10	40	151	10000	125	10	256
IA-19	BL26B	26-Jun-01	0.17	0.33	39	13	40	99	10000	136	10	275
IA-19	BL26C	13-Aug-01	1	2	31	12	40	140	12000	180	10	190
IA-19	BL27A	26-Jun-01	0	0.17	20	14	40	96	9900	95	10	85
IA-19	BL27B	26-Jun-01	0.17	0.33	25	5	40	112	14000	146	10	103
IA-19	BL27C1	13-Aug-01	1	2	18	13	40	140	12000	130	10	110
IA-19	BL28A	26-Jun-01	0	0.17	38	5	40	79	15000	50	10	5
IA-19	BL28B	26-Jun-01	0.17	0.33	61	5	40	70	15000	65	10	5
IA-19	BL28C	13-Aug-01	1	2	55	5	40	80	13000	77	10	5
IA-19	BL29A	26-Jun-01	0	0.17	192	42	40	1400	16000	1600	10	1100
IA-19	BL29B	26-Jun-01	0.17	0.33	23	5	40	38	12000	48	10	19
IA-19	BL29C	13-Aug-01	1	2	37	5	40	74	11000	130	10	23
IA-19	BL2A	27-Jul-00	0	0.2	310	5	170	2900	73000	800	5	3800
IA-19	BL30A	26-Jun-01	0	0.17	145	24	85	1360	32000	662	10	1380
IA-19	BL30B	26-Jun-01	0.17	0.33	23	13	40	36	13000	44	10	5
IA-19	BL30C	13-Aug-01	1	2	33	5	40	57	14000	61	10	32
IA-19	BL51	26-Jun-01	0	0.17	166	29	40	991	7800	1690	10	758
Count					**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**
Maximum					**310**	**42**	**170**	**2900**	**73000**	**1690**	**10**	**3800**
Mean					**71**	**12**	**49**	**434**	**16215**	**347**	**10**	**434**
Std Deviation					**75**	**10**	**30**	**720**	**14230**	**489**	**1**	**879**
95% Confidence					**33**	**4**	**13**	**315**	**6237**	**214**	**0**	**385**

*** DL = Most commonly used reporting detection limit. All values reported as less than detection limit were divided by 2.**

Appendix N

Statistical Evaluation of Surface Soils
Asarco El Paso Smelter, Remedial Investigation Phase III

Investigation Area	Sample Code	Sample Date	Sample Top Depth (feet)	Sample Bottom Depth (feet)	Arsenic (mg/kg) *DL = 10 mg/kg	Cadmium (mg/kg) *DL = 10 mg/kg	Chromium (mg/kg) *DL = 80 mg/kg	Copper (mg/kg) *DL = 20 mg/kg	Iron (mg/kg) *DL = 20 mg/kg	Lead (mg/kg) *DL = 10 mg/kg	Selenium (mg/kg) *DL = 10 mg/kg	Zinc (mg/kg) *DL = 10 mg/kg
IA-20	BL10	28-Jul-00	0	0.17	23	5	120	10	23000	61	5	47
IA-20	BL11	28-Jul-00	0	0.17	47	5	40	40	32000	36	5	48
IA-20	BL12	28-Jul-00	0	0.17	5	5	150	10	14000	56	5	81
IA-20	BL13	28-Jul-00	0	0.17	140	28	99	1200	25000	680	5	530
IA-20	BL14	07-Jun-00	0	0.17	21	5	40	52	25000	29	5	69
IA-20	BL15	07-Jun-00	0	0.17	5	5	40	33	21000	39	5	56
IA-20	BL16	06-Jun-00	0	0.17	34	5	40	57	28000	25	5	33
IA-20	BL17	05-Jun-00	0	0.17	34	5	140	100	21000	71	5	120
IA-20	BL18	05-Jun-00	0	0.17	30	5	120	440	19000	220	5	250
IA-20	BL19	01-Aug-00	0	0.17	14	5	97	10	21000	34	5	43
IA-20	BL1A	26-Jul-00	0	0.2	1200	44	350	5900	220000	6700	5	20000
IA-20	BL20	01-Aug-00	0	0.17	5	5	99	10	19000	46	5	14
IA-20	BL21A	06-Jun-01	0	0.17	34	5	40	94	14000	110	10	16
IA-20	BL22A	06-Jun-01	0	0.17	22	5	40	89	14000	55	10	38
IA-20	BL23A	06-Jun-01	0	0.17	38	13	40	230	22000	260	10	190
IA-20	BL24A	06-Jun-01	0	0.17	30	12	40	180	15000	170	10	51
IA-20	BL31A	27-Jun-01	0	0.17	25	5	40	121	14000	134	10	54
IA-20	BL31B	27-Jun-01	0.17	0.33	35	5	40	25	12000	38	10	5
IA-20	BL32A	27-Jun-01	0	0.17	37	18	40	240	12000	300	10	149
IA-20	BL32B	27-Jun-01	0.17	0.33	35	5	40	42	11000	62	10	5
IA-20	BL33A	27-Jun-01	0	0.17	40	5	40	299	17000	230	10	130
IA-20	BL33B	27-Jun-01	0.17	0.33	28	5	40	54	5700	59	10	5
IA-20	BL34A	27-Jun-01	0	0.17	37	5	40	261	15000	163	10	78
IA-20	BL34B	27-Jun-01	0.17	0.33	19	5	40	10	5100	45	10	5
IA-20	BL35A	27-Jun-01	0	0.17	33	10	40	158	15000	206	10	74
IA-20	BL35B	27-Jun-01	0.17	0.33	29	5	40	89	12000	101	10	5
IA-20	BL36A	27-Jun-01	0	0.17	38	5	40	145	16000	135	10	37
IA-20	BL36B	27-Jun-01	0.17	0.33	38	11	40	23	13000	44	10	5
IA-20	BL37A	27-Jun-01	0	0.17	27	5	40	49	17000	38	10	17
IA-20	BL37B	27-Jun-01	0.17	0.33	11	5	40	10	17000	40	10	5
IA-20	BL38A	27-Jun-01	0	0.17	12	18	40	23	12000	37	10	5
IA-20	BL39A	27-Jun-01	0	0.17	62	5	40	668	20000	414	10	344
IA-20	BL39B	27-Jun-01	0.17	0.33	51	5	40	101	16000	95	10	5
IA-20	BL3A	27-Jul-00	0	0.2	5	5	170	160	18000	190	5	140
IA-20	BL40A	27-Jun-01	0	0.17	54	18	91	711	22000	440	10	306
IA-20	BL40B	27-Jun-01	0.17	0.33	54	5	40	177	13000	171	10	5

*** DL = Most commonly used reporting detection limit. All values reported as less than detection limit were divided by 2.**

Appendix N

Statistical Evaluation of Surface Soils
Asarco El Paso Smelter, Remedial Investigation Phase III

Investigation Area	Sample Code	Sample Date	Sample Top Depth (feet)	Sample Bottom Depth (feet)	Arsenic (mg/kg) *DL = 10 mg/kg	Cadmium (mg/kg) *DL = 10 mg/kg	Chromium (mg/kg) *DL = 80 mg/kg	Copper (mg/kg) *DL = 20 mg/kg	Iron (mg/kg) *DL = 20 mg/kg	Lead (mg/kg) *DL = 10 mg/kg	Selenium (mg/kg) *DL = 10 mg/kg	Zinc (mg/kg) *DL = 10 mg/kg
IA-20	BL41A	27-Jun-01	0	0.17	20	12	40	274	13000	205	10	277
IA-20	BL41B	27-Jun-01	0.17	0.33	38	5	40	284	11000	258	10	105
IA-20	BL42	28-Jun-01	0	0.17	31	12	40	71	22000	79	10	155
IA-20	BL43A	28-Jun-01	0	0.17	235	34	130	1790	38000	1180	10	1940
IA-20	BL44A	27-Jun-01	0	0.17	27	12	90	46	23000	46	10	18
IA-20	BL44B	28-Jun-01	0.17	0.33	40	11	40	56	15000	73	10	5
IA-20	BL45A	27-Jun-01	0	0.17	37	5	85	38	26000	36	10	59
IA-20	BL46A	28-Jun-01	0	0.17	36	5	40	48	22000	47	10	62
IA-20	BL47	27-Jun-01	0	0.17	33	5	83	46	22000	42	10	79
IA-20	BL48	28-Jun-01	0	0.17	39	10	83	109	20000	96	10	118
IA-20	BL49A	28-Jun-01	0	0.17	62	5	40	449	24000	245	10	254
IA-20	BL49B	28-Jun-01	0.17	0.33	43	5	83	34	16000	28	10	14
IA-20	BL4A	28-Jul-00	0	0.2	5	5	40	86	14000	85	5	62
IA-20	BL50A	28-Jun-01	0	0.17	187	47	117	1940	32000	1160	10	1440
IA-20	BL50B	28-Jun-01	0.17	0.33	60	5	40	59	13000	64	10	5
IA-20	BL52	27-Jun-01	0	0.17	15	5	40	10	11000	38	10	5
IA-20	BL5A	29-Jul-00	0	0.2	5	5	40	260	11000	120	5	140
IA-20	BL6	05-Jun-00	0	0.17	27	5	160	10	24000	27	5	35
IA-20	BL7	28-Jul-00	0	0.17	5	5	190	10	7300	67	5	5
IA-20	BL8		0	0.17	5	5	140	10	6100	71	5	5
IA-20	BL9	28-Jul-00	0	0.17	5	5	40	10	4700	5	5	20
Count					**57**	**57**	**57**	**57**	**57**	**57**	**57**	**57**
Maximum					**1200**	**47**	**350**	**5900**	**220000**	**6700**	**10**	**20000**
Mean					**58**	**9**	**72**	**306**	**20893**	**272**	**8**	**487**
Std Deviation					**159**	**9**	**56**	**845**	**27691**	**896**	**2**	**2650**
95% Confidence					**41**	**2**	**15**	**219**	**7189**	**233**	**1**	**688**

*** DL = Most commonly used reporting detection limit. All values reported as less than detection limit were divided by 2.**

Appendix N

Statistical Evaluation of Surface Soils
Asarco El Paso Smelter, Remedial Investigation Phase III

Investigation Area	Sample Code	Sample Date	Sample Top Depth (feet)	Sample Bottom Depth (feet)	Arsenic (mg/kg) *DL = 10 mg/kg	Cadmium (mg/kg) *DL = 10 mg/kg	Chromium (mg/kg) *DL = 80 mg/kg	Copper (mg/kg) *DL = 20 mg/kg	Iron (mg/kg) *DL = 20 mg/kg	Lead (mg/kg) *DL = 10 mg/kg	Selenium (mg/kg) *DL = 10 mg/kg	Zinc (mg/kg) *DL = 10 mg/kg

Note:
DL = Laboratory Detection Limit

*** DL = Most commonly used reporting detection limit. All values reported as less than detection limit were divided by 2.**

APPENDIX O

EPA SOIL SAMPLE RESULTS AND ASTDR REPORT

APPENDIX O

EPA SOIL SAMPLE RESULTS
AND ATSDR REPORT

El Paso Draft Data
EPA Sampling Results
El Paso High
Sampling Date: July 31, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ELH02-020-51-02	073101029-96	9.7	12.	<3.0	3.0
ELH02-020-51-01	073101029-95	49	6.0	<3.0	3.0
ELH02-019-51-02	073101029-108	<3.0	3.0	<3.0	3.0
ELH02-019-51-01	073101029-107	34	3.0	<3.0	3.0
ELH02-018-51-02	073101029-128	<3.0	3.0	<3.0	3.0
ELH02-018-51-01	073101029-127	6.7	3.0	<3.0	3.0
ELH02-017-51-02	073101029-102	16	3.0	<3.0	3.0
ELH02-017-51-01	073101029-101	47	12.	<3.0	3.0
ELH01-016-51-02	073101029-110	16	3.0	<3.0	3.0
ELH01-016-51-01	073101029-109	110	3.0	<3.0	3.0
ELH01-015-51-02	073101029-6	<3.0	3.0	<3.0	3.0
ELH01-015-51-01	073101029-5	71	3.0	<3.0	3.0
ELH01-014-51-02	073101029-20	7.2	3.0	<3.0	3.0
ELH01-014-51-01	073101029-19	67	6.0	<3.0	3.0
ELH01-013-51-02	073101029-130	33	3.0	<3.0	3.0
ELH01-013-51-01	073101029-129	43	3.0	<3.0	3.0
ELH01-012-51-02	073101029-124	34	3.0	<3.0	3.0
ELH01-012-51-01	073101029-123	39	3.0	<3.0	3.0
ELH01-011-51-02	073101029-10	124	3.0	<3.0	3.0
ELH01-011-51-01	073101029-9	14	3.0	<3.0	3.0
ELH01-010-51-02	073101029-18	<3.0	3.0	<3.0	3.0
ELH01-010-51-01	073101029-17	6.5	3.0	<3.0	3.0
ELH01-009-51-02	073101029-16	<3.0	3.0	<3.0	3.0
ELH01-009-51-01	073101029-15	93	3.0	<3.0	3.0
ELH01-008-51-02	073101029-14	37	12.	<3.0	3.0
ELH01-008-51-01	073101029-13	41	3.0	<3.0	3.0
ELH01-007-51-02	073101029-12	68	3.0	<3.0	3.0
ELH01-007-51-01	073101029-11	16	3.0	<3.0	3.0
ELH01-006-52-01	073101029-133	57	3.0	<3.0	3.0
ELH01-006-51-02	073101029-22	<3.0	3.0	<3.0	3.0
ELH01-006-51-01	073101029-21	45	12.	<3.0	3.0
ELH01-005-51-02	073101029-8	11	3.0	<3.0	3.0
ELH01-005-51-01	073101029-7	37	3.0	<3.0	3.0

El Paso Draft Data
EPA Sampling Results
El Paso High
Sampling Date: July 31, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ELH01-004-51-02	073101029-112	98	3.0	<3.0	3.0
ELH01-004-51-01	073101029-111	16	3.0	<3.0	3.0
ELH01-004-052-02	073101029-135	120	6.0	<3.0	3.0
ELH01-003-52-02	073101029-134	36	3.0	<3.0	3.0
ELH01-003-52-01	073101029-131	28	3.0	<3.0	3.0
ELH01-003-51-02	073101029-122	40	3.0	<3.0	3.0
ELH01-003-51-01	073101029-121	24	3.0	<3.0	3.0
ELH01-002-51-02	073101029-116	4.3	3.0	<3.0	3.0
ELH01-002-51-01	073101029-115	45	3.0	<3.0	3.0
ELH01-002-052-01	073101029-137	87	3.0	<3.0	3.0
ELH01-001-52-01	073101029-132	40	3.0	<3.0	3.0
ELH01-001-51-02	073101029-4	56	3.0	<3.0	3.0
ELH01-001-51-01	073101029-3	40	3.0	<3.0	3.0
ELH01-001-052-02	073101029-136	87	12.	<3.0	3.0
ELH03-021-51-01	073101029-49	67	3.0	<3.0	3.0
ELH03-021-51-02	073101029-50	6.7	3.0	<3.0	3.0
ELH04-022-51-01	073101029-89	22	3.0	<3.0	3.0
ELH04-022-51-02	073101029-90	4.0	3.0	<3.0	3.0
ELH04-023-51-01	073101029-27	29	12.	<3.0	3.0
ELH04-023-51-02	073101029-28	21	3.0	<3.0	3.0
ELH04-024-51-01	073101029-41	64	3.0	<3.0	3.0
ELH04-024-51-02	073101029-42	51	3.0	<3.0	3.0
ELH05-025-51-01	073101029-65	50	3.0	<3.0	3.0
ELH05-025-51-02	073101029-66	<3.0	3.0	<3.0	3.0
ELH05-026-51-01	073101029-31	67	3.0	<3.0	3.0
ELH05-026-51-02	073101029-32	<3.0	3.0	<3.0	3.0
ELH06-027-51-01	073101029-85	30	3.0	<3.0	3.0
ELH06-027-51-02	073101029-86	99	3.0	<3.0	3.0
ELH07-028-51-01	073101029-47	61	3.0	<3.0	3.0
ELH07-028-51-02	073101029-48	<3.0	3.0	<3.0	3.0
ELH07-029-51-01	073101029-33	92	12.	<3.0	3.0
ELH07-029-51-02	073101029-34	<3.0	3.0	<3.0	3.0
ELH07-030-51-01	073101029-83	17	3.0	<3.0	3.0

El Paso Draft Data
EPA Sampling Results
El Paso High
Sampling Date: July 31, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ELH07-030-51-02	073101029-84	7.4	3.0	<3.0	3.0
ELH07-031-51-01	073101029-81	42	3.0	<3.0	3.0
ELH07-031-51-02	073101029-82	<3.0	3.0	<3.0	3.0
ELH07-032-51-01	073101029-79	63	3.0	<3.0	3.0
ELH07-032-51-02	073101029-80	14	3.0	<3.0	3.0
ELH07-033-51-01	073101029-105	66	3.0	<3.0	3.0
ELH07-033-51-02	073101029-106	55	3.0	<3.0	3.0
ELH07-034-51-01	073101029-91	49	3.0	<3.0	3.0
ELH07-034-51-02	073101029-92	4.0	3.0	<3.0	3.0
ELH07-035-51-01	073101029-125	65	3.0	<3.0	3.0
ELH07-035-51-02	073101029-126	<3.0	3.0	<3.0	3.0
ELH07-036-51-01	073101029-69	82	3.0	<3.0	3.0
ELH07-036-51-02	073101029-70	14	3.0	<3.0	3.0
ELH07-037-51-01	073101029-67	35	3.0	<3.0	3.0
ELH07-037-51-02	073101029-68	4.3	3.0	<3.0	3.0
ELH07-038-51-01	073101029-99	59	3.0	<3.0	3.0
ELH07-038-51-02	073101029-100	8.3	3.0	<3.0	3.0
ELH08-039-51-01	073101029-119	36	3.0	<3.0	3.0
ELH08-039-51-02	073101029-120	<3.0	3.0	<3.0	3.0
ELH08-040-51-01	073101029-63	21	3.0	<3.0	3.0
ELH08-040-51-02	073101029-64	<3.0	3.0	<3.0	3.0
ELH08-041-51-01	073101029-25	18	6.0	<3.0	3.0
ELH08-041-51-02	073101029-26	<3.0	3.0	<3.0	3.0
ELH09-042-51-01	073101029-29	31	6.0	<3.0	3.0
ELH09-042-51-02	073101029-30	<3.0	3.0	<3.0	3.0
ELH09-043-51-01	073101029-35	14	3.0	<3.0	3.0
ELH09-043-51-02	073101029-36	83	12.	<3.0	3.0
ELH10-044-51-01	073101029-117	41	12.	<3.0	3.0
ELH10-044-51-02	073101029-118	96	3.0	<3.0	3.0
ELH10-045-51-01	073101029-113	55	3.0	<3.0	3.0
ELH10-045-51-02	073101029-114	71	3.0	<3.0	3.0
ELH10-046-51-01	073101029-87	8.1	3.0	<3.0	3.0
ELH10-046-51-02	073101029-88	11	3.0	<3.0	3.0

El Paso Draft Data
EPA Sampling Results
El Paso High
Sampling Date: July 31, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ELH10-047-51-01	073101029-97	60	3.0	<3.0	3.0
ELH10-047-51-02	073101029-98	54	3.0	<3.0	3.0
ELH10-048-51-01	073101029-75	21	3.0	<3.0	3.0
ELH10-048-51-02	073101029-76	190	3.0	4.9	3.0
ELH10-049-51-01	073101029-77	<3.0	12.	<3.0	3.0
ELH10-049-51-02	073101029-78	4.7	3.0	<3.0	3.0
ELH10-050-51-01	073101029-73	<3.0	3.0	<3.0	3.0
ELH10-050-51-02	073101029-74	21	3.0	<3.0	3.0
ELH10-051-51-01	073101029-71	<3.0	3.0	<3.0	3.0
ELH10-051-51-02	073101029-72	18	3.0	<3.0	3.0
ELH10-052-51-01	073101029-23	24	3.0	<3.0	3.0
ELH10-052-51-02	073101029-24	16	3.0	<3.0	3.0
ELH10-053-51-01	073101029-53	11	3.0	<3.0	3.0
ELH10-053-51-02	073101029-54	6.5	3.0	<3.0	3.0
ELH10-054-51-01	073101029-1	<3.0	3.0	<3.0	3.0
ELH10-054-51-02	073101029-2	23	3.0	<3.0	3.0
ELH10-055-51-01	073101029-59	<3.0	3.0	<3.0	3.0
ELH10-055-51-02	073101029-60	12	3.0	<3.0	3.0
ELH10-056-51-01	073101029-57	20	3.0	<3.0	3.0
ELH10-056-51-02	073101029-58	21	3.0	<3.0	3.0
ELH10-057-51-01	073101029-93	<3.0	3.0	<3.0	3.0
ELH10-057-51-02	073101029-94	42	3.0	<3.0	3.0
ELH10-058-51-01	073101029-103	5.7	3.0	<3.0	3.0
ELH10-058-51-02	073101029-104	250	12.	<3.0	3.0
ELH10-059-51-01	073101029-43	3.6	3.0	<3.0	3.0
ELH10-059-51-02	073101029-44	108	3.0	<3.0	3.0
ELH11-060-51-01	073101029-55	220	6.0	<3.0	3.0
ELH11-060-51-02	073101029-56	40	12.	<3.0	3.0
ELH15-067-51-01	073101029-37	76	3.0	<3.0	3.0
ELH15-067-51-02	073101029-38	14	3.0	<3.0	3.0
ELH15-068-51-02	073101029-40	200	6.0	<3.0	3.0
ELH16-068-51-01	073101029-39	1500	150	<3.0	3.0
ELH16-068-51-03	073101029-138	100	3.0	<3.0	3.0

El Paso Draft Data
EPA Sampling Results
El Paso High
Sampling Date: July 31, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ELH16-068A-51-01	080401008-94	170	6.0	PR	3.0
ELH16-068A-51-02	080401008-95	240	12	<3.0	3.0
ELH16-068B-51-01	080401008-96	140	6.0	<3.0	3.0
ELH16-068B-51-02	080401008-97	160	6.0	<3.0	3.0
ELH16-069-51-01	073101029-45	60	3.0	<3.0	3.0
ELH16-069-51-01	073101029-45	122	3.0	<3.0	3.0
ELH16-069-51-02	073101029-46	<3.0	3.0	<3.0	3.0
ELH16-069-51-02	073101029-46	227	3.0	<3.0	3.0
ELH16-070-51-01	073101029-61	320	12.	<3.0	3.0
ELH16-070-51-01	073101029-61	110	12.	<3.0	3.0
ELH16-070-51-02	073101029-62	14	3.0	<3.0	3.0
ELH16-070-51-02	073101029-62	220	3.0	<3.0	3.0
ELH17-071-51-01	073101029-51	13	3.0	<3.0	3.0
ELH17-071-51-01	073101029-51	150	3.0	<3.0	3.0
ELH17-071-51-02	073101029-52	<3.0	3.0	<3.0	3.0
ELH17-071-51-02	073101029-52	120	3.0	<3.0	3.0

EPA Sampling Results
Alethea Park
Sampling Date - August, 2001
Method of Analysis - 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ALA01-001-51-01	080101003-21	61	3.0	<3.0	3.0
ALA01-001-51-02	080101003-22	7.2	3.0	<3.0	3.0
ALA01-002-51-01	080101003-9	9.3	3.0	<3.0	3.0
ALA01-002-51-02	080101003-10	190	6.0	<3.0	3.0
ALA01-003-51-01	080101003-17	110	3.0	<3.0	3.0
ALA01-003-51-02	080101003-18	21	3.0	<3.0	3.0
ALA01-004-51-01	080101003-7	67	3.0	<3.0	3.0
ALA01-004-51-02	080101003-8	66	3.0	<3.0	3.0
ALA01-005-51-01	080101003-5	28	3.0	<3.0	3.0
ALA01-005-51-02	080101003-6	10	3.0	<3.0	3.0
ALA01-005-52-01	080101003-46	28	3.0	<3.0	3.0
ALA01-006-51-01	080101003-3	59	3.0	<3.0	3.0
ALA01-006-51-02	080101003-4	<3.0	3.0	<3.0	3.0
ALA01-007-51-01	080101003-1	60	3.0	<3.0	3.0
ALA01-007-51-02	080101003-2	32	3.0	<3.0	3.0
ALA01-008-51-01	080101003-19	50	3.0	<3.0	3.0
ALA01-008-51-02	080101003-20	8.6	3.0	<3.0	3.0
ALA01-008-52-02	080101003-47	11	3.0	<3.0	3.0
ALA01-009-51-01	080101003-13	71	3.0	<3.0	3.0
ALA01-009-51-02	080101003-14	32	3.0	<3.0	3.0
ALA01-010-51-01	080101003-11	63	3.0	<3.0	3.0
ALA01-010-51-02	080101003-12	42	3.0	<3.0	3.0
ALA01-011-51-01	080101003-15	70	3.0	<3.0	3.0
ALA01-011-51-02	080101003-16	18	3.0	<3.0	3.0
ALA01-011-52-02	080101003-45	27	3.0	<3.0	3.0
ALA01-012-51-01	080101003-27	105	3.0	<3.0	3.0
ALA01-012-51-02	080101003-28	140	6.0	6.8	3.0
ALA01-013-51-01	080101003-23	53	3.0	<3.0	3.0
ALA01-013-51-02	080101003-24	39	3.0	<3.0	3.0
ALA01-014-51-01	080101003-25	29	3.0	<3.0	3.0
ALA01-014-51-02	080101003-26	9.5	3.0	<3.0	3.0

EPA Sampling Results
Alamo Park
Sampling Date - August 1, 2001
Method of Analysis 6010B -

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ALM01-001-51-01	080101003-50	110	3.0	<3.0	3.0
ALM01-001-51-02	080101003-51	160	6.0	<3.0	3.0
ALM01-002-51-01	080101003-43	328	15	<3.0	3.0
ALM01-002-51-02	080101003-44	1800	75	<3.0	3.0
ALM01-003-51-01	080101003-41	140	6.0	<3.0	3.0
ALM01-003-51-02	080101003-42	23	3.0	<3.0	3.0
ALM01-004-51-01	080101003-39	86	3.0	<3.0	3.0
ALM01-004-51-02	080101003-40	73	3.0	<3.0	3.0
ALM02-005-51-01	080101003-37	14	3.0	<3.0	3.0
ALM02-005-51-02	080101003-38	<3.0	3.0	<3.0	3.0
ALM02-006-51-01	080101003-35	3.5	3.0	<3.0	3.0
ALM02-006-51-02	080101003-36	<3.0	3.0	<3.0	3.0
ALM01-002A-51-01	080401008-92	280	12	<3.0	3.0
ALM01-002A-51-02	080401008-93	130	6.0	<3.0	3.0
ALM01-002-51-03	080101003-52	<3.0	3.0	<3.0	3.0

EPA Sampling Results
Doniphan Park
Sampling Date - August 1, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
DON01-001-51-01	080101003-33	13	3.0	<3.0	3.0
DON01-001-51-02	080101003-34	5.7	3.0	<3.0	3.0
DON01-002-51-01	080101003-31	13	3.0	<3.0	3.0
DON01-002-51-02	080101003-32	5.8	3.0	<3.0	3.0
DON01-003-51-01	080101003-29	14	3.0	<3.0	3.0
DON01-003-51-02	080101003-30	7.2	3.0	<3.0	3.0

EPA sampling Results
Rooselvet School
Sampling date August 1, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
RVS01-001-51-01	080101003-48	21	3.0	<3.0	3.0
RVS01-001-51-02	080101003-49	31	3.0	<3.0	3.0

EPA Sampling Results
Arroyo Park
Sampling data August 2, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ARR01-001-51-01	080201004-1	21	5.0	11	5.0
ARR01-001-51-02	080201004-2	6.5	5.0	<5.0	5.0
ARR01-002-51-01	080201004-3	200	10	28	5.0
ARR01-002-51-02	080201004-4	220	10	29	5.0
ARR01-002-52-02	080201004-94	120	5.0	18	5.0
ARR01-003-51-01	080201004-5	27	5.0	12	5.0
ARR01-003-51-02	080201004-6	<5.0	5.0	7.1	5.0
ARR01-004-51-01	080201004-7	33	5.0	8.7	5.0
ARR01-004-51-02	080201004-8	<5.0	5.0	<5.0	5.0
ARR01-004-52-01	080201004-92	31	5.0	<5.0	5.0
ARR01-005-51-01	080201004-9	110	5.0	8.3	5.0
ARR01-005-51-02	080201004-10	13	5.0	<5.0	5.0
ARR01-005-52-01	080201004-93	96	5.0	8.9	5.0
ARR01-006-51-01	080201004-11	54	5.0	6.2	5.0
ARR01-006-51-02	080201004-12	15	5.0	<5.0	5.0
ARR01-007-51-01	080201004-13	45	5.0	<5.0	5.0
ARR01-007-51-02	080201004-14	<5.0	5.0	<5.0	5.0
ARR01-008-51-01	080201004-15	48	5.0	9.4	5.0
ARR01-008-51-02	080201004-16	27	5.0	9.0	5.0
ARR01-009-51-01	080201004-17	<5.0	5.0	5.4	5.0
ARR01-009-51-02	080201004-18	<5.0	5.0	<5.0	5.0
ARR01-010-51-01	080201004-19	100	5.0	7.8	5.0
ARR01-010-51-02	080201004-20	6.1	5.0	8.6	5.0
ARR01-011-51-01	080201004-21	10	5.0	<5.0	5.0
ARR01-011-51-02	080201004-22	40	5.0	<5.0	5.0
ARR01-012-51-01	080201004-23	66	5.0	<5.0	5.0
ARR01-012-51-02	080201004-24	280	20	7.1	5.0
ARR01-013-51-01	080201004-25	110	5.0	8.3	5.0
ARR01-013-51-02	080201004-26	8.8	5.0	<5.0	5.0
ARR01-014-51-01	080201004-27	<5.0	5.0	18	5.0
ARR01-014-51-02	080201004-28	2	5.0	<5.0	5.0
ARR01-015-51-01	080201004-29	28	5.0	9.8	5.0
ARR01-015-51-02	080201004-30	5.7	5.0	<5.0	5.0
ARR01-015-52-01	080201004-95	28	5.0	9.4	5.0
ARR01-016-51-01	080201004-31	53	5.0	13	5.0
ARR01-016-51-02	080201004-32	13	5.0	5.0	5.0
ARR01-017-51-01	080201004-33	24	5.0	9.3	5.0
ARR01-017-51-02	080201004-34	27	5.0	6.9	5.0
ARR01-018-51-01	080201004-35	<5.0	5.0	21	5.0
ARR01-018-51-02	080201004-36	<5.0	5.0	<5.0	5.0
ARR01-019-51-01	080201004-37	56	5.0	5.0	5.0
ARR01-019-51-02	080201004-38	<5.0	5.0	<5.0	5.0
ARR01-020-51-01	080201004-39	28	5.0	12	5.0
ARR01-020-51-02	080201004-40	<5.0	5.0	<5.0	5.0
ARR01-021-51-01	080201004-41	25	5.0	<5.0	5.0

EPA Sampling Results
Arroyo Park
Sampling data August 2, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ARR01-021-51-02	080201004-42	<5.0	5.0	<5.0	5.0
ARR01-022-51-01	080201004-43	360	20	20	5.0
ARR01-022-51-02	080201004-44	82	5.0	6.2	5.0
ARR01-023-51-01	080201004-45	170	10	<5.0	5.0
ARR01-023-51-02	080201004-46	68	5.0	5.7	5.0
ARR01-024-51-01	080201004-47	130	10	13	5.0
ARR01-024-51-02	080201004-48	13	5.0	5.5	5.0
ARR01-025-51-01	080201004-49	420	20	15	5.0
ARR01-025-51-02	080201004-50	42	5.0	<5.0	5.0
ARR01-026-51-01	080201004-51	<5.0	5.0	10	5.0
ARR01-026-51-02	080201004-52	<5.0	5.0	8.1	5.0
ARR01-027-51-01	080201004-53	5.7	5.0	15	5.0
ARR01-028-51-01	080201004-54	64	5.0	6.8	5.0
ARR01-028-51-02	080201004-55	<5.0	5.0	<5.0	5.0
ARR01-029-51-01	080201004-56	250	20	14	5.0
ARR01-031-51-01	080201004-57	36	5.0	7.8	5.0
ARR01-031-51-02	080201004-58	<5.0	5.0	<5.0	5.0
ARR01-032-51-01	080201004-59	100	5.0	12	5.0
ARR01-032-51-02	080201004-60	7.1	5.0	17	5.0
ARR01-033-51-01	080201004-61	16	5.0	8.6	5.0
ARR01-033-51-02	080201004-62	<5.0	5.0	<5.0	5.0
ARR01-033-52-02	080201004-91	<5.0	5.0	<5.0	5.0
ARR01-034-51-01	080201004-63	20	5.0	<5.0	5.0
ARR01-034-51-02	080201004-64	29	5.0	<5.0	5.0
ARR01-035-51-01	080201004-65	<5.0	5.0	<5.0	5.0
ARR01-036-51-01	080201004-66	16	5.0	<5.0	5.0
ARR01-036-51-02	080201004-67	<5.0	5.0	<5.0	5.0
ARR01-037-51-01	080201004-68	18	5.0	<5.0	5.0
ARR01-038-51-01	080201004-69	23	5.0	6.3	5.0
ARR01-038-51-02	080201004-70	<5.0	5.0	<5.0	5.0
ARR01-039-51-01	080201004-71	6.5	5.0	9.8	5.0
ARR01-039-51-02	080201004-72	9.5	5.0	<5.0	5.0
ARR01-040-51-01	080201004-73	40	5.0	<5.0	5.0
ARR01-040-51-02	080201004-74	58	5.0	<5.0	5.0
ARR01-041-51-01	080201004-75	8	5.0	<5.0	5.0
ARR01-041-51-02	080201004-76	<5.0	5.0	<5.0	5.0
ARR01-042-51-01	080201004-77	410	25	14	5.0
ARR01-042-51-02	080201004-78	9	5.0	5.2	5.0
ARR01-043-51-01	080201004-79	310	25	13	5.0
ARR01-043-51-02	080201004-80	14	5.0	<5.0	5.0
ARR01-044-51-01	080201004-81	33	5.0	<5.0	5.0
ARR01-044-51-02	080201004-82	24	5.0	<5.0	5.0
ARR01-045-51-01	080201004-83	18	5.0	14	5.0
ARR01-045-51-02	080201004-84	<5.0	5.0	<5.0	5.0
ARR01-046-51-01	080201004-85	<5.0	5.0	<5.0	5.0

EPA Sampling Results
Arroyo Park
Sampling data August 2, 2001
Method of Analysis 6010B

Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
ARR01-046-51-02	080201004-86	<5.0	5.0	<5.0	5.0
ARR01-047-51-01	080201004-87	92	5.0	8.6	5.0
ARR01-047-51-02	080201004-88	6.4	5.0	<5.0	5.0
ARR01-048-51-01	080201004-89	77	5.0	<5.0	5.0
ARR01-048-51-01	080201004-90	27	5.0	6.1	5.0

EPA Samplin Results
San Marcos
Sampling daste August 3, 2001
Method of Analysis 6010B

SMS01-004-51-01	080301007-57	220	6.0	26	3.0
SMS01-004-51-02	080301007-58	560	15	59	3.0
SMS01-005-51-01	080301007-55	111	3.0	16	3.0
SMS01-005-51-02	080301007-56	270	12	21	3.0
SMS01-006-51-01	080301007-53	200	6.0	22	3.0
SMS01-006-51-02	080301007-54	480	15	62	3.0
SMS01-007-51-01	080301007-51	140	6.0	18	3.0
SMS01-007-51-02	080301007-52	95	3.0	6.7	3.0
SMS01-008-51-01	080301007-50	140	6.0	14	3.0
SMS01-009-51-01	080301007-48	190	6.0	24	3.0
SMS01-009-51-02	080301007-49	150	6.0	13	3.0
SMS01-009-52-01	080301007-85	240	12	23	3.0
SMS01-009-52-02	080301007-84	180	6.0	10	3.0
SMS01-010-51-01	080301007-46	68	3.0	<5.0	5.0
SMS01-010-51-02	080301007-47	34	3.0	<3.0	3.0
SMS01-011-51-01	080301007-44	100	3.0	12	3.0
SMS01-011-51-02	080301007-45	120	3.0	16	3.0
SMS01-012-51-01	080301007-42	45	3.0	<3.0	3.0
SMS01-012-51-02	080301007-43	69	3.0	4.4	3.0
SMS01-013-51-01	080301007-40	100	3.0	<3.0	3.0
SMS01-013-51-02	080301007-41	170	6.0	4.9	3.0
SMS01-014-51-01	080301007-38	150	6.0	11	3.0
SMS01-014-51-02	080301007-39	220	6.0	16	3.0
SMS01-015-51	080301007-37	70	3.0	8.7	3.0
SMS01-016-51	080301007-36	43	3.0	<3.0	3.0
SMS01-017-51	080301007-34	32	3.0	<5.0	5.0
SMS01-017-51	080301007-35	120	3.0	<3.0	3.0
SMS01-018-51	080301007-32	19	3.0	<3.0	3.0
SMS01-018-51	080301007-33	13	3.0	<3.0	3.0
SMS01-019-51-01	080301007-30	25	3.0	<3.0	3.0
SMS01-019-51-02	080301007-31	17	3.0	<3.0	3.0
SMS01-025-51-01	080301007-28	260	15	34	3.0
SMS01-025-51-02	080301007-29	110	3.0	15	3.0
SMS01-026-51-01	080301007-26	180	6.0	17	3.0
SMS01-026-51-02	080301007-27	850	30	28	3.0
SMS01-027-51-01-	080301007-24	180	6.0	23	3.0
SMS01-027-51-02	080301007-25	57	3.0	14	3.0
SMS01-028-51-01	080301007-22	210	6.0	25	3.0

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SMS01-028-51-02	080301007-23	240	12	28	3.0
SMS01-029-51-01	080301007-20	210	6.0	22	3.0
SMS01-029-51-02	080301007-21	88	3.0	11	3.0

EPA Sampling Results
Library
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Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
EPL01-001-51-01	080301007-75	130	6.0	<3.0	3.0
EPL01-001-51-02	080301007-76	120	3.0	<3.0	3.0
EPL01-003-51-01	080301007-73	250	15	<3.0	3.0
EPL01-003-51-02	080301007-74	54	3.0	<3.0	3.0
EPL01-004-51-01	080301007-71	310	12	<3.0	3.0
EPL01-004-51-02	080301007-72	120	3.0	<3.0	3.0
EPL01-005-51-01	080301007-69	120	12	<3.0	3.0
EPL01-005-51-02	080301007-70	150	12	10	3.0
EPL01-006-51-01	080301007-67	170	6.0	<3.0	3.0
EPL01-006-51-02	080301007-68	45	3.0	<3.0	3.0
EPL01-008-51-01	080301007-65	98	6.0	<3.0	3.0
EPL01-008-51-02	080301007-66	37	3.0	<3.0	3.0
EPL01-008-52-01	080301007-86	190	6.0	<3.0	3.0
EPL01-009-51-01	080301007-63	100	3.0	<3.0	3.0
EPL01-009-51-02	080301007-64	160	6.0	<3.0	3.0
EPL01-010-51-01	080301007-61	330	15	<3.0	3.0
EPL01-010-51-02	080301007-62	470	15	13	3.0
EPL01-011-51-01	080301007-59	350	15	9.3	3.0
EPL01-011-51-02	080301007-60	440	15	12	3.0

EPA Sampling Results
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Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
UTP01-001-51-01	080301007-18	26	3.0	8.4	3.0
UTP01-001-51-02	080301007-19	<3.0	3.0	<3.0	3.0
UTP01-002-51-01	080301007-16	120	3.0	6.6	3.0
UTP01-002-51-02	080301007-17	<3.0	3.0	<3.0	3.0
UTP01-002-52-02	080301007-82	170	6.0	9.1	3.0
UTP01-003-51-01	080301007-15	590	15	51	3.0
UTP01-004-51-01	080301007-13	400	12	39	3.0
UTP01-004-51-02	080301007-14	17	3.0	8.3	3.0
UTP01-005-51-01	080301007-11	480	15	37	3.0
UTP01-005-51-02	080301007-12	310	12	26	3.0
UTP01-006-51-01	080301007-9	420	12	34	3.0
UTP01-006-51-02	080301007-10	380	12	23	3.0
UTP02-007-51-01	080301007-8	<3.0	3.0	<3.0	3.0
UTP02-008-51-01	080301007-7	<3.0	3.0	<3.0	3.0
UTP02-009-51-01	080301007-6	5.7	3.0	<3.0	3.0
UTP02-010-51-01	080301007-5	4.2	3.0	<3.0	3.0
UTP02-010-52-01	080301007-83	<5.0	5.0	<3.0	3.0
UTP03-011-51-01	080301007-4	8.1	3.0	<3.0	3.0
UTP03-012-51-01	080301007-3	7.3	3.0	<3.0	3.0
UTP03-013-51-01	080301007-2	11	3.0	<3.0	3.0
UTP03-014-51-01	080301007-1	7.0	3.0	<3.0	3.0
UTP04-015-51-01	080301007-79	23	3.0	<3.0	3.0
UTP04-016-51-01	080301007-80	24	3.0	<3.0	3.0
UTP04-017-51-01	080301007-81	25	3.0	<3.0	3.0
UTP04-018-51-01	080301007-78	22	3.0	<3.0	3.0
UTP04-019-51-01	080301007-77	22	3.0	<3.0	3.0
UTP05-020-51-01	080401008-1	220	12	6.4	3.0
UTP05-020-51-02	080401008-2	100	3.0	<5.0	5.0
UTP05-020-52-02	080401008-87	130	6.0	<3.0	3.0
UTP05-021-51-01	080401008-3	44	3.0	<3.0	3.0
UTP05-021-51-02	080401008-4	450	24	15	3.0
UTP05-022-51-01	080401008-5	54	3.0	<3.0	3.0
UTP05-022-51-02	080401008-6	26	3.0	<3.0	3.0
UTP05-023-51-01	080401008-7	38	3.0	<3.0	3.0

EPA Sampling Results
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Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
UTP05-023-51-02	080401008-8	95	3.0	<5.0	5.0
UTP05-024-51-01	080401008-9	280	12	4.5	3.0
UTP05-024-51-02	080401008-10	490	15	18	3.0
UTP05-025-51-01	080401008-11	120	6.0	<5.0	5.0
UTP05-025-51-02	080401008-12	63	3.0	<5.0	5.0
UTP05-026-51-01	080401008-13	160	6.0	<3.0	3.0
UTP05-026-51-02	080401008-14	220	12	<5.0	5.0
UTP05-027-51-01	080401008-15	130	6.0	<3.0	3.0
UTP05-027-51-02	080401008-16	590	30	24	3.0
UTP05-028-51-01	080401008-17	94	3.0	<3.0	3.0
UTP05-028-51-02	080401008-18	240	12	6.6	3.0
UTP05-029-51-01	080401008-19	65	3.0	<3.0	3.0
UTP05-029-51-02	080401008-20	190	6.0	5.3	3.0
UTP05-029-52-02	080401008-88	74	3.0	<3.0	3.0
UTP06-030-51-01	080401008-21	1400	60	51	3.0
UTP06-030-51-02	080401008-22	250	12	6.5	3.0
UTP06-031-51-01	080401008-23	890	30	20	3.0
UTP06-031-51-02	080401008-24	22	3.0	<3.0	3.0
UTP06-032-51-01	080401008-25	12	3.0	<3.0	3.0
UTP06-032-51-02	080401008-26	1100	60	38	3.0
UTP06-033-51-01	080401008-27	420	15	13	3.0
UTP06-033-51-02	080401008-28	6.2	3.0	9.7	3.0
UTP06-034-51-01	080401008-29	650	30	16	3.0
UTP06-034-51-02	080401008-30	11	3.0	40	3.0
UTP06-035-51-01	080401008-31	610	30	21	3.0
UTP06-035-51-02	080401008-32	14	3.0	14	3.0
UTP07-036-51-01	080401008-33	850	30	23	3.0
UTP07-036-51-02	080401008-34	730	30	16	3.0
UTP07-036-52-01	080401008-90	790	30	21	3.0
UTP07-037-51-01	080401008-35	240	12	9.2	3.0
UTP07-037-51-02	080401008-36	270	12	<6.0	6.0
UTP07-038-51-01	080401008-37	750	30	30	3.0
UTP07-038-51-02	080401008-38	1500	60	49	3.0
UTP08-039-51-01	080401008-39	220	12	<5.0	5.0

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Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
UTP08-039-51-02	080401008-40	390	15	8.5	3.0
UTP08-040-51-01	080401008-41	140	6.0	<3.0	3.0
UTP08-040-51-02	080401008-42	310	12	<6.0	6.0
UTP09-041-51-01	080401008-43	750	30	21	3.0
UTP09-041-51-02	080401008-44	79	3.0	14	3.0
UTP09-042-51-01	080401008-45	810	30	12	3.0
UTP09-042-51-02	080401008-46	30	3.0	17	3.0
UTP09-043-51-01	080401008-47	850	30	38	3.0
UTP09-043-51-02	080401008-48	160	6.0	13	3.0
UTP09-044-51-01	080401008-49	520	15	17	3.0
UTP09-044-51-02	080401008-50	74	3.0	20	3.0
UTP10-045-51-01	080401008-51	150	6.0	<3.0	3.0
UTP10-045-51-02	080401008-52	<3.00	3.0	<3.0	3.0
UTP10-046-51-01	080401008-53	140	6.0	<3.0	3.0
UTP10-046-51-02	080401008-54	62	3.0	<3.0	3.0
UTP10-046-52-02	080401008-89	84	3.0	<3.0	3.0
UTP10-047-51-01	080401008-55	140	6.0	<3.0	3.0
UTP11-047-51-02	080401008-56	12	3.0	<3.0	3.0
UTP11-048-51-01	080401008-57	140	6.0	<5.0	5.0
UTP11-048-51-02	080401008-58	27	3.0	<3.0	3.0
UTP11-048-52-02	080401008-86	18	3.0	<3.0	3.0
UTP11-049-51-01	080401008-59	64	3.0	<3.0	3.0
UTP11-049-51-02	080401008-60	<3.00	3.0	<3.0	3.0
UTP12-050-51-01	080401008-61	43	3.0	<3.0	3.0
UTP12-050-51-02	080401008-62	170	6.0	5.7	3.0
UTP12-051-51-01	080401008-63	270	15	7.9	3.0
UTP12-051-51-02	080401008-64	320	15	11	3.0
UTP12-052-51-01	080401008-65	63	3.0	<3.0	3.0
UTP12-052-51-02	080401008-66	29	3.0	<3.0	3.0
UTP12-053-51-01	080401008-67	17	3.0	<3.0	3.0
UTP12-053-51-02	080401008-68	210	12	<15	15
UTP12-054-51-01	080401008-69	36	3.0	<3.0	3.0
UTP12-054-51-02	080401008-70	160	6.0	7.5	3.0
UTP12-055-51-01	080401008-71	120	6.0	<3.0	3.0

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Sample Number	Lab ID Number	Lead mg/kg	Reporting Limit	Arsenic mg/kg	Reporting Limit
UTP12-055-51-02	080401008-72	48	3.0	<3.0	3.0
UTP12-056-51-01	080401008-73	150	6.0	<3.0	3.0
UTP12-056-51-02	080401008-74	190	6.0	<5.0	5.0
UTP12-056-52-02	080401008-85	180	6.0	<5.0	5.0
UTP12-057-51-01	080401008-75	180	6.0	<3.0	3.0
UTP12-057-51-02	080401008-76	150	6.0	16	3.0
UTP13-058-51-01	080401008-77	10	3.0	<3.0	3.0
UTP13-058-51-02	080401008-78	5.0	3.0	<3.0	3.0
UTP13-059-51-01	080401008-79	27	3.0	<3.0	3.0
UTP13-059-51-02	080401008-80	8.7	3.0	<3.0	3.0
UTP13-060-51-01	080401008-81	26	3.0	<3.0	3.0
UTP13-060-51-02	080401008-82	21	3.0	<3.0	3.0
UTP13-061-51-01	080401008-83	25	3.0	<3.0	3.0
UTP13-061-51-02	080401008-84	4.5	3.0	<3.0	3.0

El Paso Historical Soil Sample

HEALTH CONSULTATION

Review of Historical Soil Sampling Results

EL PASO COUNTY METAL SURVEY SITE

EL PASO, EL PASO COUNTY, TEXAS

Prepared by:

Texas Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

El Paso Historical Soil Sample Health Consultation

BACKGROUND AND STATEMENT OF ISSUES

The Texas Department of Health (TDH) and the Agency for Toxic Substances and Disease Registry (ATSDR) were asked by the U. S. Environmental Protection Agency (EPA) to determine the public health significance of arsenic and lead found in historical soil samples collected in El Paso by the Texas Air Control Board (predecessor of the Texas Natural Resource Conservation Commission) in 1989 and by graduate students from the University of Texas at El Paso in 1993 and 1994. Specifically, EPA asked TDH and ATSDR to determine whether confirmation of these data is warranted.

History

Historically, there have been several potential point sources for metals contamination in El Paso. These sources include the ASARCO Smelter on the west side of the city, the Federal Smelter in central El Paso, and the Phelps Dodge Copper refinery on the east side of the city. Much of the history pertaining to the study of industrial pollution in the El Paso has focused on the ASARCO Smelter which occupies 123 acres of a 585 acre property along the Rio Grande, near the U.S - Mexico border (Figure 1). Originally known as El Paso Smelting Works, the plant was built in 1887 and was the first smelter in Texas. In 1899 it became part of the American Smelting and Refining Company (ASARCO). Lead smelting was the primary activity at ASARCO until approximately 1910 or 1920 when copper smelting was initiated. The facility became one of the world's largest copper smelters. The smelter had a secondary zinc fuming operation from the late 1940s until 1982. A smaller cadmium roasting unit also was operated on an intermittent basis beginning in the 1950s. In 1967, a 828 foot stack was installed as the centerpiece of its operations. Lead smelting was discontinued in 1985 and the Plant was placed on care and maintenance status in 1999 [1].

In December 1971, the El Paso City-County Health Department discovered that the ASARCO facility in El Paso was discharging large quantities of lead and other metals into the air. Reportedly, between 1969 and 1971, the smelter had released 1,116 tons of lead, 560 tons of zinc, 12 tons of cadmium, and 1.2 tons of arsenic into the atmosphere. Twenty-four hour air samples collected in 1971, 1972, and 1973 by the local health department indicated that the mean concentrations of metals in the air were highest immediately downwind of the smelter and decreased logarithmically with distance from the smelter. In 1971, the annual mean lead level immediately downwind of the smelter was 92 micrograms per cubic meter ($\mu g/m^3$). Soil samples taken by the health department between June and December of 1972 showed the highest concentrations of lead and other metals to be in surface soil from within 0.2 miles of the smelter [2].

In August 1972, in part to determine whether high blood lead levels in children were associated with smelter emissions or could be explained by other lead sources in the community, the health

department and the Centers for Disease Control and Prevention (CDC) measured the blood lead levels of 758 people 1–19 years of age. They found that the percentage of the people with blood lead levels greater than 40 micrograms per deciliter (µg/dL) decreased with distance from the smelter. The inverse gradient between lead in air and distance from the ASARCO smelter and the parallel blood lead gradient supported an association between the smelter emissions and the blood lead levels in the children.

They also found that people with blood lead levels ≥40 µg/dL had been exposed to soil and dust with significantly higher ($p<0.001$) mean lead concentrations (3,264 parts per million [ppm] for soil; 3,522 ppm for dust) than people with lead levels below 40 µg/dL (means: 1,032 ppm for soil; 1,279 ppm for dust). These findings supported the argument that soil and dust could be important vehicles of exposure for children [2].

Up until the early 1970s, lead attributable to emission and dispersion into the general ambient environment was not thought to have any known harmful effects [3]. The investigations conducted around the ASARCO El Paso facility played an important role in identifying the potential public health significance of lead released into the environment.

Historical Environmental Sampling Data Reviewed in this Consultation

In 1989, the Texas Air Control Board collected surface soil (top ½ inch) samples in El Paso, Texas [4]. In choosing the sampling locations an emphasis was placed on collecting samples in the vicinity of schools and recreational parks (Figure 1; Table 1). The highest concentration, 1,100 milligrams of arsenic per kilogram of soil (1,100 mg/kg), detected in the soil was found in the sample taken at the International Boundary and Water Commission, an area identified as being close to the ASARCO facility and directly across from a brick manufacturing company in Mexico. At that time the levels of contaminants were judged not to pose a threat to human health because the areas with the highest concentrations were not considered to be in places frequented by the general public.

Between 1993 and 1994, the University of Texas at El Paso released four master of science theses (Barnes, Ndame, Srinivas, and Devenahalli) documenting metals concentrations in El Paso soils [5–8]. These students collected surface soil samples (0–2.5 centimeters [cm]) from various areas around El Paso (Figure 1). There was a strong correlation (0.94) between the concentrations of lead and arsenic found in the soil (Figure 2). The highest concentrations of lead (5,194 mg/kg) and arsenic (589 mg/kg) were found in the area identified by Barnes as the ASARCO Area (Table 2a and 2b). The distribution of lead and arsenic in soil from the areas that included the ASARCO facility differed from the distribution of these contaminants in soil collected from areas that did not include the facility with a greater percentage of the samples skewed towards higher concentrations (Figure 3 and 4).

El Paso Historical Soil Sample Health Consultation

Previous TDH and ATSDR Involvement

In 1995, TDH investigated a concern that there was an excessive occurrence of multiple sclerosis (MS) among people who spent their childhoods in the Kern Place-Mission Hills area of El Paso [9]. Residents also had asked whether there could be a connection between the MS and exposure to contaminants from a nearby smelter. On the basis of initial referrals, TDH identified 15 likely cases of MS among persons who resided in this neighborhood as children. All of the people were born between 1943 and 1953 and spent at least four years of their childhood (before age 16 years) in the Kern Place-Mission Hills neighborhood. During the 1950s and 1960s, the neighborhood was comprised of upper-income, single-family housing and was considered to be among the most affluent areas of El Paso. The population was predominantly, if not exclusively, white and non-Hispanic. Of the 15 persons identified as likely cases of MS (medical verification was not performed for this evaluation), 14 went to Mesita School (the local public elementary school for grades 1–7) and one went to a private school. Mesita School, located on the east side of Kern Place, is approximately 1 mile east-northeast of the smelter.

TDH determined that the number of apparent MS cases in the age group of concern appeared to be unusual and, although the etiology of MS is unknown, epidemiologic studies provide evidence that environmental exposures, whether infectious or non-infectious, before puberty might have an important role in the risk for developing the disease later in life. Although TDH did find some studies identifying metals as having a possible etiologic role in the development of the disease, determining if contaminants from the smelter were associated with the apparent unusual number of MS cases in the area was not possible. TDH recommended further investigation of the apparent cluster and subsequently received funds from ATSDR to better verify the cluster. A final report on the investigation is being prepared.

In response to a recent concern over the possibility that soil in the area still might contain excess lead, TDH reviewed data (for 1997–1999) from the Texas Childhood Lead Surveillance Program for El Paso County. They found that 117 (4.5%) of 2,628 children tested in the combined ZIP codes 79901, 79902, 79912, 79922, and 79968 had elevated blood lead levels (>10µg/dL); 16 (9.6%) of the 167 children tested in ZIP code 79922 had elevated blood lead levels; and 385 (1.7%) of the 22,397 children tested in the rest of El Paso County had elevated blood lead levels. For the same 3–year period, 2.4% of the children tested in Texas had elevated blood lead levels [10].

DISCUSSION

The environmental sampling data that we used in this discussion include data from the 1989 Texas Air Control Board report and data from the four masters' theses written by students from the University of Texas at El Paso. In preparing this report on the public health significance of these data, we relied on the information provided in the referenced documents and assumed

adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain-of-custody, laboratory procedures, and data reporting. The analysis and conclusions in this report are valid only if the referenced information is valid and complete.

To facilitate our interpretation of these data we made a reasonable attempt at delineating samples either as having been collected from the area identified in the Barnes thesis as the ASARCO area or from other areas of El Paso. For ease of presentation and historical consistency we have identified these areas as the "ASARCO area" and "Other El Paso". For lead, the data used to describe the ASARCO area includes data from the Barnes thesis (ASARCO area) and the Ndame thesis. For arsenic, the data used to describe the ASARCO area includes data from the Barnes thesis (ASARCO area) and portions of the TACB data that we were able to identify as having been collected from this area. Data collected from all other areas were included in the Other El Paso area (Figure 5). While the designation of these areas is not perfect, it is consistent with historical reports of metals contamination in the El Paso area. The concentrations of lead and arsenic in soil from the ASARCO area were significantly higher ($p<0.05$) than the concentrations of these contaminants in soil from other areas of El Paso (Figures 6 and 7; Table 3).

In assessing the potential public health significance of these sample results we recognize that the data used in this assessment were not collected with the goal of assessing exposure. Our knowledge of exactly where the samples were collected and the potential for human contact is poor. As such, the exposure estimates used in this consult are theoretical and in many cases worst case scenarios used only to determine if confirmation sampling is warranted. The exposure estimates used in this assessment should not be taken to apply to any individual or group of individuals.

We also recognize that the unique vulnerabilities of children demand special attention. Windows of vulnerability (critical periods) exist during development, particularly during early gestation, but also throughout pregnancy, infancy, childhood and adolescence — periods when toxicants may permanently impair or alter structure and function [11]. Unique childhood vulnerabilities may be present because, at birth, many organs and body systems (including the lungs and the immune, endocrine, reproductive, and nervous systems) have not achieved structural or functional maturity. These organ systems continue to develop throughout childhood and adolescence. Children may exhibit differences in absorption, metabolism, storage, and excretion of toxicants, resulting in higher biologically-effective doses to target tissues. Depending on the affected media, they also may be more exposed than adults because of behavior patterns specific to children. In an effort to account for children's unique vulnerabilities, and in accordance with ATSDR's Child Health Initiative [12] and EPA's National Agenda to Protect Children's Health from Environmental Threats [13], we used the potential exposure of children to the contaminants found in the soil as a guide in assessing the need for confirmation sampling.

El Paso Historical Soil Sample Health Consultation

Lead

To assess the potential health risks associated with the lead in the soil we used the CDC's definition of excessive lead absorption in children and the estimated relationship between blood lead in children and soil lead concentrations (EPA's integrated uptake biokinetic model) to derive a health-based assessment comparison (HAC) value for this contaminant. HAC values are guidelines that specify levels of chemicals in specific environmental media (soil, air, water) that are considered safe for human contact. Exceeding a health-based HAC value does not imply that a contaminant will cause harm but suggests that potential exposure to the contaminant warrants further consideration.

Based on observations of enzymatic abnormalities in the red blood cells at blood lead levels below 25 µg/dL and observations of neurologic and cognitive dysfunction in children with blood lead levels from 10–15 µg/dL, the CDC has determined that a blood lead level ≥10 µg/dL in children indicates excessive lead absorption and constitutes the grounds for intervention [14]. The relationship between soil lead levels and blood lead levels is affected by factors such as the age of the population exposed to the contaminated soil, the physical availability of the contaminated soil, the bioavailability of the lead in the soil, and differences in individual behavioral patterns [15–17]. While there is no clear relationship applicable to all sites, a number of models have been developed to estimate the potential impact that soil lead could have on the blood lead levels in different populations [17–19]. In general, soil lead will have the greatest impact on the blood lead levels of preschool-age children. These children are more likely to play in dirt and to place their hands and other contaminated objects in their mouths, they are better at absorbing lead through the gastrointestinal tract than adults, and they are more likely to exhibit the types of nutritional deficiencies that facilitate the absorption of lead. For children, the predicted 95th percentile blood lead level associated with a soil lead concentration of 500 mg/kg is approximately 10 µg/dL. This means that except in the most extreme cases (i.e., frequent contact by children exhibiting pica behavior, or desire for unnatural foods such as dirt or ashes) children regularly exposed to soil lead levels of 500 mg/kg should have no more than a 5% probability of having blood lead levels greater than 10 µg/dL.

Fitting a lognormal distribution to the available data we estimate that approximately 33 % of the soil samples from the ASARCO area could exceed 500 mg/kg (Table 3). Based on the goal of limiting the probability of exceeding a blood lead level of 10 µg/dL to no more than 5%, depending on individual exposure situations, the concentrations of lead found in some of the soil from the ASARCO area could be considered unacceptable.

Further Analysis of the Blood Lead Level Results

In the recent analysis of childhood blood lead levels for El Paso County, TDH examined two factors that could have influenced the results in the comparisons of the five ZIP codes to the rest

of El Paso County [10]. Those factors were socioeconomic status (SES) and Medicaid enrollment. Lower SES is a known risk factor associated with higher rates of elevated blood lead levels in a population. Neither SES or Medicaid enrollment could explain the findings.

According to the CDC, lead-based paint remains the most common high-dose source of lead exposure for preschool age children [14]. Numerous studies have established that the risk of lead poisoning is related to the presence of lead-based paint in the home [14]. Lead-based paint containing up to 50% lead was widely used through the 1940s and although the use of interior lead-based paint declined thereafter, exterior lead-based paint and lesser amounts of interior lead-based paint continued to be available until the mid-1970s.

In an effort to examine whether lead-based paint could in part explain the differences in the blood lead data between the ZIP codes, for each ZIP code, we regressed the percentage of children with blood lead levels greater than 10 µg/dL with the median year that the houses in the ZIP code were built (Figure 8). The earlier the median age, the older the housing stock in the area. The implied assumption is that the probability that lead-based paint is present in the home increases with the age of the home. The percentage of children with elevated blood lead levels increased as the median age of the homes increased. The slope of the regression line was significantly different from zero (p=0.003) suggesting that the age of the housing stock could to some extent explain the blood lead results. When plotting the data, the data point for ZIP code area 79922 appeared to lie far from the regression line so we tested the significance of the deviation of this data point from the regression line and found it to be large enough to excite suspicion (p<0.05). While the overall analysis suggests that the age of the homes (and by inference lead-based paint) could to some extent explain the blood lead data for the different ZIP codes, the data also suggest that something else may be contributing to the blood lead level results for ZIP code 79922. ZIP code area 79922 is within the area identified by Barnes as the ASARCO area. In addition to lead-based paint, other common potential sources of lead that could explain these results include lead in soil and dust, lead from food stored in some types of glazed pottery or ceramic ware, lead from old water pipes made of lead, lead from newer water pipes that contain lead solder, and lead from certain folk or home remedies such as greta and azarcon.

Arsenic

To assess the potential health risks associated with the arsenic in soil we compared the soil concentrations to health-based assessment comparison (HAC) values for non-cancer and cancer endpoints. The non-cancer HAC values for arsenic in soil (20 mg/kg for children and 200 mg/kg for adults) are based on EPA's reference dose (RfD) for arsenic of 0.3 µg/kg/day [19]. RfDs are based on the assumption that an there is an identifiable exposure threshold (both for the individual and for populations) below which there are no observable adverse effects. Thus, the RfD is an estimate of a daily exposure to arsenic that is unlikely to cause adverse non-cancer health effects even if exposure were to occur for a lifetime. For arsenic, the RfD was derived by

dividing the identified no observable adverse effects level (NOAEL[1]) of 0.8 µg/kg/day, obtained from human epidemiologic studies, by an uncertainty factor of three. The lowest observable adverse effects level (LOAEL[2]) associated with these epidemiologic studies was 14 µg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [20–22]. We used standard assumptions for body weight (70 kg adult and 15 kg child) and soil ingestion (100 mg per day for adults and 200 mg per day for a child) to calculate the HAC values.

The average concentration of arsenic in soil from the area identified as the ASARCO area (105 mg/kg), is five times greater than the non-cancer HAC value for children. Fitting a lognormal distribution to the data we estimate that approximately 73% of the soil samples from the ASARCO area could exceed the non-cancer HAC value for children (Table 3). Fifty percent of the soil samples from the ASARCO area were over 44 mg/kg, a concentration two times greater than the non-cancer HAC value. The average concentration of arsenic found in soil from other areas of El Paso was 20 mg/kg, a value equal to the non-cancer HAC value. Approximately 36% of the samples from other areas of El Paso exceeded the non-cancer HAC value (Table 3). Arsenic does occur naturally in the earth's crust and can usually be found in the inorganic form in the environment at background levels ranging from less than 1 mg/kg to 97 mg/kg with average concentrations of 7 to 8 mg/kg [23].

Assuming that the concentrations of arsenic in these soil samples are representative of the concentrations to which people may be exposed, children regularly exposed to soil from the ASARCO area could be exposed to arsenic at levels above the NOAEL. It is less likely that they would be exposed to levels above the LOAEL. Since by definition neither the NOAEL or the LOAEL represent a sharp dividing line between "safe" and "unsafe" exposures, we assume that the public health significance of the arsenic increases as the ratio of the NOAEL to the estimated exposure dose decreases. We refer to this ratio as the margin of exposure (MOE) and consider MOEs less than 10 to be unacceptable. Under some potential exposure scenarios MOEs for both children and adults could be less than 10. On the basis of these data, under some conditions the concentrations of arsenic in the soil from the area identified as the ASARCO area could be considered to be unacceptable (Table 4a, 4b).

The average concentration of arsenic found in soil from other areas of El Paso is five times lower than the average concentration found in the ASARCO area but higher than the average concentration generally found in soil from the western United States [23]. Under a limited subset of potential exposure scenarios, the MOE for children could be less than 10. Thus, the arsenic in the soil from some of these areas also could be considered unacceptable (Table 5a).

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[1]The highest dose at which adverse effects were not observed.

[2]The lowest dose at which adverse effects were observed.

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EPA classifies arsenic as a known human carcinogen on the basis of sufficient evidence from human data. An increase in lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer (non-malignant) were observed in populations consuming water high in inorganic arsenic [21]. The carcinogenic HAC value for arsenic of 0.5 mg/kg is based on EPA's cancer slope factor (CSF) for skin cancer and an estimated excess lifetime cancer risk of one cancer in 1 million (1×10^{-6}) people exposed for 70 years.

Arsenic was detected in virtually all the soil samples at concentrations above its carcinogenic HAC value; however, an important note is that background levels of arsenic also exceed this HAC value. To estimate a broad range of conservative (with respect to protecting public health) exposure scenarios we assumed that an individual would ingest 50 or 100 milligrams of soil (containing the average concentration of arsenic), 50 weeks per year, one to seven days per week. Depending on the exposure scenario, we would qualitatively interpret the potential excess lifetime cancer risk associated with soil from the ASARCO area to range from an insignificant increased lifetime risk to a low increased lifetime risk (Table 6a). We would interpret the potential excess lifetime cancer risk associated with soil from other areas of El Paso to range from an insignificant lifetime risk to no apparent increased lifetime risk (Table 6b).

Uncertainties

General Uncertainties

Because of the nature of the data used in this report we were not able to estimate exposure with any degree of certainty. Our lack of knowledge pertaining to where the samples were taken prevents us from adequately estimating whether the samples were taken from areas where people would come into contact with the soil on a regular basis.

While our analysis of the blood lead data suggest that the age of housing may to some extent explain the differences between the ZIP codes and that something else may be contributing to the blood lead levels in children from ZIP code area 79922, these data are not random and were not collected with the purpose of performing such an analysis.

Specific Uncertainties

Considerable controversy also is associated with any estimate of risk, non-cancer or cancer, associated with exposure to arsenic. Both the RfD and the CSF are based on human ecological studies that have recognized uncertainties with respect to the assignation of exposure. Such studies find it difficult to avoid errors in assigning people to specific exposure groups. The studies upon which the RfD and the CSF are based also involved exposure to arsenic in drinking water. The ability of the body to absorb arsenic in water is likely to be higher than the ability of the body to absorb arsenic in soil. In our analysis we assumed that the arsenic in the soil was 100% bioavailable. Assuming that the applied dose (the amount available for absorption) is the

same as the internal dose (the amount of that has been absorbed), is very conservative with respect to protecting public health and to some unknown degree overestimates the risk. We did not consider the kinetics of arsenic in the body in our risk estimates. The RfD and the CSF are based on daily exposures over a lifetime. Since the half-life of arsenic in the body (the time it takes one-half of the arsenic to be excreted) is short (40-60 hours), the risk estimates for exposures that occur less frequently than everyday also may result in an overestimate of the risks.

With specific respect to the cancer risk estimates, the mechanisms through which arsenic causes cancer are not known; however, arsenic is not thought to act directly with DNA. Since the studies used to derive the CSF are based on exposure doses much higher than those likely to be encountered at this site, it is questionable whether it is appropriate to assume linearity for the dose-response assessment for arsenic at low doses. The actual dose-response curve at low doses may be sublinear which would mean that the above risk estimates overestimate the actual risks.

CONCLUSIONS

1. Under some theoretical exposure situations, the lead and arsenic found in the soil from some areas of El Paso could be considered unacceptable. However, in light of the uncertainties associated with site-specific exposures we would have to categorize the contaminants found in the soil to pose an indeterminate public health hazard.

2. Although our analysis suggests that the blood lead level results for the different zip codes could to some extent be explained by the age of the housing, it would not be inconsistent with the data to suspect that other causal factors could be at work in ZIP code area 79922. Such factors could include lead in soil and dust, lead from food stored in some types of glazed pottery or ceramic ware, lead in old water pipes made from lead, lead from water pipes that contain lead solder, and lead from certain folk or home remedies such as greta and azarcon.

PUBLIC HEALTH ACTION PLAN

Actions Recommended

1. Confirmation of the results from the referenced documents is warranted. Samples should be obtained from areas identified as having elevated levels of arsenic and lead and from areas known to be frequented by people, particularly children since they are at greater risk from exposure to contaminants in soil.

2. TDH and ATSDR should be provided with the sample results so that they may determine whether the concentrations found in the soil pose a threat to public health.

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Actions Planned

1. EPA will be conducting confirmation sampling in publicly accessible areas within an area identified as the El Paso County /Dona Ana County study area. Sampling is to be conducted in July 2001.

2. EPA will provide TDH and ATSDR with the sample results so that they may prepare a health consultation to determine whether the concentrations found in the soil present a continuing threat to public health.

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Table 1. 1989 Texas Air Control Board Surface Soil Sample Results – El Paso, Texas

Sample location	Arsenic concentration (mg/kg)
Dunn Park	10
Tom Lea Park	7
Mission Hills Park	11
Westside Park	5
Madeline Park	16
Ascarte Park	<3
Washington Park	<3
Loretto Park	<3
Memorial Park	6
Grandview Park	5
Newmann Park	6
Houston Square Park	7
Armijo Park	6
Kerr Park	59
Doniphan Park	6
Vilas Elementary School	10
Mesita Elementary School	24
University of Texas at El Paso	12
University of Texas at El Paso	15
Crazycat Mountain	16
Rio Bravo Drive	15
Interstate Hwy. 10	250
International Boundary and Water Commission	1,100
W. Robertson Water Treatment Plant	26

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Table 2a. Soil Lead Levels in Surface Soil Collected from Various Areas of El Paso					
Parameter	Barnes ASARCO area	Barnes other El Paso areas	Ndame ASARCO area	Srinivas other El Paso areas	Devanahalli other El Paso areas
Average	963	93	385	55	103
Min-max	54 - 5,194	27 - 390	34 - 1,500	30 - 135	17 - 560
50th Percentile	541	68	163	50	65

Table 2b. Soil Arsenic Levels in Surface Soil Collected from Various Areas of El Paso				
Parameter	Barnes ASARCO area	Barnes other El Paso areas	TACB mixed areas	Devanahalli other El Paso areas
Average	115	23	65	18
Min-max	19 - 589	10 - 66	3 - 1,100	13 - 92
50th Percentile	72	19	12	14

Table 3. Lead and Arsenic in El Paso Soil. ASARCO area vs. other El Paso areas				
Parameter	Lead		Arsenic	
	ASARCO area	other El Paso	ASARCO area	other El Paso
Arithmetic average (mg/kg)	606	84	105	20
Geometric mean (mg/kg)	276	62	44	16
Percent > 400 mg/kg (lead) Percent >20 mg/kg (Arsenic)	39	< 1	73	36
Percent > 500 mg/kg (lead) Percent >30 mg/kg (arsenic)	33	< 1	62	18

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Table 4a. ASARCO Area Margin of Exposure[1] Analysis for exposure of Children to Arsenic[2]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	16.0	8.0	5.3	4	3.2	2.7	2.3
75	10.7	5.3	3.6	2.7	2.1	1.8	1.5
100	8.0	4	2.7	2	1.6	1.3	1.1
125	6.4	3.2	2.1	1.6	1.3	1.1	0.9
150	5.3	2.7	1.8	1.3	1.1	0.9	0.8
175	4.6	2.3	1.5	1.1	0.9	0.8	0.7
200	4	2	1.3	1.0	0.8	0.7	0.6

Table 4b. ASARCO Area Margin of Exposure[1] Analysis for exposure of Adults to Arsenic[2]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	74.7	37.3	24.9	18.7	14.9	12.4	10.7
75	49.8	24.9	16.6	12.4	10.0	8.3	7.1
100	37.3	18.7	12.4	9.3	7.5	6.2	5.3
125	29.9	14.9	10.0	7.5	6.0	5.0	4.3
150	24.9	12.4	8.3	6.2	5.0	4.2	3.6
175	21.3	10.7	7.1	5.3	4.3	3.6	3.1
200	16.7	9.3	6.2	4.7	3.7	3.1	2.7

[1] No observable adverse effects level (NOAEL) divided by the estimated exposure dose. Shaded areas represent those conditions under which the MOE is less than 10. Body weights assumed to be 15 kilograms (kg) for children and 70 kg for adults.

[2] This analysis likely overestimates the actual risks as it assumes that the arsenic in the soil is 100% bioavailable and does not take into account the biokinetics of arsenic in the body.

Table 5a. Other El Paso Areas Margin of Exposure[1] Analysis for exposure of Children to Arsenic[2]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	84.0	42.0	28.0	21.0	16.8	14.0	12.0
75	56.0	28.0	18.7	14.0	11.2	9.3	8.0
100	42.0	21.0	14.0	10.5	8.4	7.0	6.0
125	33.6	16.8	11.2	8.4	6.7	5.6	4.8
150	28.0	14.0	9.3	7.0	5.6	4.7	4.0
175	24.0	12.0	8.0	6.0	4.6	4.0	3.4
200	21.0	10.5	7.0	5.3	4.2	3.5	3.0

Table 5b. Other El Paso Areas Margin of Exposure[1] Analysis for exposure of Adults to Arsenic[2]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	392	196	131	98	78	65	56
75	261	131	87	65	52	44	37
100	196	98	65	49	39	33	28
125	157	78	52	39	31	26	22
150	131	65	44	33	26	22	19
175	112	56	37	28	22	19	16
200	98	49	33	25	20	16	14

[1] No observable adverse effects level (NOAEL) divided by the estimated exposure dose. Shaded areas represent those conditions under which the MOE is less than 10. Body weights assumed to be 15 kilograms (kg) for children and 70 kg for adults.

[2] This analysis likely overestimates the actual risks as it assumes that the arsenic in the soil is 100% bioavailable and does not take into account the biokinetics of arsenic in the body.

Table 6a. ASARCO Area Estimated Excess Lifetime Cancer Risk from Exposure to Arsenic in Soil[1]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	6.6×10^{-6}	1.3×10^{-5}	2.0×10^{-5}	2.6×10^{-5}	3.3×10^{-5}	4.0×10^{-5}	4.6×10^{-5}
100	1.3×10^{-5}	2.6×10^{-5}	4.0×10^{-5}	5.3×10^{-5}	6.6×10^{-5}	7.9×10^{-5}	9.3×10^{-5}

Table 6b. Other El Paso Areas Estimated Excess Lifetime Cancer Risk from Exposure to Arsenic in Soil[1]							
Soil ingestion rate (milligrams/day)	Days per week of exposure						
	1	2	3	4	5	6	7
50	1.3×10^{-6}	2.5×10^{-6}	3.8×10^{-6}	5.0×10^{-6}	6.3×10^{-6}	7.6×10^{-6}	8.8×10^{-6}
100	2.5×10^{-6}	5.0×10^{-6}	7.6×10^{-6}	1.0×10^{-5}	1.3×10^{-5}	1.5×10^{-5}	1.8×10^{-5}

[1] This analysis likely overestimates the actual risks as it assumes that the arsenic in the soil is 100% bioavailable and does not take into account the biokinetics of arsenic in the body.

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CERTIFICATION

This health consultation was prepared by the Texas Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.

Technical Project Officer, SPS, SSAB, DHAC, ATSDR

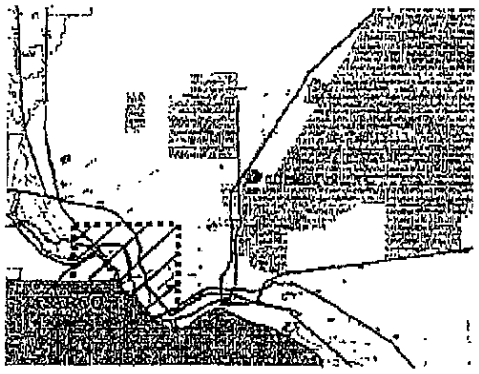
The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

Chief, State Programs Section, SSAB, DHAC, ATSDR

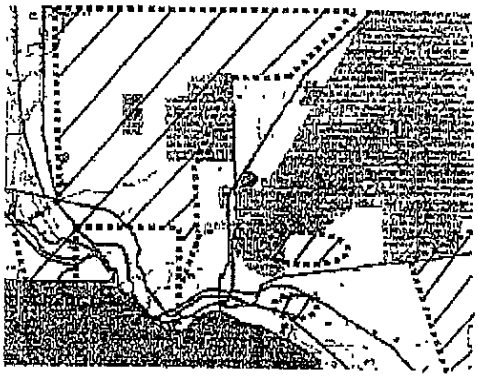
ASARCO El Paso Health Consultation

Figure 1. Approximate location of the ASARCO Facility and Sampling Areas

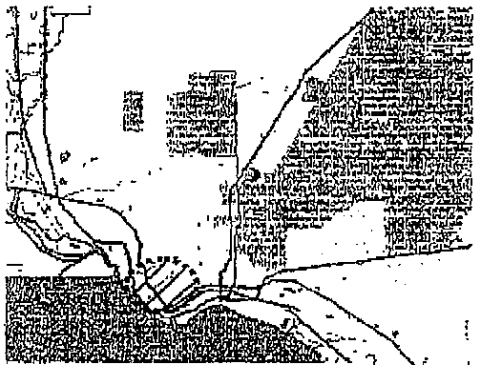
Barnes – ASARCO Area



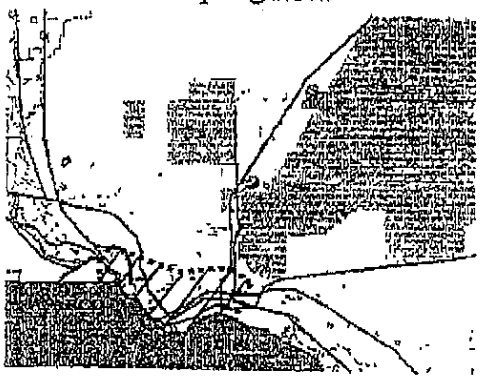
Barnes – Other El Paso Areas



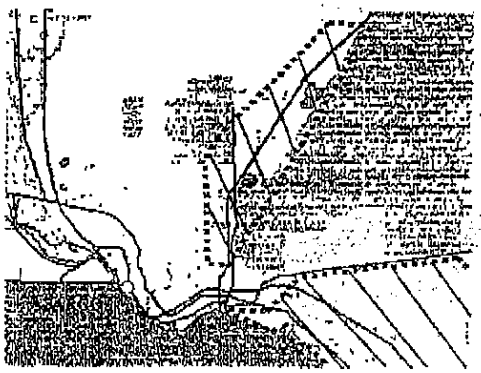
Ndame Sampling Area



TACB Sampling Area



Srinivas Sampling Areas



Devanahalli Sampling Areas

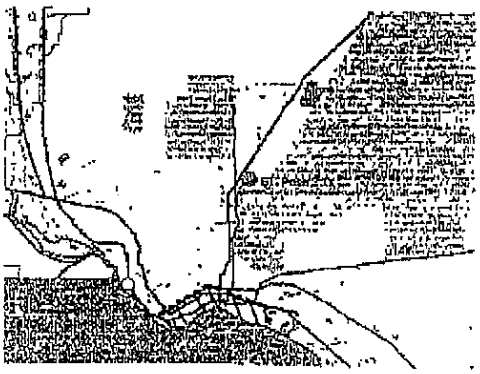


Figure 2
Barnes Thesis
Arsenic vs Lead Surface Soil Concentrations El Paso, Texas

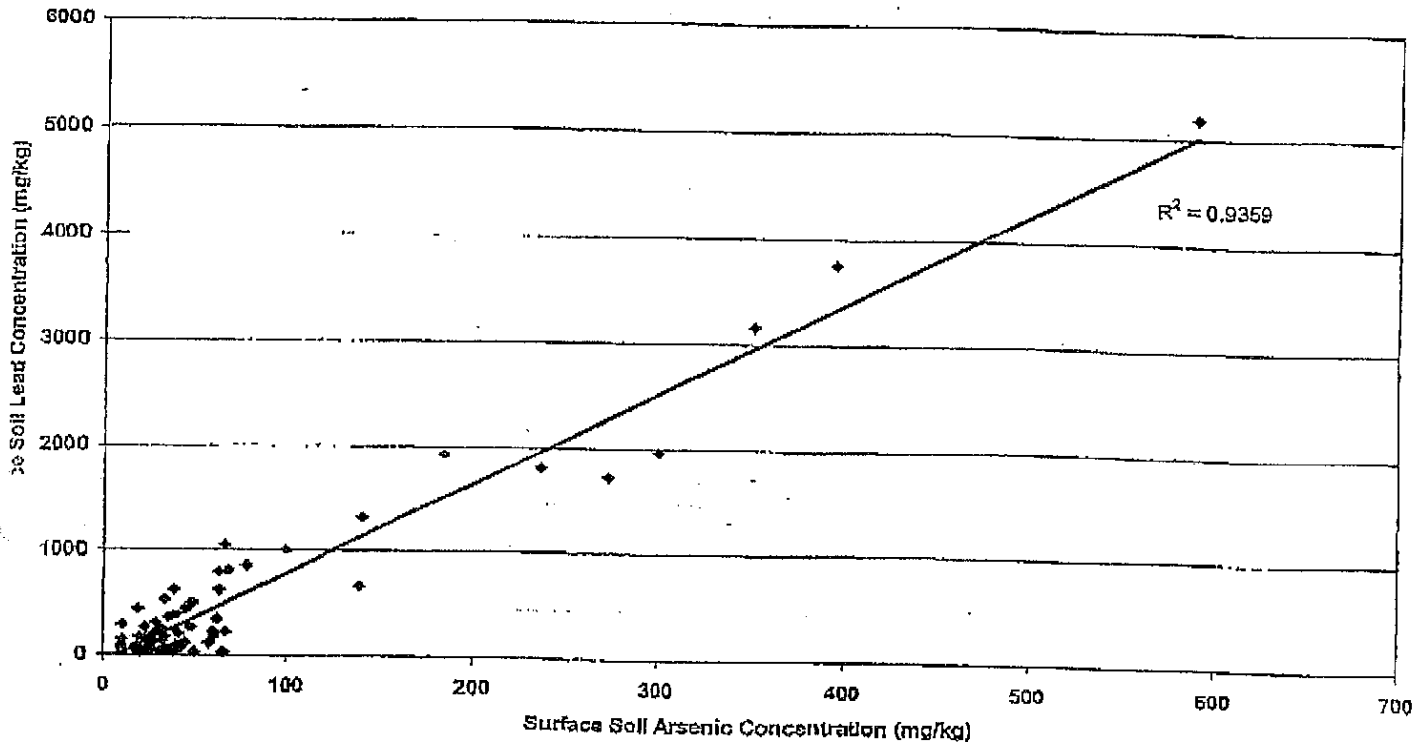
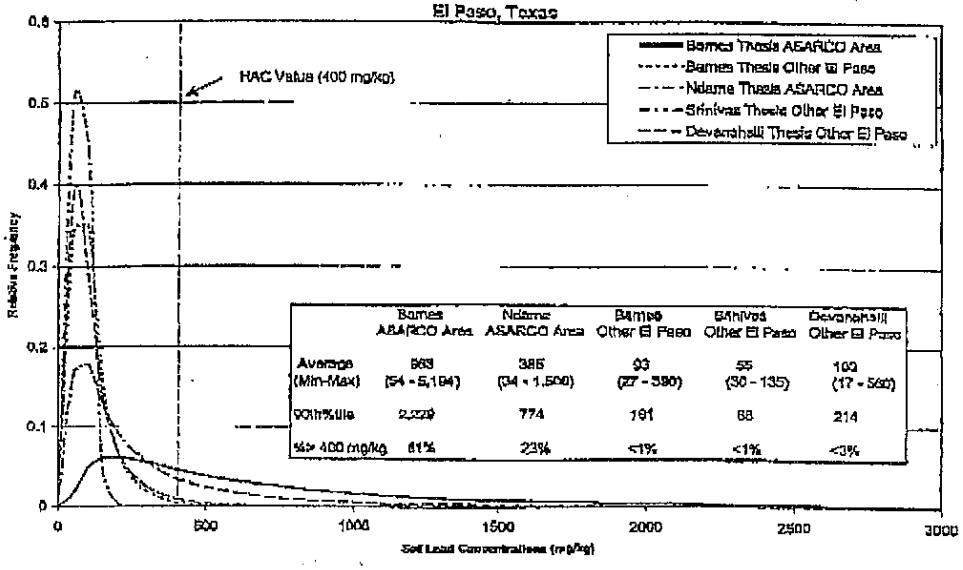
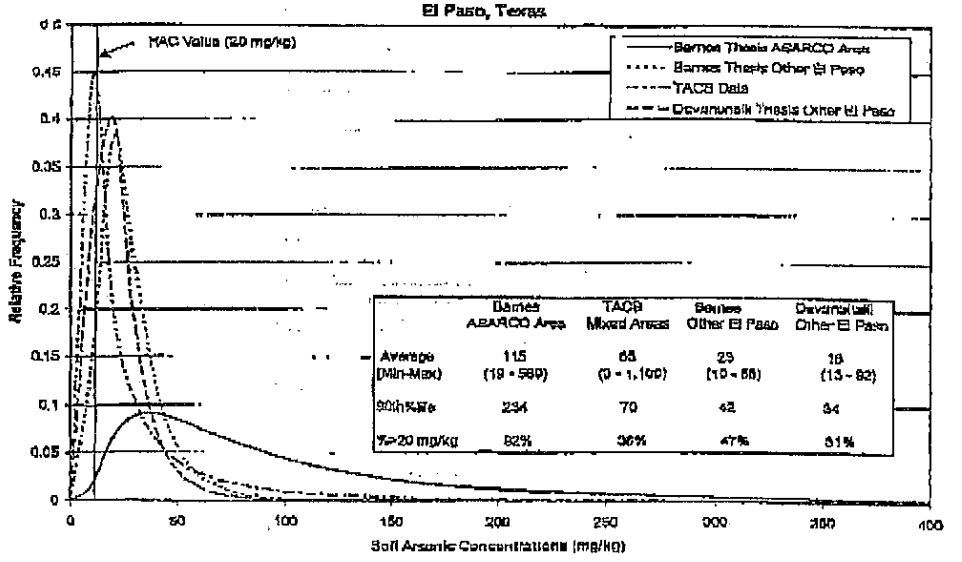


Figure 3.
Available Surface Soil Lead Data
El Paso, Texas



	Barnes ASARCO Area	Ndame ASARCO Area	Barnes Other El Paso	Srinivas Other El Paso	Devanahalli Other El Paso
Average (Min-Max)	668 (54 - 5,194)	385 (34 - 1,500)	93 (27 - 390)	55 (30 - 135)	100 (17 - 560)
90th%ile	2,229	774	191	88	214
%> 400 mg/kg	61%	23%	<1%	<1%	<3%

Figure 4
Available Surface Soil Arsenic Data
El Paso, Texas



	Barnes ASARCO Area	TACB Mixed Areas	Barnes Other El Paso	Devanahalli Other El Paso
Average (Min-Max)	115 (19 - 589)	65 (9 - 1,100)	29 (10 - 68)	18 (13 - 82)
90th%ile	234	79	42	34
%>20 mg/kg	82%	36%	47%	31%

Figure 5. Approximate delineation of sampling areas: ASARCO Area vs. Other El Paso.

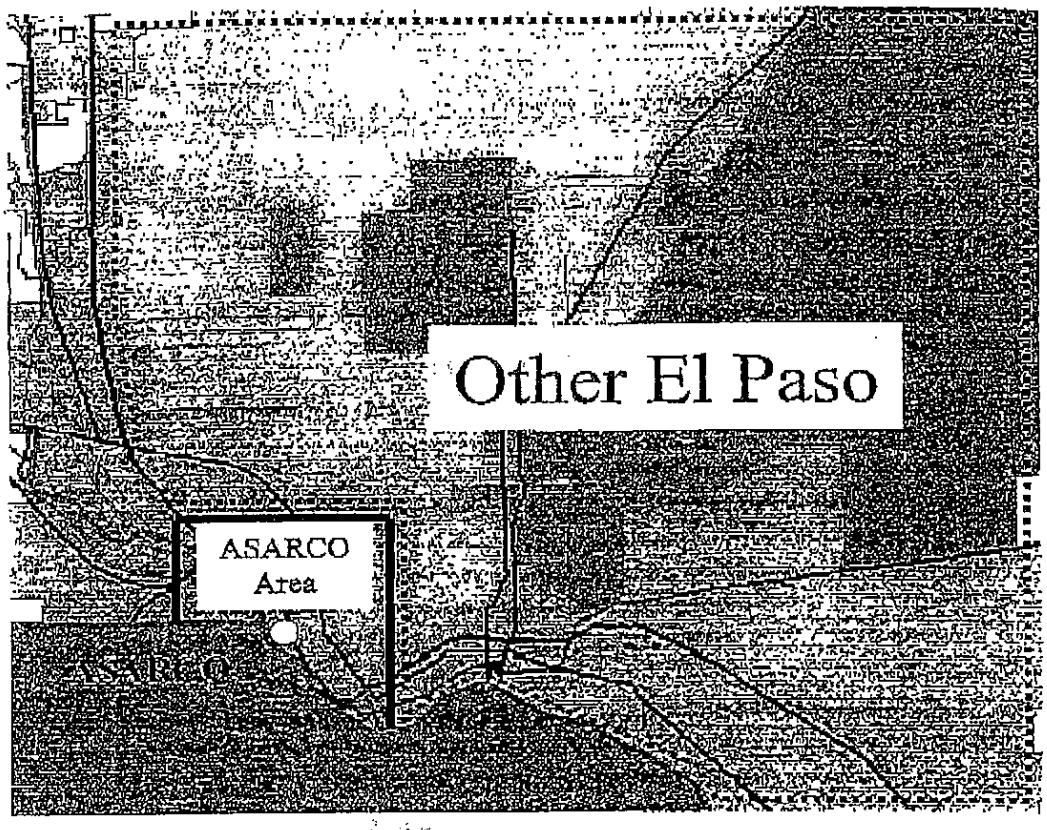


Figure 6.
Surface Soil Lead Data ASARCO Area vs. Other El Paso
El Paso, Texas

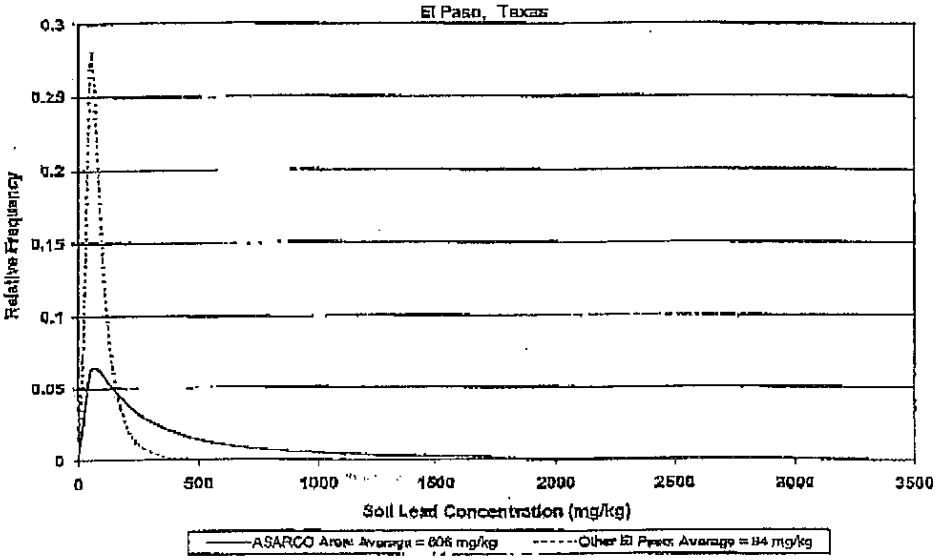


Figure 7.
Surface Soil Arsenic Data ASARCO Area vs. Other El Paso
El Paso, Texas

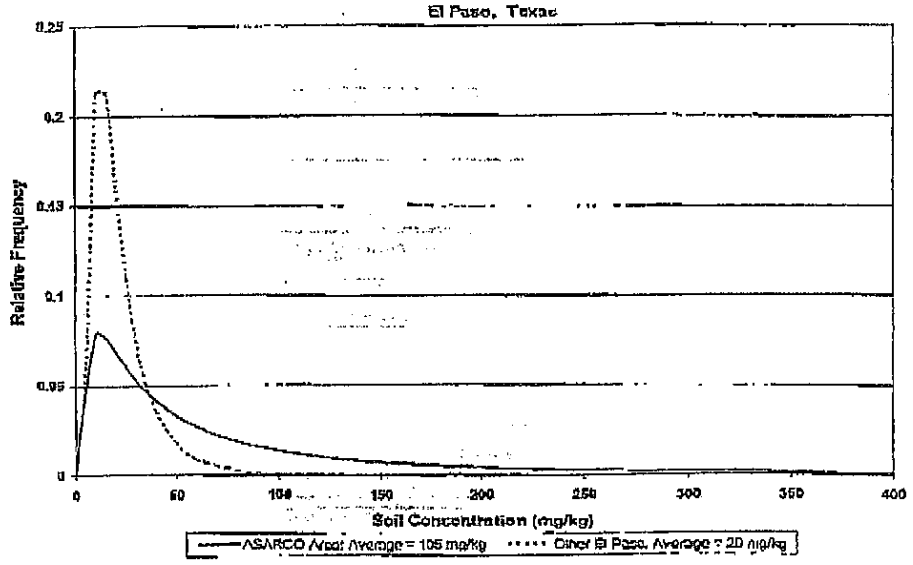
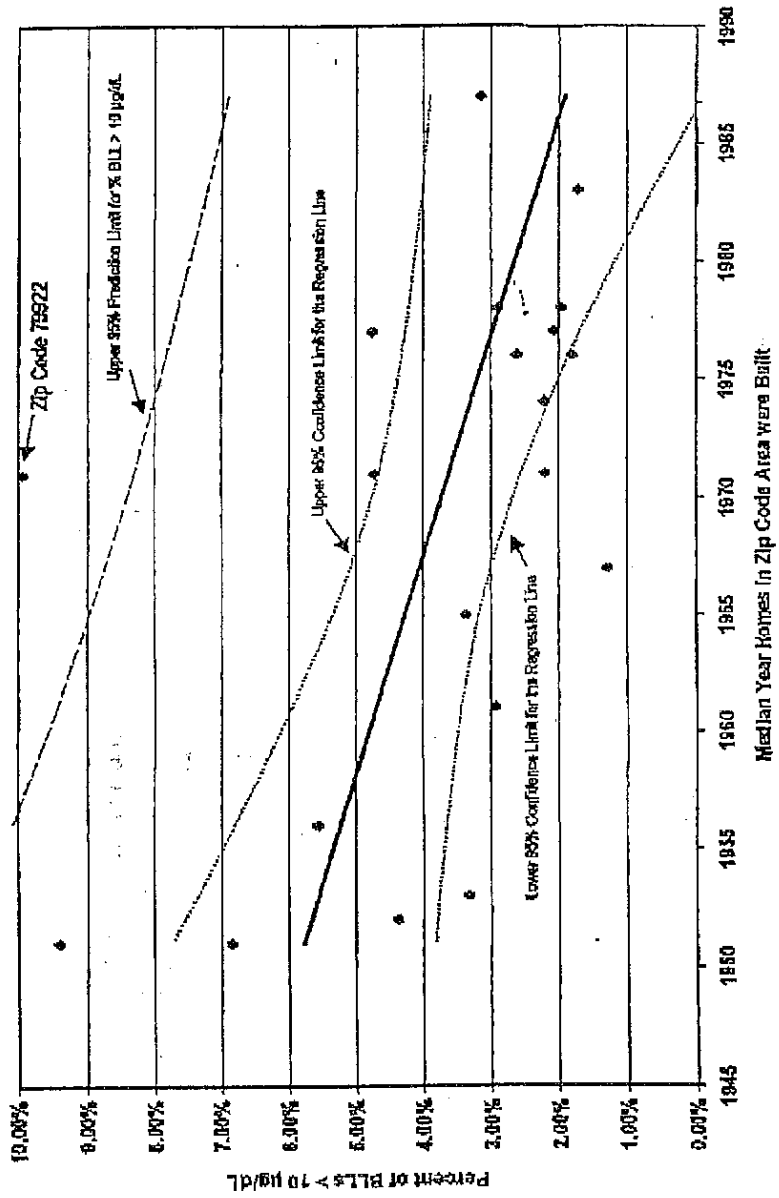


Figure 8
Regression of Percent of Children With Blood Levels Greater Than 10 µg/dL
on the Median Year that Houses were Built



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FAX COVER SHEET

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FROM: Keith Hopson
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Austin Office
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512/479-1101 [Fax]

DATE: August 7, 2001

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TOTAL PAGES: 28

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Health Consultation

University of Texas at El Paso (UTEP) Soil Sample Results

EL PASO COUNTY METAL SURVEY

EL PASO, EL PASO COUNTY, TEXAS

EPA FACILITY ID: TX0000605388

AUGUST 24, 2001

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

University of Texas at El Paso (UTEP) Soil Sample Results

EL PASO COUNTY METAL SURVEY

EL PASO, EL PASO COUNTY, TEXAS

EPA FACILITY ID: TX0000605388

Prepared by:

Texas Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

BACKGROUND AND STATEMENT OF ISSUES

Previously, at the request of the U.S. Environmental Protection Agency (EPA), the Texas Department of Health (TDH) and the Agency for Toxic Substances and Disease Registry (ATSDR) reviewed historical data collected in the El Paso area by the Texas Air Control Board in 1989 and by University of Texas at El Paso (UTEP) graduate students in 1993 and 1994. TDH and ATSDR concluded that additional samples were needed to confirm the results of the historical data [1]. EPA collected confirmation samples from various locations in the El Paso, Texas, and Sunland Park, New Mexico, area. Based on the results of the confirmation sampling, TDH and ATSDR suggested that the nature and extent of the contamination on the UTEP campus should be better characterized [2]. EPA collected soil samples from various locations on the UTEP campus and asked TDH and ATSDR to determine the public health significance of the lead and arsenic found in soil.

DISCUSSION

The environmental sampling data that we reviewed for this consultation were collected from the UTEP campus on August 3, 2001. Zero to 1 inch and 0 to 6 inch samples were collected from various locations on the campus. These locations included the bike and dune trails, the soccer and baseball fields, apartments, North Kidd field, Memorial Triangle, Jack C. Vowell Hall, the Geosciences building, Leech Grove, the Liberal Arts building, the Engineering building, the daycare facility, and the library. All samples were analyzed for lead and arsenic.

Combining all the samples from the UTEP property, the concentration of lead in the 0 to 1 inch samples ranged from less than 3.0 milligrams per kilogram (mg/kg) to 1,400 mg/kg, with an arithmetic average concentration of 237 mg/kg [Figure 1]. The concentration of arsenic in the soil ranged from less than 3.0 mg/kg to 51 mg/kg, with an arithmetic average concentration of 8.8 mg/kg [Figure 2]. Looking at the samples by area, the average concentration of lead ranged from 5 mg/kg at the soccer and baseball fields to 727 mg/kg at Leech Grove (Table 1). The average concentration of arsenic at the various locations ranged from less than 3.0 mg/kg to 29.3 mg/kg (Table 1).

Public Health Implications

Lead

We evaluate the public health significance of lead in soil by estimating the potential impact that it may have on the blood lead levels of potentially exposed populations. For this consult we considered potential exposure to adults (UTEP students, faculty, and staff), children, and the developing fetus (of adult females that frequent the campus). In general, lead in soil has the greatest impact on preschool-age children as they are more likely to play in dirt and place their

hands and other contaminated objects in their mouths. They also are better at absorbing lead through the gastrointestinal tract than adults and are more likely to exhibit the types of nutritional deficiencies that facilitate the absorption of lead. While lead in soil also can have an impact on adults and the developing fetus (through maternal exposure), the potential impact on these populations is low compared to the potential impact on young pre-school age children.

The Centers for Disease Control and Prevention (CDC) has determined that a blood lead level ≥ 10 µg/dL in children indicates excessive lead absorption and constitutes the grounds for intervention [3, 4]. While there is no clear relationship between soil lead and blood lead applicable to all sites, a number of models have been developed to estimate the potential impact that lead in soil could have on different populations [5–7]. For children, the predicted 95th percentile blood lead level associated with a soil lead concentration of 500 mg/kg is approximately 10 µg/dL. This means that except in the most extreme cases (i.e., frequent contact by children exhibiting pica behavior, or desire for unnatural foods such as dirt or ashes) children regularly exposed to soil lead levels of 500 mg/kg should have no more than a 5% probability of having blood lead levels greater than 10 µg/dL. Based on the goal of limiting the probability of exceeding a blood lead level of 10 µg/dL to no more than 5%, depending on individual exposure situations, the concentrations of lead in soil where children might have regular contact should be less than 500 mg/kg. Exceeding this value should not be taken to imply that the contaminant will cause harm but does suggest that it warrants further consideration.

Critical blood lead levels for adults are less well established. The Occupational Safety and Health Administration (OSHA) recommends that workers whose blood lead levels exceed 40 µg/dL should have medical evaluations, and workers whose blood lead levels exceed 60 µg/dL be removed from the exposure. In Texas workers, blood lead levels greater than 25 µg/dL must be reported to TDH. For UTEP students, faculty, and staff, we used the same goal of limiting the probability of exceeding a blood lead level of 10 µg/dL to no more than 5 percent.

The average concentration of lead in the soil exceeded the 500 mg/kg screening value for children at three locations; Leech Grove (727 mg/kg), Memorial Triangle (664 mg/kg), and Jack C. Vowell Hall (658 mg/kg). As a college campus, it is unlikely that young (pre-school age) children would regularly come into contact with soil from these areas. The one area where children could regularly come into contact with soil, the daycare facility, had an average soil lead level of 110 mg/kg, a level that does not pose a risk to children. Based on the predicted impact that lead in soil can have on adults and the developing fetus [7], it is not likely that the lead found in the soil at these locations would have a significant affect on blood lead levels. The probability that students, faculty, and staff who regularly ate soil from the area with the highest concentration would have a blood lead level ≥ 10 µg/dL would be less than 1 percent. For the developing fetus, exposed in-utero through the mother, the probability would be approximately 2 percent. Additionally, any potential risks are further reduced by the presence of grass which limits the potential for exposure to the soil (Figures 3–7). Based on these data we would not anticipate the lead in the soil to present a public health hazard to any of the potentially exposed populations.

Arsenic

To assess the potential health risks associated with the arsenic in the soil, we compared the soil concentrations to health-based screening values specific to arsenic for children and adults. These screening values represent levels in the soil that are considered safe for human contact. Exceeding these screening values does not imply that a contaminant will cause harm, but suggests that potential exposure to the contaminant warrants further consideration.

The screening value that we used for arsenic in soil (20 mg/kg) is based on a child exposure scenario and EPA's reference dose (RfD) for arsenic of 0.3 µg/kg/day [8]. RfDs are based on the assumption that there is an identifiable exposure threshold (both for the individual and for populations) below which there are no observable adverse effects. Thus, the RfD is an estimate of a daily exposure to arsenic that is unlikely to cause adverse non-cancer health effects even if exposure were to occur for a lifetime. For arsenic, the RfD was derived by dividing the identified no observable adverse effects level (NOAEL[1]) of 0.8 µg/kg/day, obtained from human epidemiologic studies, by an uncertainty factor of three. The lowest observable adverse effects level (LOAEL[2]) associated with these epidemiologic studies was 14 µg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [8–10]. We used standard assumptions for body weight (15 kg) and soil ingestion (200 mg per day for a child) to calculate the screening value.

The average concentration of arsenic exceeded the screening value for children at four of the sampling locations–the Bike and Dune Trail (29.3 mg/kg), Memorial Triangle (24.2 mg/kg), Jack C. Vowell Hall (20.8 mg/kg), and Leech Grove (22 mg/kg). Because UTEP is a college campus, it is unlikely that young children would regularly come into contact with soil at any of these locations. The one area where children could regularly come into contact with soil, the daycare facility, had an average soil arsenic concentration of 2.3 mg/kg, a level that does not pose a risk to children. Based on estimated exposures, it is not likely that adults who regularly ate soil from any of these areas would experience adverse non-cancer health effects. Students, faculty, and staff who regularly (everyday) ate 100 mg of soil, from the area with the highest average concentration, would receive a daily dose approximately 7 times lower than the RfD, 19 times lower than the NOAEL, and 334 times lower than the LOAEL. Additionally, any potential risks are further reduced by the presence of grass, which limits the potential for exposure to the soil (Figures 3–7).

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[1]The highest dose at which adverse effects were not observed.

[2]The lowest dose at which adverse effects were observed.

EPA also classifies arsenic as a known human carcinogen based on sufficient evidence from human data. An increase in lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer (non-malignant) were observed in populations consuming water high in inorganic arsenic [8]. We used EPA's cancer slope factor (CSF) for arsenic to estimate the potential increased lifetime cancer risks associated with exposure to arsenic in soil from each of these locations, for both students (four years of exposure) and faculty/staff (30 years of exposure). Qualitatively, we would classify these as no apparent increased risk to an insignificant increased risk (Table 2). Based on these data, we would not anticipate the arsenic in the soil to present a public health hazard to any of the potentially exposed populations.

Uncertainties

General Uncertainties

In preparing this report, we relied on the information provided and assumed adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain-of-custody, laboratory procedures, and data reporting. The analysis and conclusions in this report are valid only if the referenced information is valid and complete.

The most likely routes of exposure to the contaminants found in the soil are ingestion (eating the soil) and inhalation (breathing in the soil as windblown dust). Based on the information available for this consult, we would not anticipate the inhalation of windblown dust to be a major contributor to exposure, even though windblown dust may be common in El Paso. The concentrations are generally low and would not result in any significant loading of the air with contaminants. Additionally, the presence of the ground cover further reduces the potential for contaminants in the soil to partition to the air. Air samples reviewed in the previous consultation suggested that the air was not a major exposure pathway at this time [2].

In order for exposure to the contaminants to occur through ingestion, the soil must be physically available. The screening values that we used in this consult assume that the soil is available and that such physical barriers are not present. The presence of the grass in the areas with the highest average concentrations reduces the likelihood that exposure will occur. Individual behavior patterns also are important in assessing risk. The amount of soil that a person eats, how often they eat the soil, and the average concentration of the contaminant in the soil that they eat all are important factors in determining potential public health implications. For this consultation we used assumptions that in most instances overestimate potential exposures.

Specific Uncertainties

There is considerable controversy with respect to assessing potential risks associated with exposure to arsenic. Both the RfD and the CSF are based on human ecological studies that have recognized uncertainties with respect to the assignation of exposure. Such studies find it difficult to avoid errors in assigning people to specific exposure groups. The studies upon which the RfD and the CSF are based also involved exposure to arsenic in drinking water. The ability of the body to absorb arsenic in water is likely higher that the ability of the body to absorb arsenic in soil. In our analysis, we assumed that the arsenic in the soil was 100% absorbed. Assuming that the applied dose (the amount available for absorption) is the same as the internal dose (the amount that has been absorbed), is conservative and, to some unknown extent, over estimates the risk. We also did not consider the kinetics of arsenic in the body in our risk estimates. The RfD and the CSF are based on daily exposures over a lifetime. Since the half-life (the time it takes ½ of the absorbed arsenic to be excreted) is short (40-60 hours), the risk estimates for exposures that occur less frequently than every day also may result in an overestimate of the risks.

With specific respect to the cancer risk estimates, the mechanisms through which arsenic causes cancer are not known; however, arsenic is not believed to act directly with DNA. Since the studies used to derive the CSF are based on exposure doses much higher than those likely to be encountered at this site, it is questionable whether it is appropriate to assume linearity for the dose-response assessment for arsenic at low doses. The actual dose-response curve at low doses may be sublinear, which would mean that the risk estimates in this consult overestimate the actual risks.

ATSDR's Child Health Initiative

We recognize that the unique vulnerabilities of children demand special attention. Windows of vulnerability (critical periods) exist during development, particularly during early gestation, but also throughout pregnancy, infancy, childhood and adolescence–periods when toxicants may permanently impair or alter structure and function [8]. Unique childhood vulnerabilities may be present because, at birth, many organs and body systems (including the lungs and the immune, endocrine, reproductive, and nervous systems) have not achieved structural or functional maturity. These organ systems continue to develop throughout childhood and adolescence. Children may exhibit differences in absorption, metabolism, storage, and excretion of toxicants, resulting in higher biologically effective doses to target tissues. Depending on the affected media, they also may be more exposed than adults because of behavior patterns specific to children. In an effort to account for children's unique vulnerabilities, and in accordance with ATSDR's Child Health Initiative [9] and EPA's National Agenda to Protect Children's Health from Environmental Threats [10], we used the potential exposure of children as a guide in assessing the potential public health implications of the contaminants.

CONCLUSIONS

1. Although the average concentrations of lead and arsenic in soil from several locations on the UTEP campus exceed their respective soil-based screening values for children, this is a college campus and these are areas that are not likely to be frequented by pre-school age children. Based on estimated exposures, it is not likely that other potentially exposed populations, including UTEP students, faculty, and staff, would experience adverse health effects associated with the contaminants found at any of the locations sampled. Potential exposures at the locations with the highest concentrations are further reduced by the presence of grass, which decreases the likelihood of exposure to the soil. Based on available information, we have concluded that the lead and arsenic found in the soil do not pose a public health hazard to any of the potentially exposed populations.

2. The concentrations of lead and arsenic in soil from the daycare facility were well below their respective health-based screening values for children. Thus, the contaminants in the soil from the daycare facility do not pose a public health hazard.

3. Qualitatively, we estimate the potential excess lifetime cancer risk associated with exposure to arsenic in soil from the UTEP campus to range from an insignificant increased risk to no apparent increased risk.

PUBLIC HEALTH ACTION PLAN

Actions Recommended

1. Appropriate environmental health education and risk communication should be provided to any interested parties.

REFERENCES

1. Agency for Toxic Substances and Disease Registry. Health Consultation: Review of historical soil sampling results El Paso County Metal Survey Site, El Paso, El Paso County, Texas. Texas Department of Health. July 20, 2001.

2. Agency for Toxic Substances and Disease Registry. Health Consultation: Heavy metals confirmation sampling El Paso, El Paso County, Texas–Sunland Park, Dona Ana County, New Mexico. Texas Department of Health. August 2001.

3. Centers for Disease Control. Preventing lead poisoning in young children. U.S. Department of Health and Human Services; October 1991.

4. Agency for Toxic Substances and Disease Registry. The nature and extent of lead poisoning in children in the United States: a report to Congress. Atlanta: U.S. Department of Health and Human Services; 1988.

5. U.S. Environmental Protection Agency (USEPA). Memorandum from Mark Maddaloni, chair, technical review workgroup, adult lead subgroup to Pat Van Leeuwen, region 5 Superfund program use of the technical review workgroup Interim Adult Lead Methodology in Risk Assessment, April 1999.

6. Agency for Toxic Substances and Disease Registry (ATSDR). Analysis paper: Impact of lead-contaminated soil on public health. U.S. Department of Health and Human Services; May 1992.

7. Society for Environmental Geochemistry and Health. 1993. Lead in soil, recommended guidelines. Science Reviews.

8. U.S. Environmental Protection Agency. 2000. Strategy for research on environmental risks to children. Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-00/068, Section 1.2.

9. Agency for Toxic Substances and Disease Registry (ATSDR). Child health initiative. Atlanta: U.S. Department of Health and Human Services; 1995.

10 U.S. Environmental Protection Agency. The children's environmental health yearbook; 1998.

Table 1. University of Texas at El Paso Soil Sampling Results (average concentrations for 0-1 inch samples by location)[1]

Location	No. of samples	Lead (mg/kg)	Arsenic (mg/kg)
Bike and dune trails	12	339	29.3
Soccer and baseball	9	5	<3.0
Apartments	5	23	<3.0
North Kidd field	22	121	5.45
Memorial Triangle	12	664	24.2
Jack C. Vowell Hall	7	658	20.8
Geosciences	4	370	2.0
Leech Grove	8	727	22
Liberal Arts	6	143	<3.0
Engineering	6	102	<3.0
Daycare	17	110	2.3
Library	8	22	<3.0

[1] Values reported as below detection limit were taken as ½ the detection limit to compute the average.

Table 2. Estimates of potential excess lifetime cancer risk associated with exposure to arsenic in soil. University of Texas at El Paso

Location	Faculty / Staff		Students	
	Quantitative[1]	Qualitative	Quantitative[2]	Qualitative
Bike and dune trail	1.4×10^{-5}	no apparent	1.9×10^{-6}	insignificant
Soccer and baseball area	$<1.4 \times 10^{-6}$	insignificant	$<1.9 \times 10^{-7}$	insignificant
Apartments	$<1.4 \times 10^{-6}$	insignificant	$<1.9 \times 10^{-7}$	insignificant
North Kidd Field	2.6×10^{-6}	insignificant	3.5×10^{-7}	insignificant
Memorial Triangle	1.2×10^{-5}	no apparent	1.5×10^{-6}	insignificant
Jack C. Vowell Hall	9.9×10^{-6}	no apparent	1.3×10^{-6}	insignificant
Geosciences building	9.5×10^{-7}	insignificant	1.3×10^{-7}	insignificant
Leech Grove	1.0×10^{-5}	no apparent	1.4×10^{-6}	insignificant
Liberal Arts building	$<1.4 \times 10^{-6}$	insignificant	$<1.9 \times 10^{-7}$	insignificant
Engineering building	$<1.4 \times 10^{-6}$	insignificant	$<1.9 \times 10^{-7}$	insignificant
Daycare	1.1×10^{-6}	insignificant	1.5×10^{-7}	insignificant
Library	$<1.4 \times 10^{-6}$	insignificant	$<1.9 \times 10^{-7}$	insignificant

[1] Based on an estimated 30 years of exposure, 9 months per year, 5 days per week.

[2] Based on an estimated 4 years of exposure, 9 months per year, 5 days per week.

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CERTIFICATION

This health consultation was prepared by the Texas Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.

Technical Project Officer, SPS, SSAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

for Chief, State Programs Section, SSAB, DHAC, ATSDR

Figure 1. Distribution of Lead in Soil from the University of Texas at El Paso
(0 to 1 inch samples and 0 to 6 inch samples)

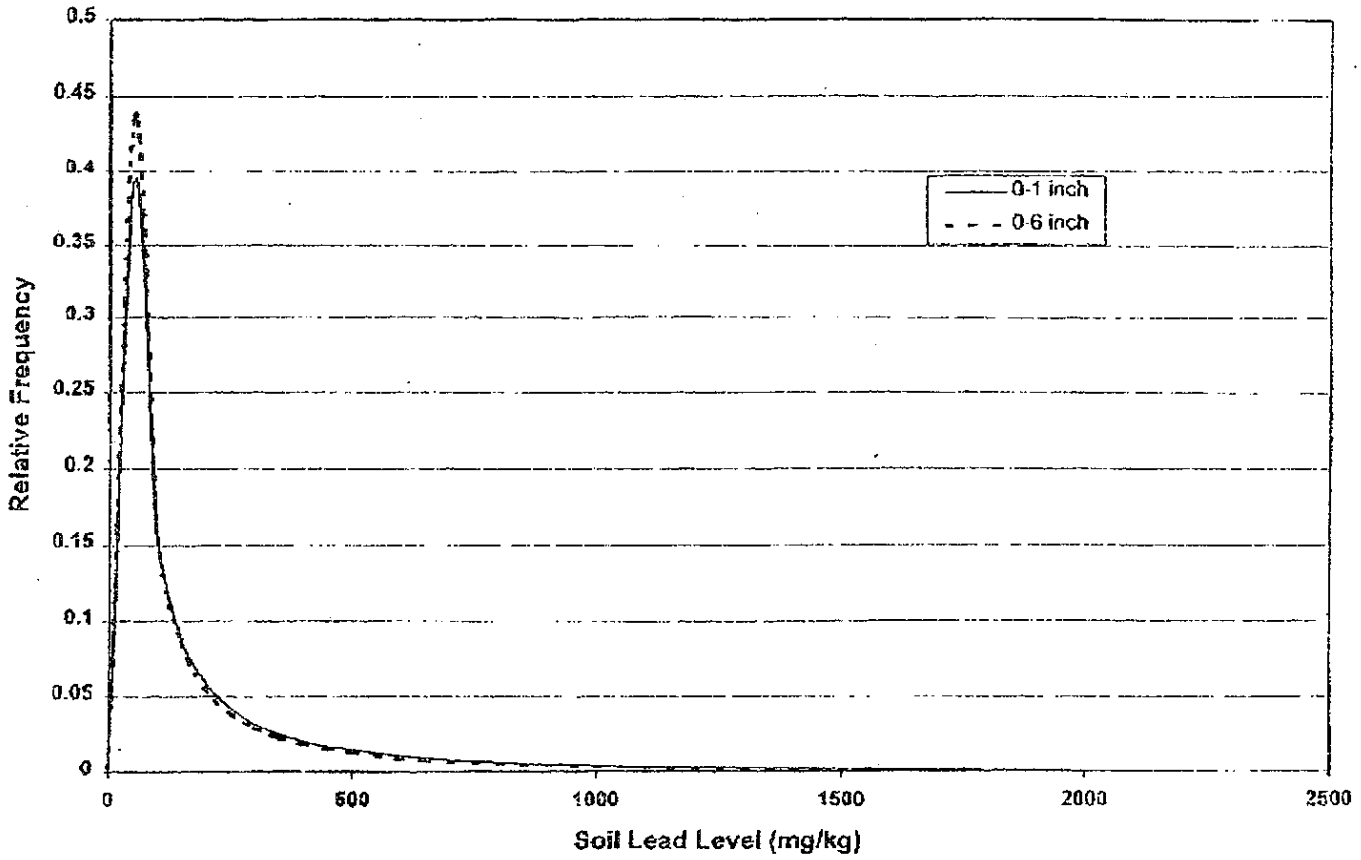


Figure 2. Distribution of Arsenic in Soil From the University of Texas at El Paso
(0 to 1 inch samples and 0 to 6 inch samples)

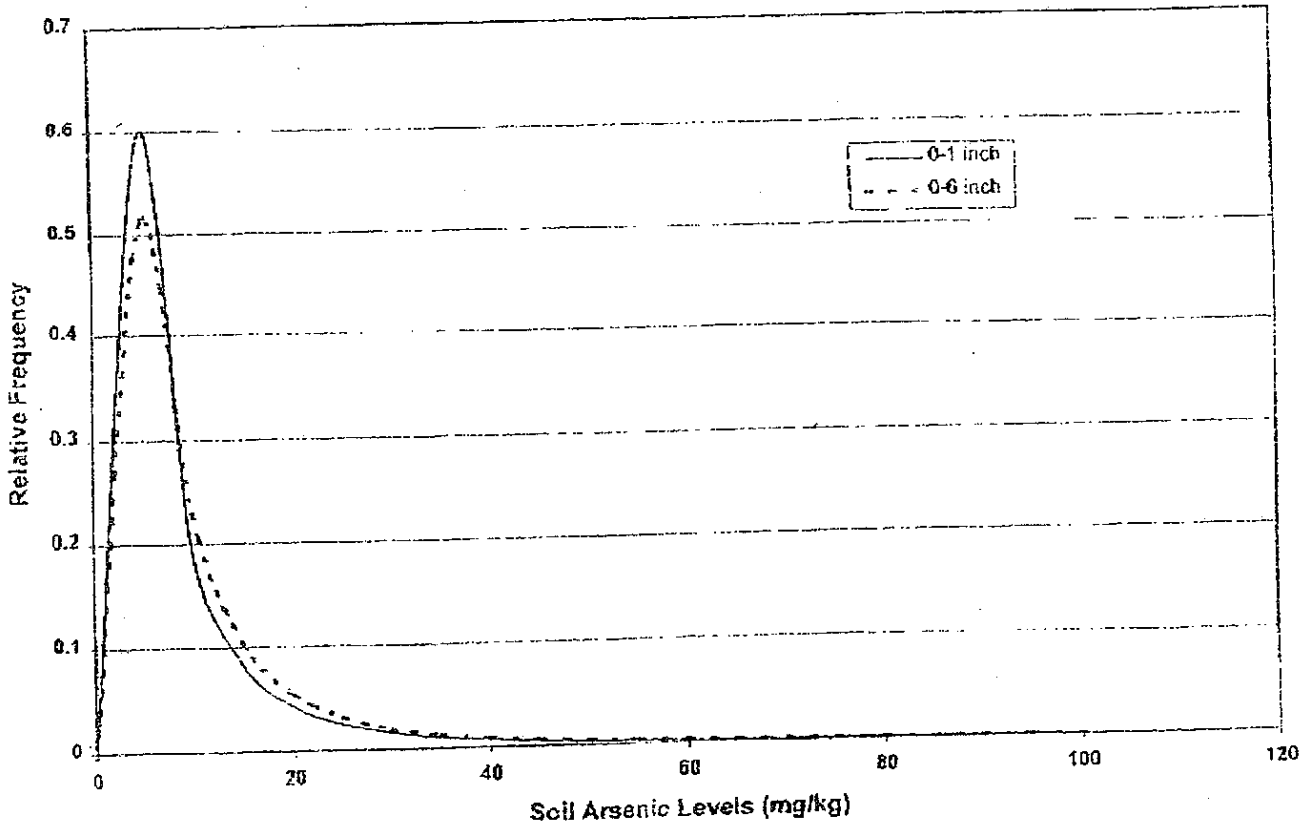


Figure 3. Leech Grove commons area

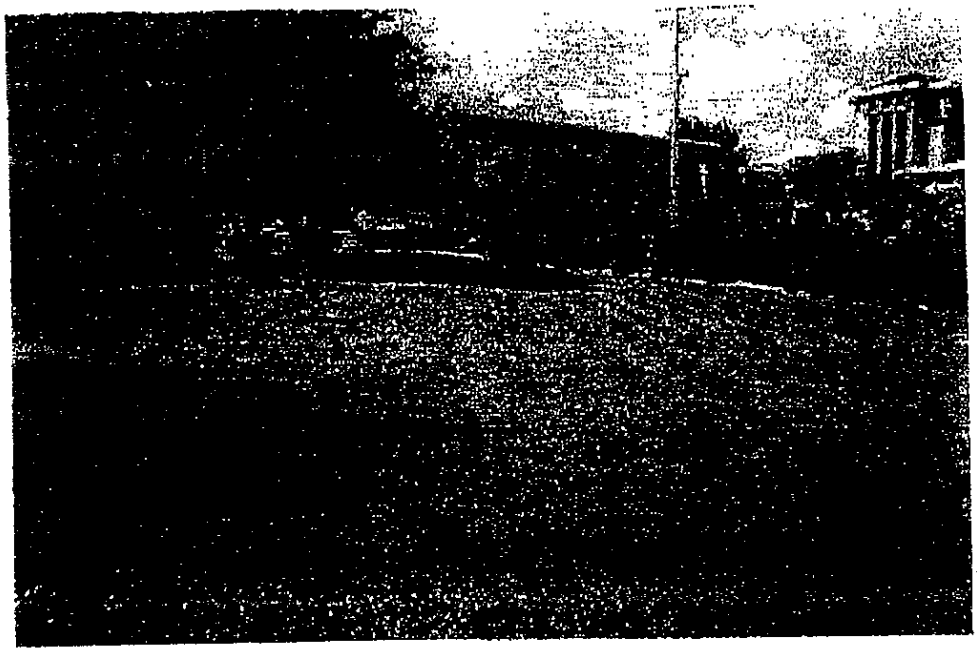
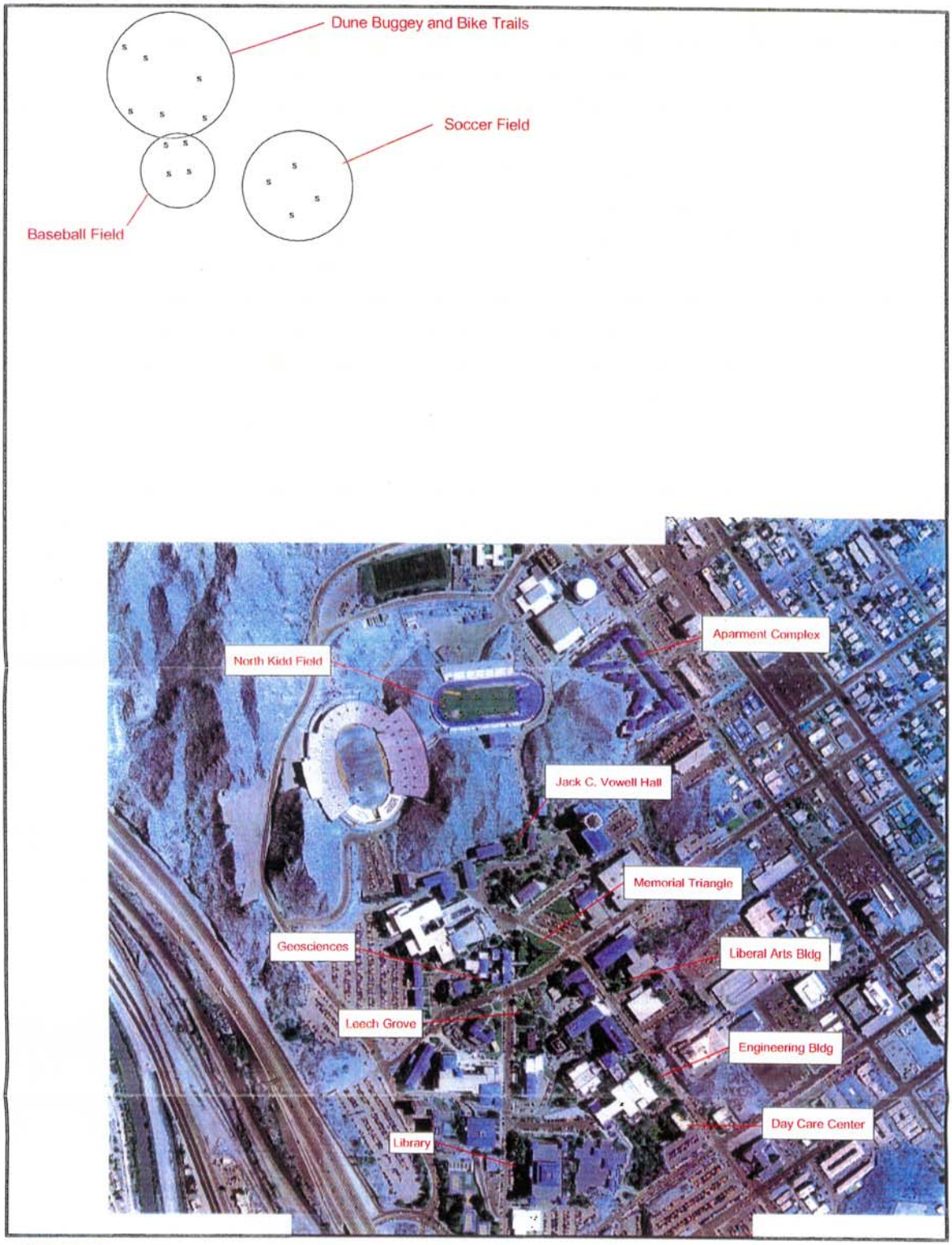


Figure 4. Memorial Triangle commons area

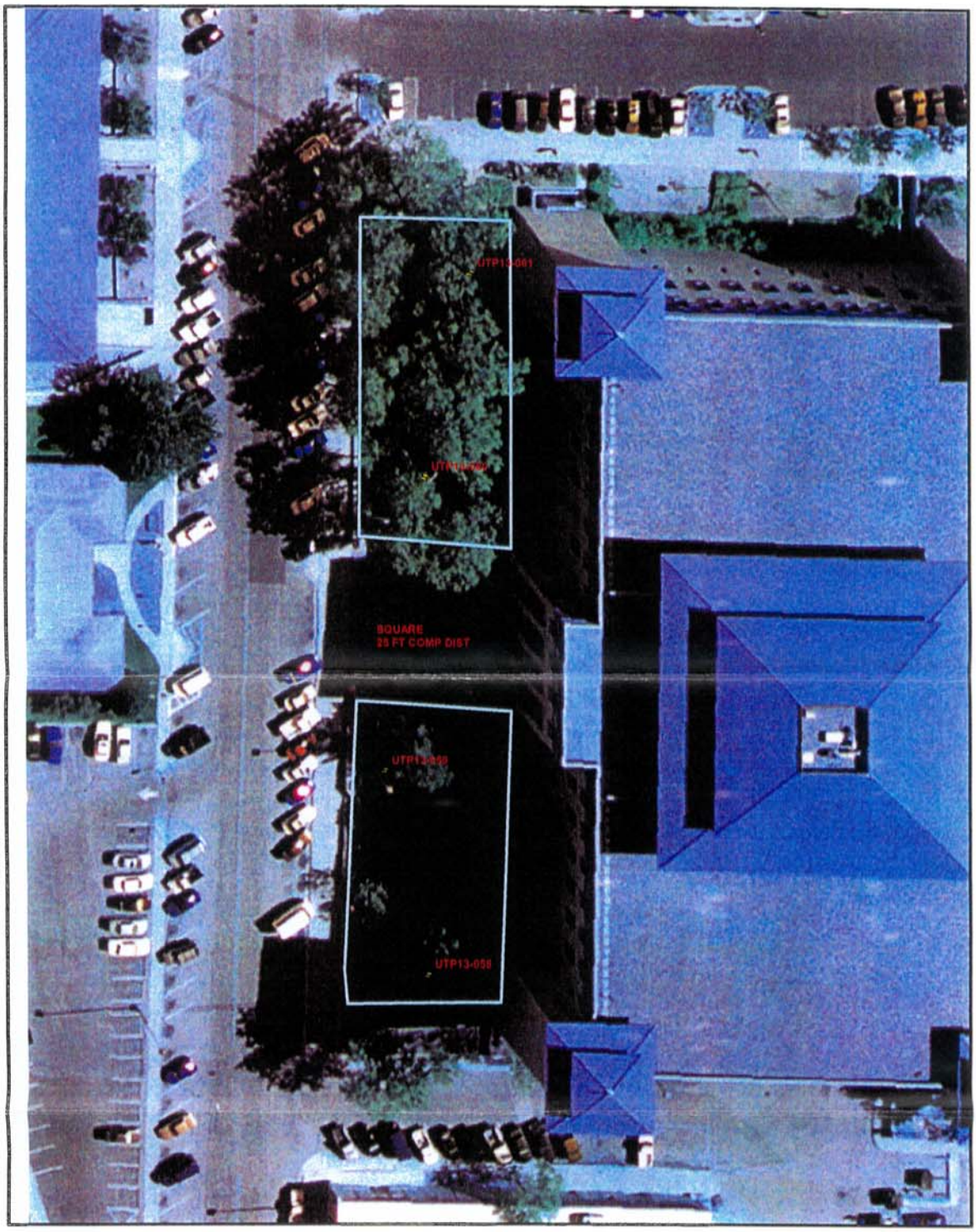
Figure 5. Jack C. Vowell Hall area outside entrance



EPA United States Environmental Protection Agency

UTEP Coverage

UTEP SAMPLING DESIGN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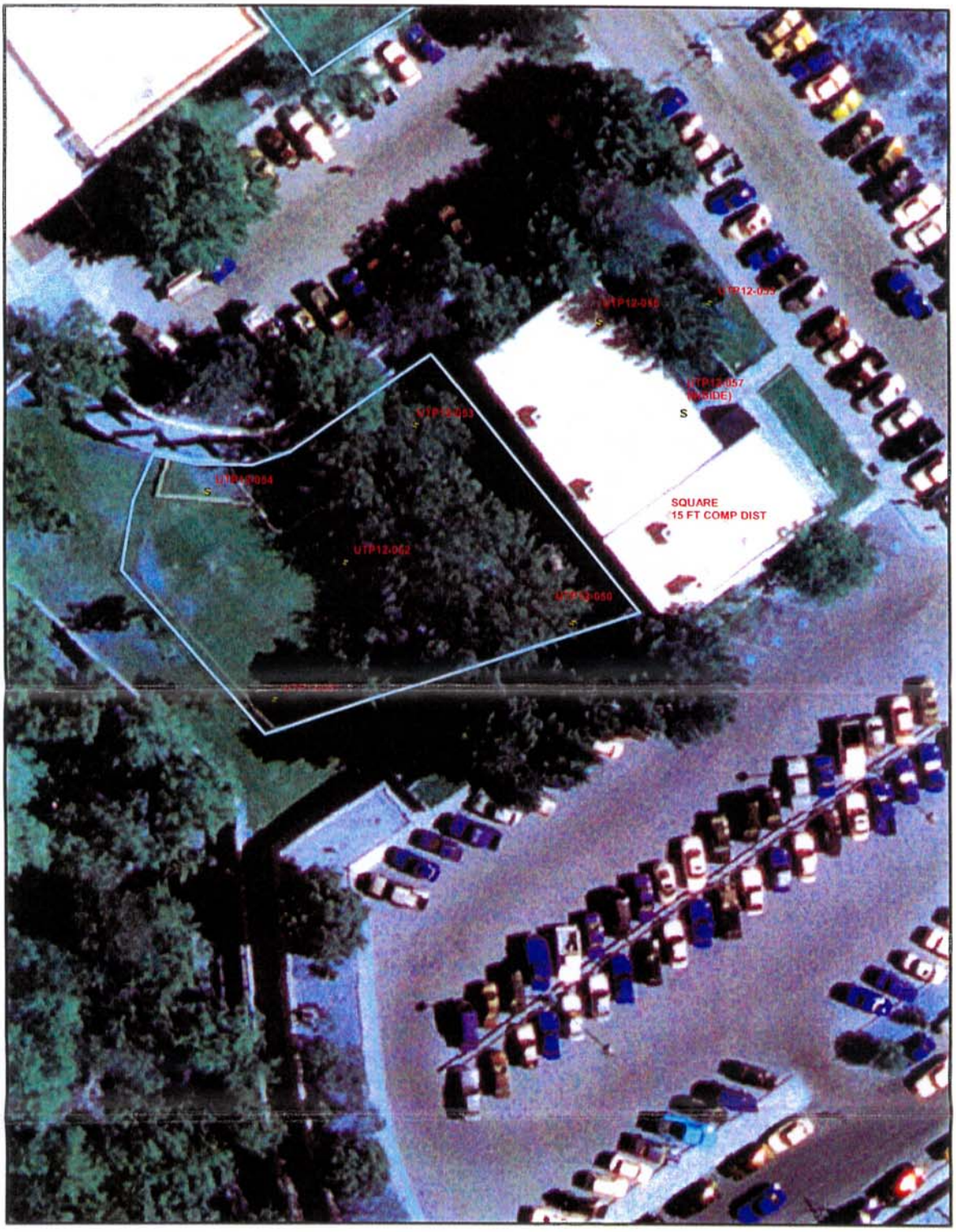
UTP13-002
SQUARE
25 FT COMP DIST
UTP13-055



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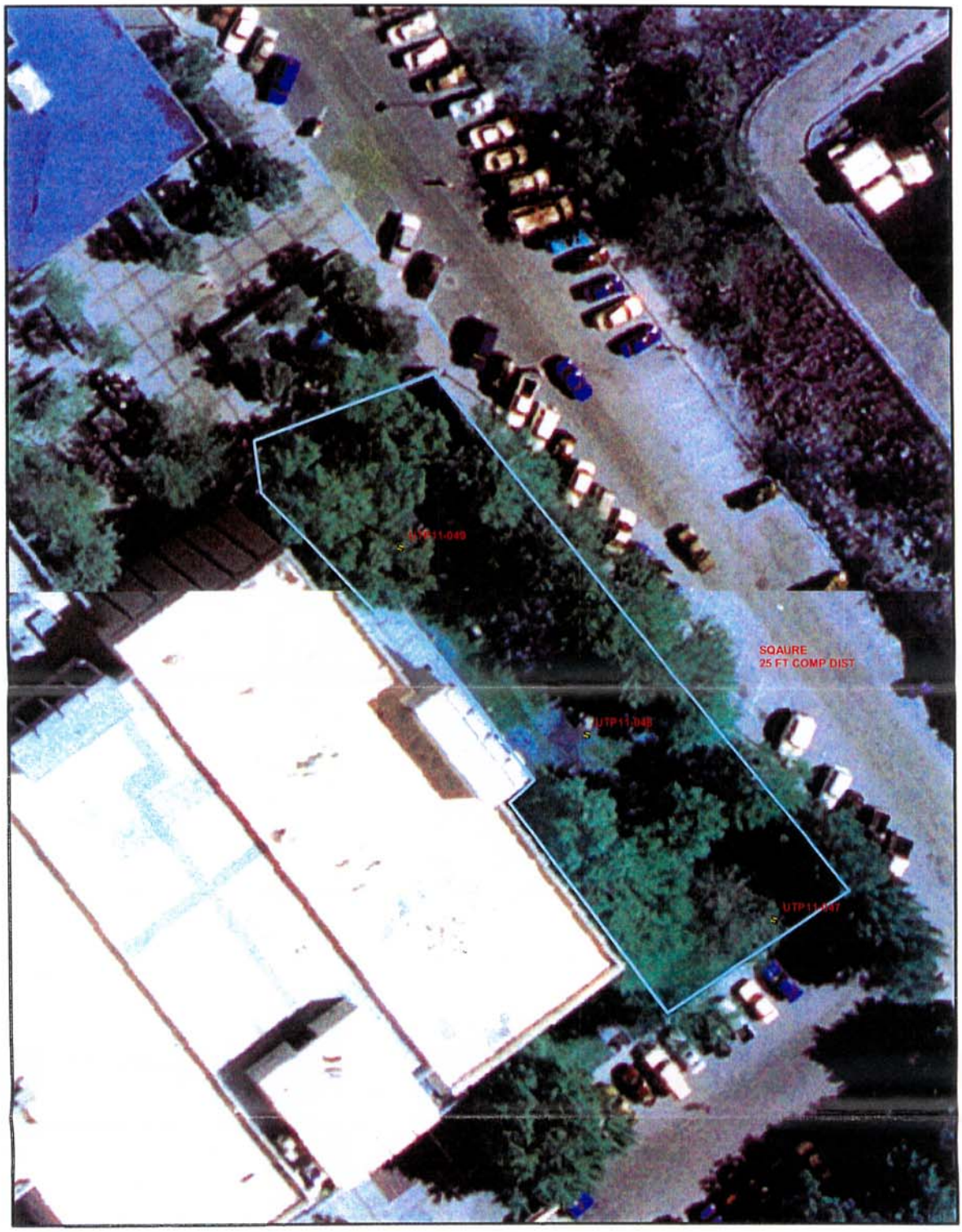
DAY CARE CENTER (70)

UTEP SAMPLING DESIGN



EPA United States Environmental Protection Agency

ENGINEERING BLDG (102)

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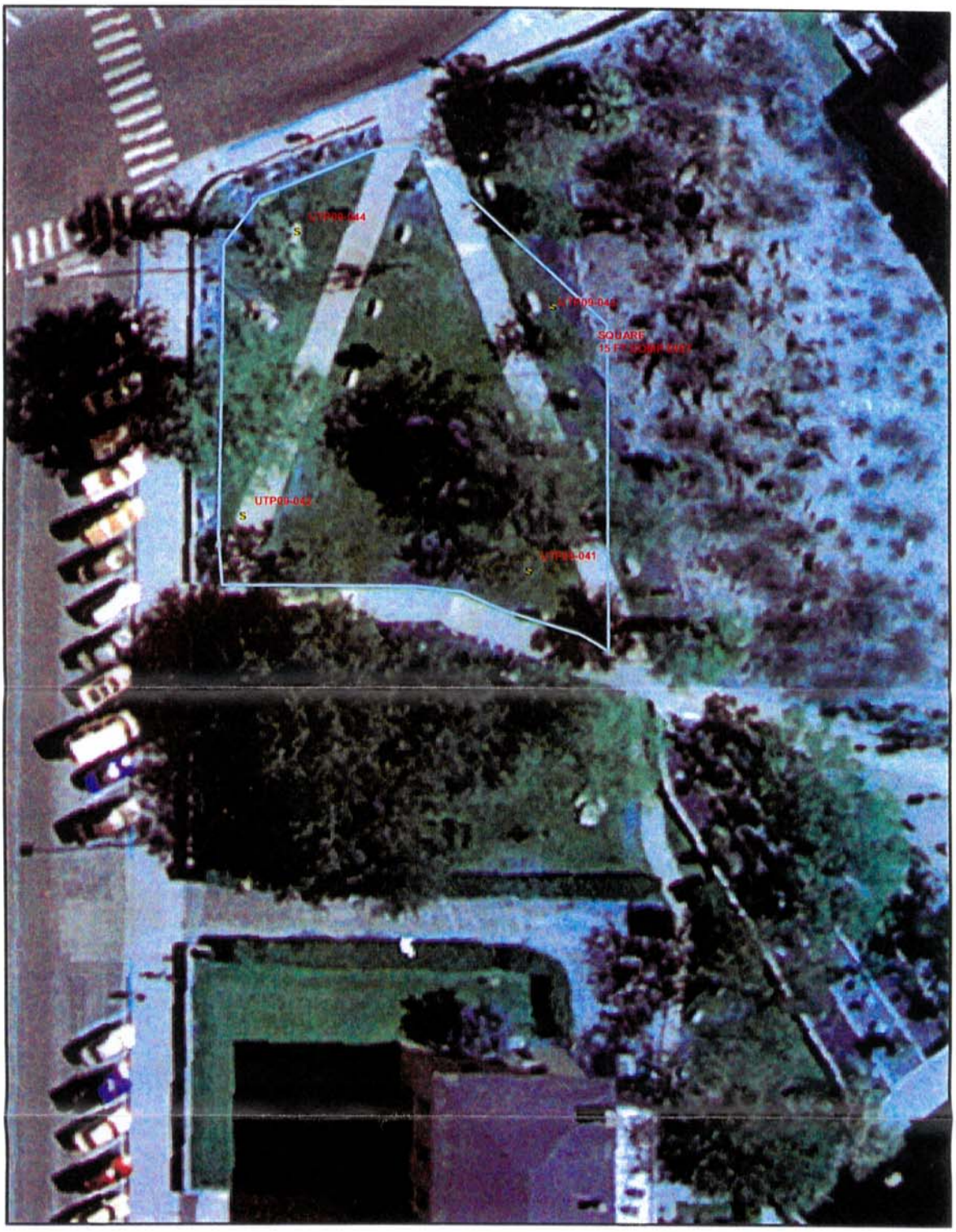

EPA United States Environmental Protection Agency

LEECH COVE (118)

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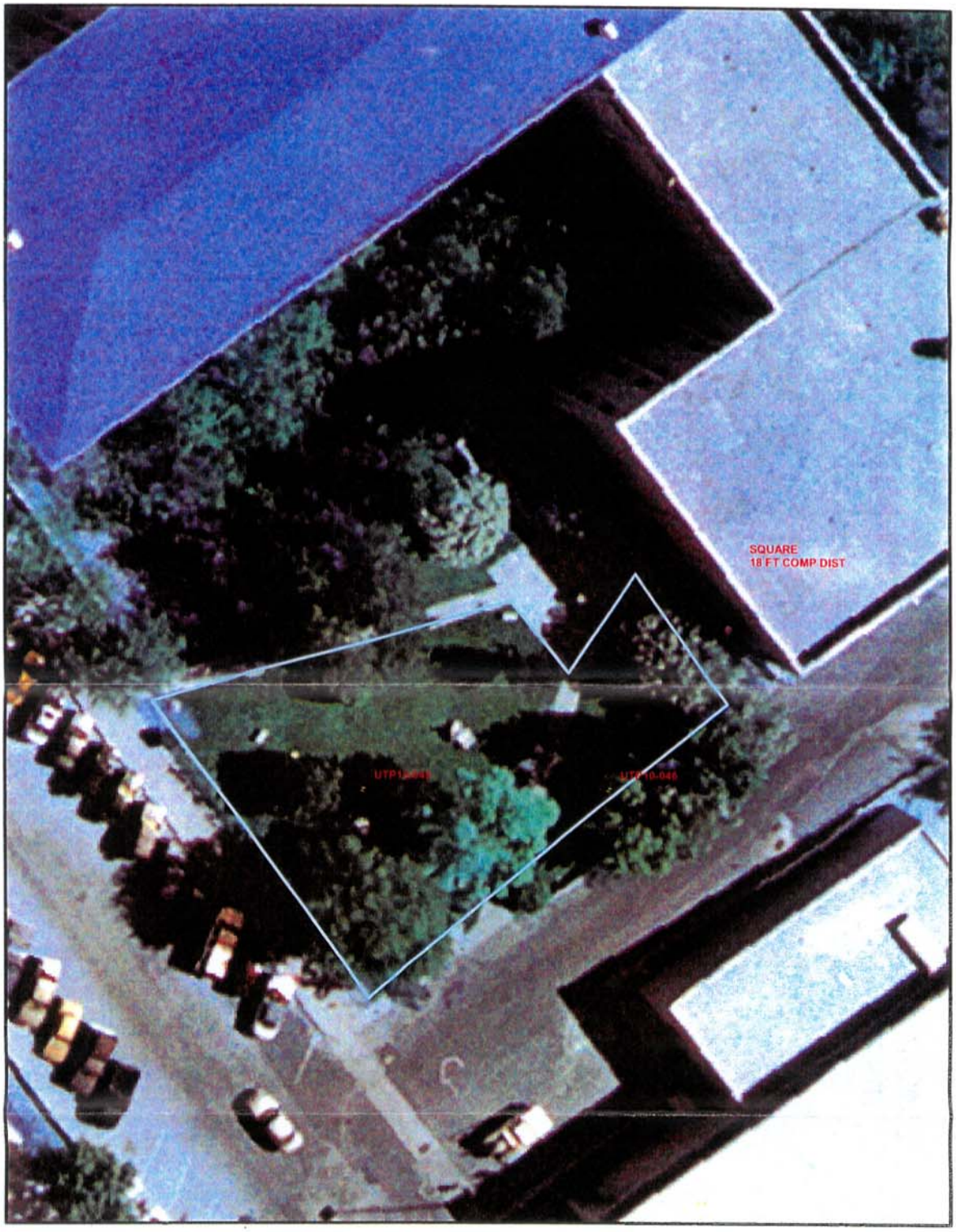

EPA United States Environmental Protection Agency

LIBERAL ARTS (8)

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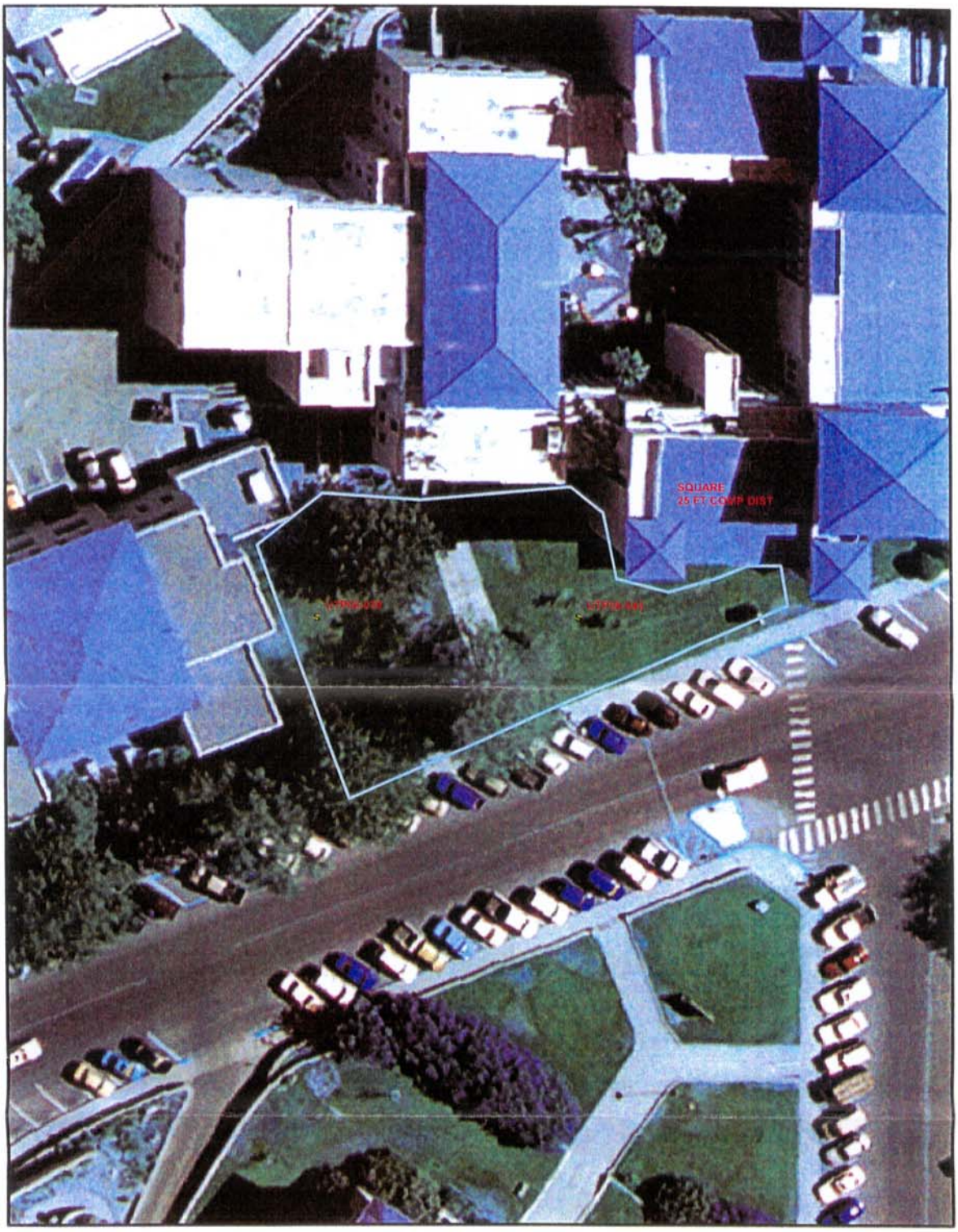

EPA United States Environmental Protection Agency

GEOSCIENCES BLDG (35)

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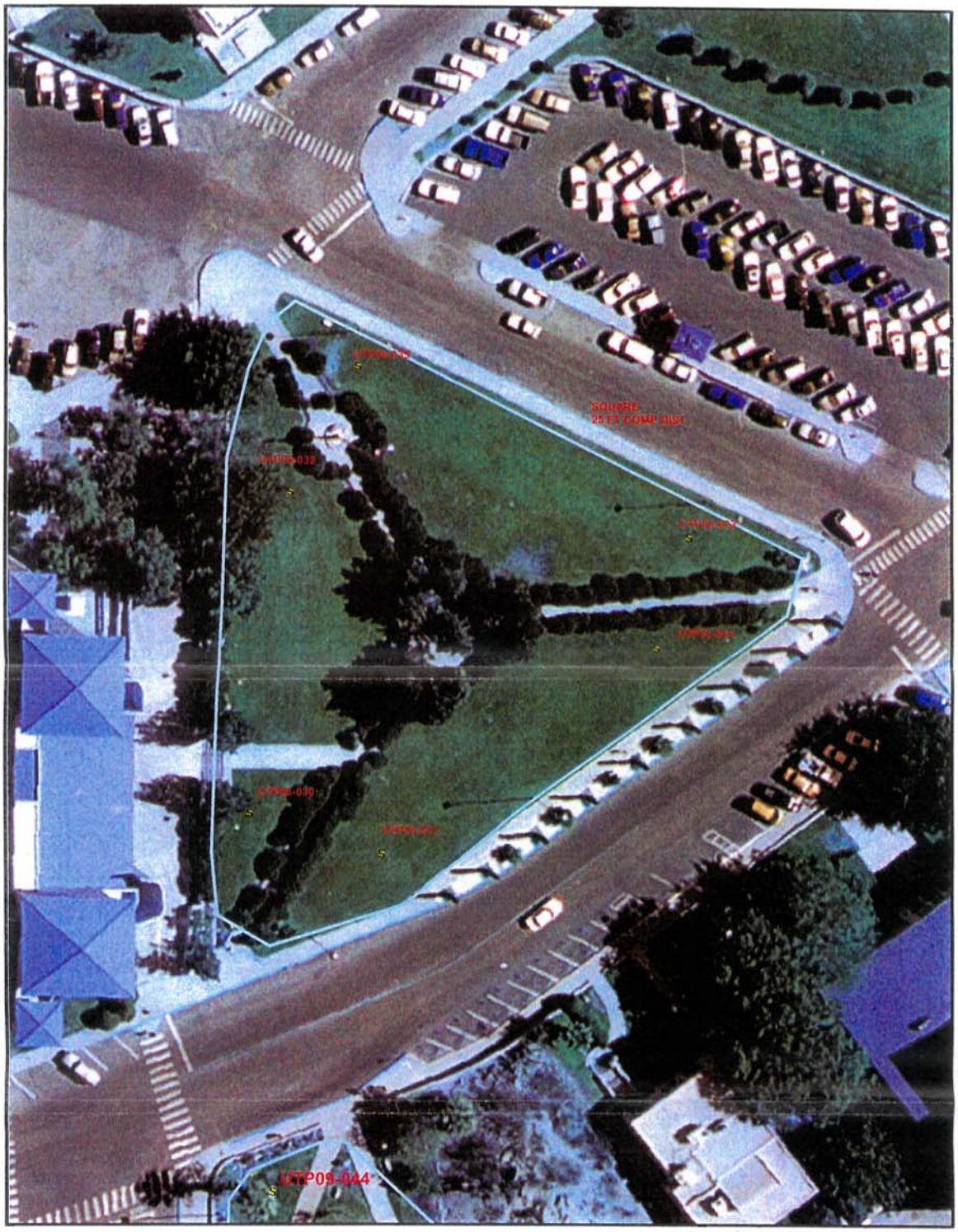

United States Environmental Protection Agency

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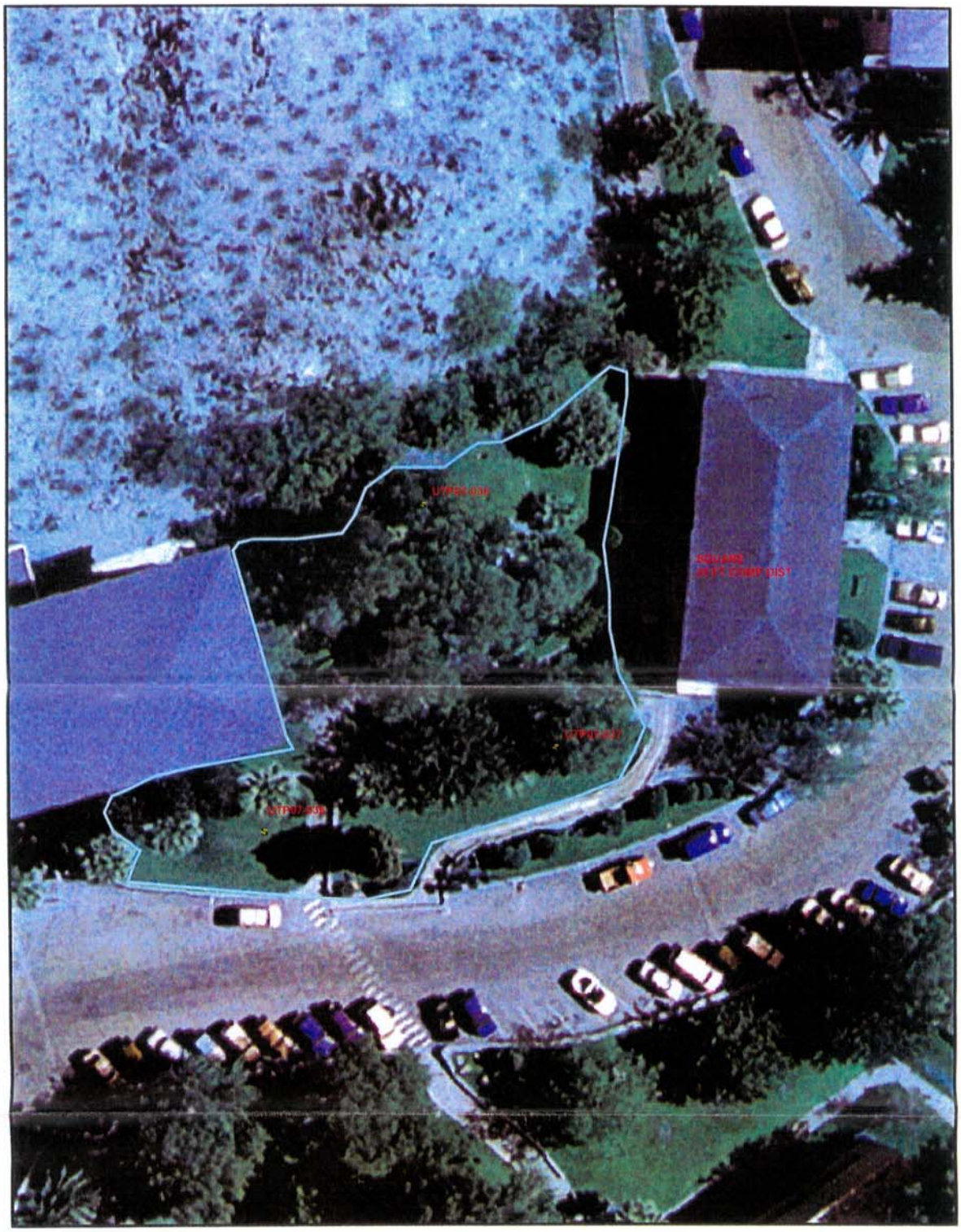

EPA United States Environmental Protection Agency

JACK C. VOWELL HALL (7)

UTEP SAMPLING DESIGN

EPA United States Environmental Protection Agency

APARTMENT COMPLEX

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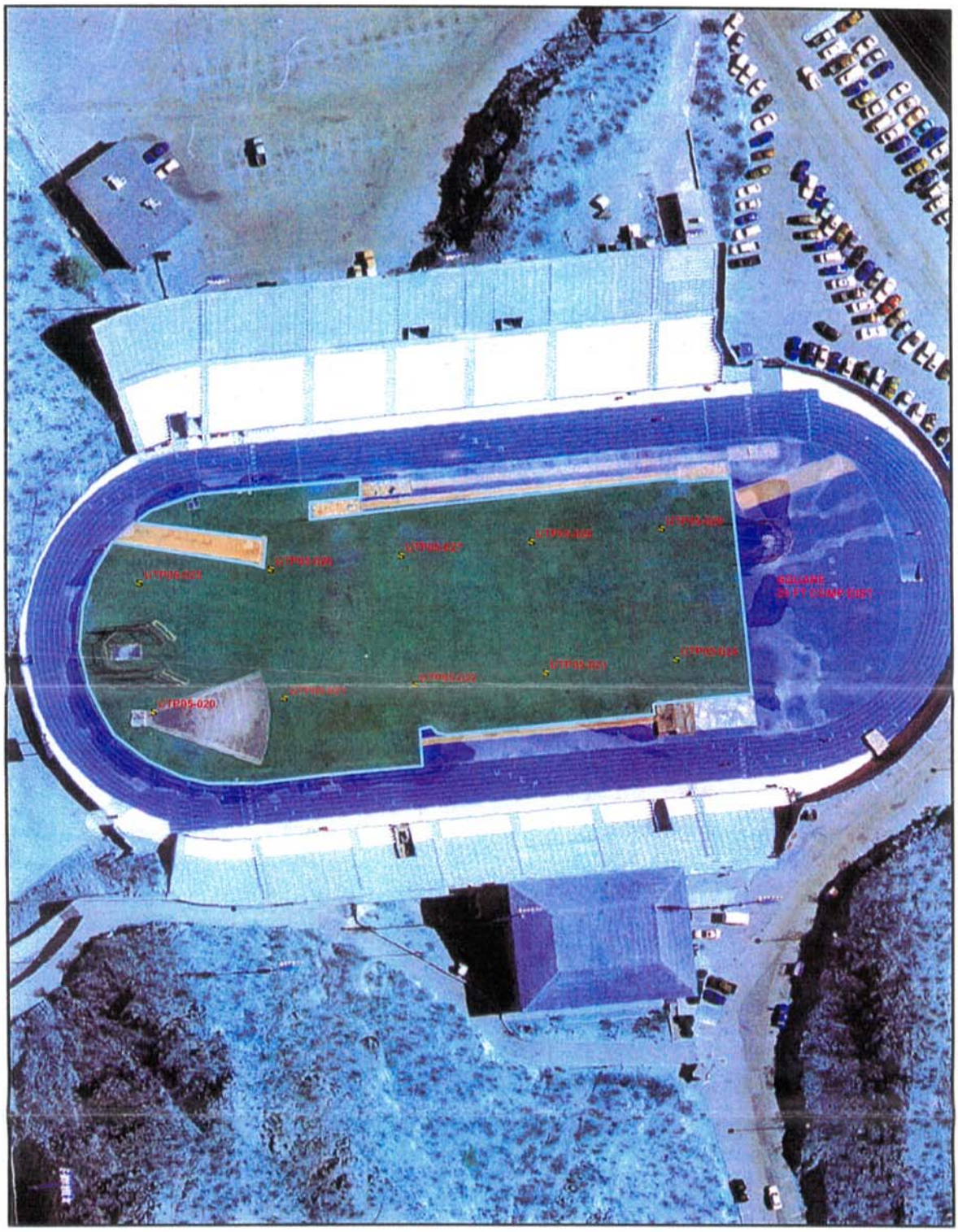


United States Environmental Protection Agency

NORTH KIDD FIELD

UTEP SAMPLING DESIGN

LEGEND

S — SAMPLE LOCATIONS

ISO-CONCENTRATIONS (PPM)

INFERRED ISO-CONCENTRATIONS (PPM)

SAMPLING BOUNDARY

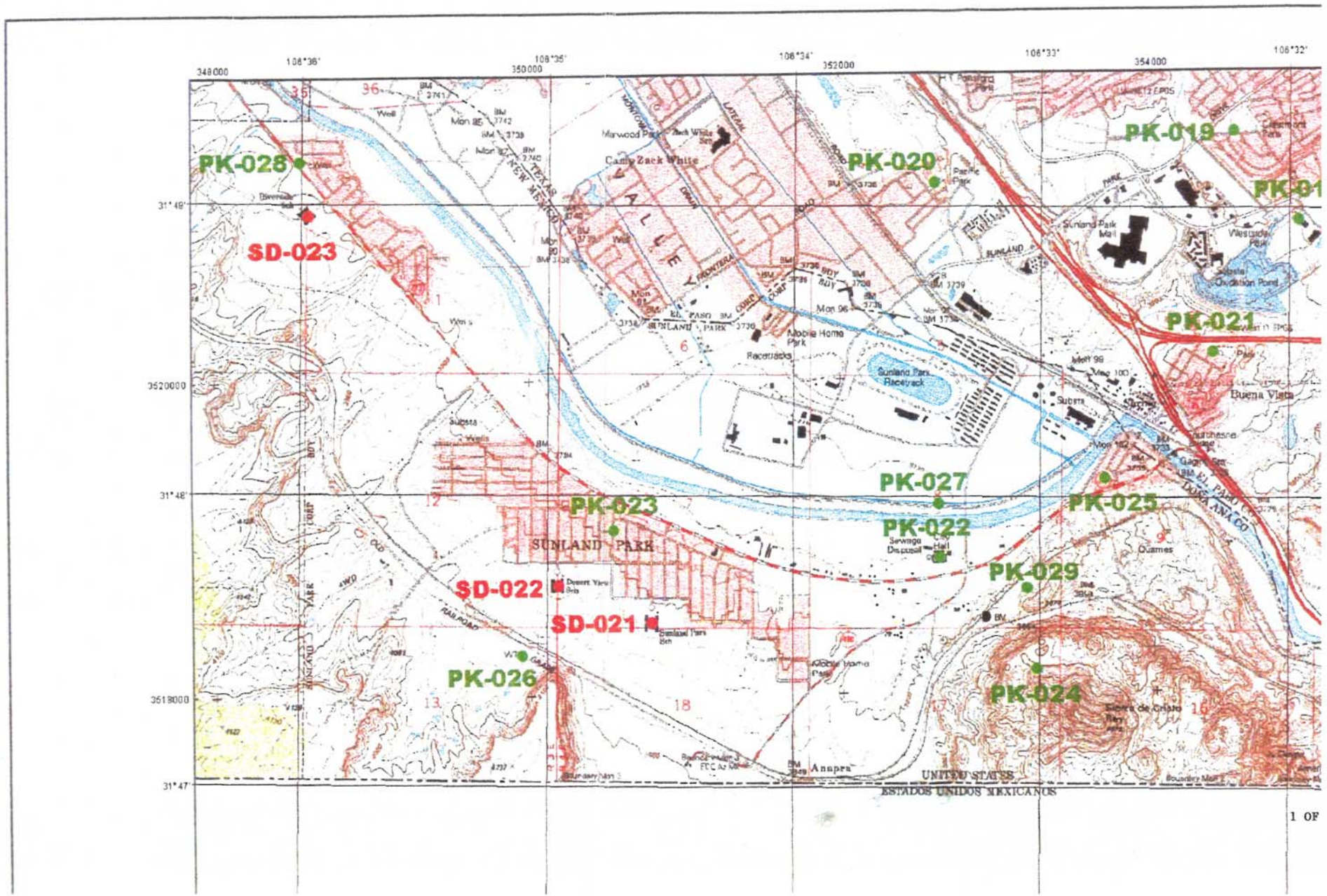
0 30 60 Feet

NOTE: THIS IS A DRAFT. DATA HAS NOT BEEN VALIDATED.

EPA United States Environmental Protection Agency

EL PASO COUNTY METALS INVESTIGATION
ARSENIC ISOPLETH MAP FOR
STATIONS EXCEEDING 20 PPM
SAN MARCOS DR.
EL PASO COUNTY, TEXAS

AUG 01	20074.515.028.0030	SCALE AS SHOWN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SUNLAND PARK
Sunland Park Racetrack
Mobile Home Park
Buena Vista
Quemes
Anapra
UNITED STATES
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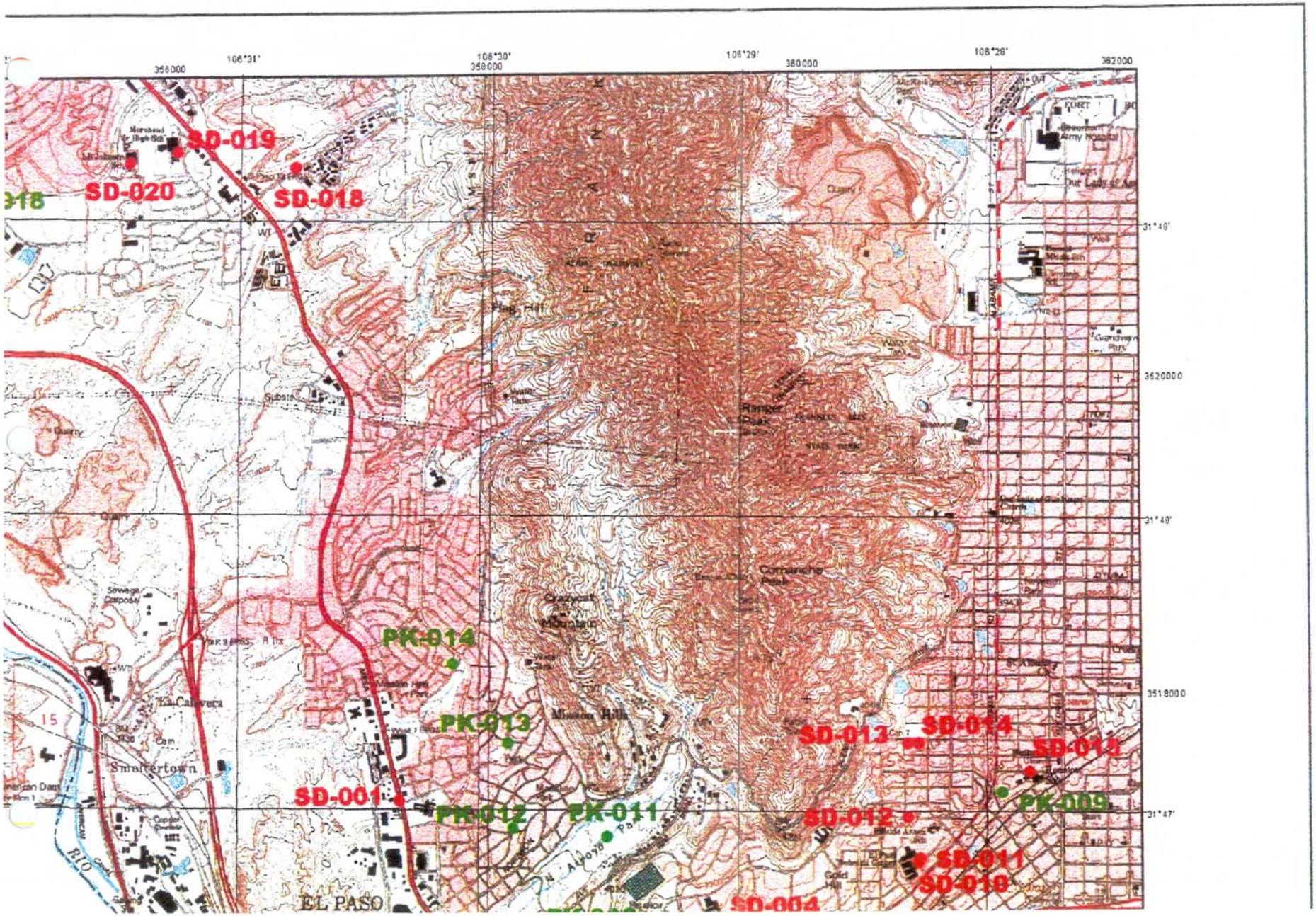
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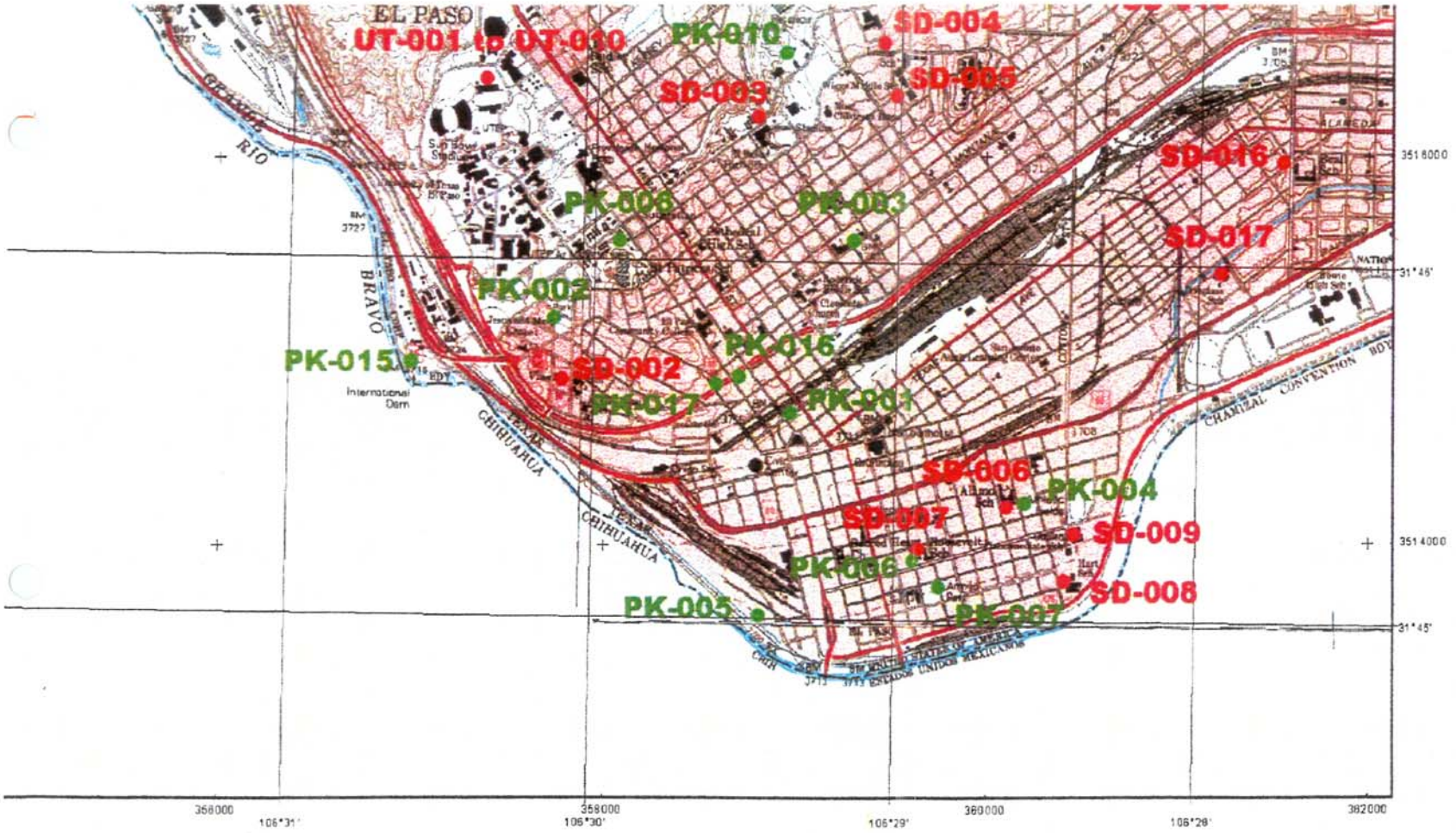
EL PASO
Smeltertown
Ranger Peak
Comanche Peak
Mission Hills
Sewage Disposal
Quarry
RIO



ns: Parks (green), Schools (red)

0.6 0 0.6 1.2 Kilometers

Projection System:
UTM Zone 13, NAD 1929

Date: 06/25/01, Version 4.2

EPA

Figure 2.

APPENDIX P

IN-VITRO BIO-AVAILABILITY RESULTS AND METHODOLOGY

APPENDIX P

IN-VITRO BIO-AVAILABILITY RESULTS AND METHODOLOGY

Bioaccessibility of Lead and Arsenic in Crushed Slag, El Paso, Texas

Prepared for:
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Technical Service Center
Salt Lake City, Utah

Prepared by:
Walker & Associates, Inc.
2618 J Street, Suite 1
Sacramento, CA 95816

1.0 Introduction

A crushed/milled slag sample from El Paso, Texas was used in an in-vitro bioavaliabiliy test for possible use in Risk Assessment calculations. The procedures and results are described below.

2.0 Methods

The objective of the study was to determine the percentage of Pb and As in a representative slag sample that is available for uptake under human gastro-intestinal conditions such that, if necessary or desured, human risk could be modeled in order to determine soil cleanup levels and/or land use restriction employed for protection of human health. The study employed in vitro methods used at other mining sites throughout the western United States.

The bioavailability test was conducted according to the method Ruby et al. (1999) as amended by Ruby *et al.* (1996). A single slag sample was were tested for lead and arsenic bioavailability. A representative (obtained from a riffle-splitter) portion of the sample was dried at 50 °C for 12 hours and sieved to <250 μm. A split of the dried, sieved sample was collected for analysis of solid phase lead, with the remaining sample was used in the bioavailability test.

Chemical composition of the sample was determined by normal EPA approved procedures for total metal analysis by ICP or ICP-MS at ASARCO's Tech Service Center in Salt Lake City. The results are summarized below.

Table 1. Slag Sample Composition

Analyte	Content (mg/kg)	Analyte	Content (mg/kg)
Ag	27	K	6020
Al	1.4 (%)	Mg	7131
		Mn	831
Ba	639	Mo	3326
Be	<1	Ni	208
Ca	2.6 (%)		
Cd	19	Sb	532
Co	131	Se	12
Cr	271	V	<10
Cu	2 (%)	Zn	3.4 (%)
Fe	35 (%)		

Gastric solution was prepared by combining 0.53 mL of 6N hydrochloric acid, 1.25 g pepsin, 0.5 g citrate, 0.5 g malate, 420 μL lactic acid, 500 μL acetic acid into one liter of

deionized water. A 250 mL Teflon® separatory funnel, containing 160 mL of gastric solution (pH 1.5), was partially submerged in a water bath maintained at 37 °C, and continuously purged with argon gas at 0.3 liters/minute. To start the bioavailability test, 1.6 g of dried, sieved sample was placed in the separatory funnel.

The pH of the gastric solution was maintained at pH 1.5 for one hour (stomach phase) by dropwise addition of 0.6N hydrochloric acid. At 20, 40, and 60 minutes of the stomach phase , 10 mL gastric solution samples were collected from the solution in the separatory funnels, following the methodology of Ruby *et al.* (1996). After collection of each 10 mL sample, 10 mL of gastric solution was added to the separatory funnel to keep the solution volume at 160 mL. Immediately upon collection of each gastric solution sample, the sample was centrifuged at 2100 r.p.m. for 12 minutes to remove any suspended particles. The mass of solid material removed from the separatory funnels during each sampling episode was inconsequential, constituting less than 1% of the total mass of solid material in the funnel.

The samples were decanted into a high-density polyethylene sample bottle, preserved with ultrapure nitric acid, and submitted to Prima Environemntal for analysis of dissolved lead following SW-846 protocols (method 6010A). The solid samples were analyzed for total lead using method 3050B for digestion and method 6010A for analysis. Standard QA/QC procedures were followed by Prima with all criteria within acceptable limits. Additionally, Paragon performed matrix spikes using four of the samples with lead recoveries ranging from 97 – 100%, indicating that all lead dissolved in the samples is being measured.

Table 2. Bioavailability Results

Analyte	Total Metal (mg/kg)	Mass Dissolved in 1 Hour	% Bioavailable
Pb	987	51	5.1
As	4903	546	11.1

APPENDIX Q

SECTION 4.2 OF THE PHASE I RI REPORT
(CORRECTIVE MEASURE ALTERNATIVES)

APPENDIX Q

SECTION 4.2 OF THE PHASE I RI REPORT
(CORRECTIVE MEASURE ALTERNATIVES)

- Possible sources of metals identified during low water flow in the American Canal should be further evaluated.

4.1.2 Corrective Action Objectives

Plant improvements such as the Stormwater Collection and Reuse project and Corrective Action Measures to remediate source areas, are an integral part of the overall corrective action approach. Plant improvements provide opportunities for management of smelter/source materials and reduce potential environmental risks. Corrective Action Objectives for the Asarco El Paso Smelter are as follows:

1. Reduce the potential for exposure to metals by plant workers and the public.
2. Minimize the potential for transport of metals to the groundwater.
3. Prevent increases in metal concentrations in the American Canal and the Rio Grande resulting from the migration of metals in groundwater, surfacewater, and wind-blown dust from the Plant.

4.2 CORRECTIVE ACTION TECHNOLOGIES AND PROCESS OPTIONS

This section summarizes information on performance, relative costs, applicability, efficiencies, operation and maintenance, and site-specific implementability of remedial technologies for soil and groundwater. Sources of information used in the literature review include compendiums of treatment technologies, the National Technologies (NTIS) database, the Site Innovative Technology Evaluation (SITE) demonstration program, treatability studies conducted at other Asarco sites having metal constituents similar to those at the Asarco El Paso Smelter, and data provided by vendors. Other technologies may be available that are not considered in this section, but the information presented is intended to be the most applicable to the Asarco El Paso Smelter site.

4.2.1 Soil

Soils on the Asarco El Paso Smelter site and in the associated study area formed in colluvium and fluvial sediments. The colluvial sediments were generated by the erosion of a laccolith locally known as the "Campus Andesite." The laccolith is located to the east of the plant, with the sediments laid to the west where it mixes with the fluvial sediments of the Rio Grande. Alluvial floodplain deposits are found along the Rio Grande below the smelter site. The stream deposits generally consist of silt, sand, and gravel. Surface soils within the Plant have been drastically disturbed, affected by the construction and operation of smelting and ore-handling facilities over a period of approximately 111 years. In particular, facilities construction and the deposition of slag from smelting operations has covered the majority of the original surface soils in the study area. The results of the on-site investigation indicate the principal source of arsenic and metals in soils to be related to historic smelter features and activities associated with the Asarco El Paso Smelter operation.

Several remedial process options could be considered in developing remedial alternatives for the Asarco El Paso Smelter site. Based on the results of the remedial investigation, the primary constituents of concern for soil are arsenic, cadmium, lead, and selenium. In some cases, specific treatment alternatives have been explored for similar smelter sites, and treatability test results are briefly discussed where relevant. Bioreclamation is not applicable to remediation of inorganics in soil and is not discussed in this section. Cost evaluations are relative to other remedial options and are general only.

4.2.1.1 Isolation/Containment

Isolation and containment technologies entail isolation of affected soils by excavation and removal, isolation through stormwater control, and caps that may include pavement, concrete, clay, synthetic liners, or clean soil and revegetation. Of all the remedial technologies considered for soil in this proposal for remedial action, source isolation probably has the greatest applicability to the Asarco El Paso Smelter site. Consistent with use of the site for industrial purposes, construction methods and materials used in the improvement of the site could provide effective isolation and containment of source materials. Potential future

redevelopment at affected Plant property to other industrial or commercial uses may be consistent with the U.S. Environmental Protection Agency's Brownfields concept (U.S.E.P.A., 1995).

Asphalt/Concrete Cap

Capping soil with asphalt or concrete effectively limits potential exposure to arsenic- and lead-affected soil and prevents downward percolation of arsenic and metals to the groundwater system. This process option is relatively easy to implement, especially if much of the site is already paved, or if there are plans for improvement of the site. Cost for asphalt or concrete capping is moderate relative to other process options. The relative cost for an asphalt cap ranges from $8 to $10 per square foot, and approximately $30 per square yard for concrete, including base materials but not site preparation and grading.

Clay and Synthetic Membranes

Additional options for capping material include clay (e.g., bentonite), that prevents infiltration to groundwater but is not implementable by itself in high traffic areas. Synthetic membrane capping such as a geomembrane liner prevents infiltration to groundwater and is not susceptible to weathering and cracking, unlike asphalt, concrete, and clay/bentonite. However, a synthetic membrane is not as easy to implement and is higher in cost. A typical cost for a synthetic membrane liner is $0.60 per square foot. Synthetic liners are typically used in conjunction with a clean soil cap and a lateral drainage layer of gravel at an additional cost of approximately $30 per cubic yard of material.

Clean Soil and Vegetation

A clean soil and vegetative cover is a low-cost process option that effectively limits exposure to affected soils and reduces the potential for migration of arsenic and metals. The effectiveness of limiting infiltration to groundwater is dependent on climate (rainfall and evapotranspiration), subsurface lithology, and capping application. The cost of importing clean soil for capping purposes is approximately $20 per cubic yard, depending on

availability and distance to a suitable source. The cost for establishing a permanent native vegetative cover can range from $200 to $800 per acre.

Stormwater Control

Surface water control can be accomplished through site grading and the construction of ditches, pipelines, sumps and ponds. The construction of stormwater improvements at the Asarco El Paso Smelter, referred to as the Stormwater Collection and Reuse Project, are scheduled to begin in late 1998 or early 1999 (Dames and Moore, 1998). The new stormwater control facilities will effectively isolate surface water from contact with potential source areas and will route stormwater to a reuse system. Underground reinforced concrete pipe (RCP) storm drains range from $11 to $30 per linear foot, depending on the size of pipe required to handle stormwater runoff from the site. Lined stormwater ponds range from $2.00 to $3.50 per square foot. The estimated cost of the entire proposed stormwater project is $9,000,000.

Excavation and Removal

Excavation and removal of contaminated soil with a backhoe, in the case of deep excavation, or with a front end loader, in the case of shallow excavation, is an effective and easily implemented method of remediation and by itself has a relatively low cost. However, excavated materials must be appropriately managed. Depending on the characteristics of the excavated materials, disposal may be as simple as transporting the materials to an on-site fill, placement in an on-site RCRA or solid waste landfill, or may require transport to an off-site RCRA or solid waste landfill. Excavated materials may also require treatment prior to disposal. Accordingly, excavation treatment options can range in cost from $50 to $500 per ton of soil removed.

4.2.1.2 Physical Treatment

Physical treatments include soil flushing and washing, acid leaching, chelation, and electro-osmosis, but are not considered practical options for the Asarco El Paso smelter site because

the costs for these options have not been well defined for large scale use and will not be addressed here.

Soil Flushing/Washing

Soil flushing for in-situ treatment, or soil washing of excavated soil, are methods of extracting constituents of concern from the surface of the soil. Either is accomplished by passing extractant solvents through the affected soil. Solvents may include water, acids or bases, chelating agents, and oxidizing or reducing agents.

Acid Leach Washing

Acid leach washing has been explored at the Asarco Tacoma Smelter site in Ruston, Washington (Hydrometrics, 1992a) for soil containing arsenic and metals. Treatability tests for Ruston soil demonstrated modest reductions in soil arsenic and metal concentrations in oversized fractions of soil greater than 200 micrometers in size. Separation and washing of the oversize fractions resulted in 40 percent to 60 percent reductions in arsenic concentrations in soils. There are a number of technical obstacles associated with this treatment, including high post-treatment leachability, effective washing of entire soil mass, large water requirements, recovery of wash fluids and sludges, treatment of fine grain fraction, and treatment and/or disposal of wash fluids and sludges. In-situ obstacles include a high potential for groundwater contamination. Well recovery systems would have to be implemented in order to contain and recover wash fluids and metals. In addition, soil pores can clog, making complete arsenic and metal removal even more difficult.

Chelation

Chelating is a physical treatment process in which a chelating chemical is used to solubilize metals from soil. Chelating agents are commercially available, and can be chosen for their affinity to particular metals. The effectiveness of this treatment is dependent on soil chemistry. This method may not work as well for the removal of arsenic as for the removal of other metals (Hydrometrics, 1992a).

Electro-Osmosis

Electro-osmosis decontamination concentrates or separates ionic species by exposing the material to an electric field. In an in-situ process, anodes and cathodes are inserted in the ground, and loosely held ions are displaced to their respective electrodes. Heavy metals present in soils can be leached or precipitated out of solution by electrolysis, oxidation and reduction reactions, or by ionic migration. Soils having higher electrical conductivity, such as saturated soils, are more suitable for this treatment. This method has been examined on a laboratory scale, and applicability in the field is questionable. Data suggest that electro-osmosis decontamination is effective on fine-grained soils of low permeability. Treatment on coarse soils such as those found typically at smelter sites showed an arsenic concentration reduction of only 10 percent (Hydrometrics, 1992a).

4.2.1.3 Chemical Neutralization/Fixation/Stabilization

Neutralization/fixation/stabilization processes alter the chemical characteristics of waste material such that the toxic and hazardous constituents are immobilized, either by changing the constituents into immobile forms, binding them to an immobile, insoluble matrix, and/or binding them in a matrix such that the constituents are not exposed on the material surface. Chemical treatment methods can employ relatively simple technology, such as the application of limestone amendments to adjust pH, to processes that involve more complex soil chemical reactions.

Chemical Neutralization

Chemical neutralization is used to control pH and the mobility of arsenic and other metals in soil. A commonly used process is the addition of crushed limestone as a soil amendment. Limestone raises the pH of soils in which acidic conditions are limited to shallow soils. In-situ application of neutralization agents such as limestone may have limited application for some surface soil situations, particularly involving vacant lots that contain affected soils. This process would probably not be effective for Plant soils having high arsenic concentrations. The costs of application and incorporation of crushed limestone ranges from $20 to $60 per acre.

Another type of neutralization involves the use of deep tillage. Deep tillage techniques can be used to mix arsenic and other metals with naturally-occurring limestone or select additives with affected surface soils (Hydrometrics, 1995b). Again, this method is restricted to open areas in which arsenic and metal concentrations are distributed in surface soils. In addition, this process is not easily implemented if there are numerous subsurface utilities and other obstructions. The cost of deep tillage ranges from $125 to $250 per acre plus the cost of the amendments.

Siliceous Chemicals

Siliceous chemicals can be used to fix and solidify polyvalent metal ions such as arsenic and lead via reactions between silicates and positively charged metals. Several siliceous processes are commercially available and have been previously demonstrated to be effective. In one process by Chemfix Technologies, Inc., the waste is blended in a reaction vessel with water-soluble silicates in the presence of a siliceous setting agent. The resulting three-dimensional polymer matrix is characterized by strong ionic bonding and cross-linking between layers of silicon-oxygen chains. In limited laboratory scale treatability testing of Tacoma plant soils, effective reduction of leachability to below Toxic Characterization Leaching Procedure (TCLP) criteria was accomplished using a similar commercial process available from Toxco (Hydrometrics, 1992a). This process has been successfully implemented at other sites, including several Superfund sites at which metals were of concern. This process has been successfully implemented at another smelter site near Omaha, Nebraska (Hydrometrics, 1996). Treatment costs range from $100 to $200 per ton of soil.

Pozzolan Processes

In pozzolan processes, arsenic and metals are bound in pozzolan-type matrices by physical sorption or chemisorption, yielding a stabilized material. The advantages of this technique include plentiful and inexpensive raw materials, improved waste handling, minimal required pretreatment, and products adequate for landfill disposal. A disadvantage is that leachate

control is variable. Soil chemistry, particularly sulfate and arsenate concentrations, can interfere with pozzolan processes; however, there are several commercial venders that have successfully used these processes for fixation of arsenic and metals in soils. The lime-based pozzolan process stabilizes waste by combination with a large amount of siliceous material and a setting agent such as lime, cement or gypsum. Portland cement-based pozzolan stabilizes waste by incorporating it in a cement matrix.

Treatability tests examined three variations of chemical fixation for the soil at the Asarco Tacoma Smelter site located in the municipalities of Ruston and Tacoma, Washington (Hydrometrics, 1993). The treatments were incorporation of soil into Portland cement, a commercial cement-based pozzolan process, and a commercial siliceous-based fixation process (Hydrometrics, 1993). Two of the three fixation processes investigated in the treatability testing effort were not able to obtain anticipated treatment objectives for arsenic. All of the processes investigated were able to successfully immobilize metals, including lead; one out of three (commercial cement-based pozzolan process) was successful in achieving treatment objectives for arsenic. A commercial cement-based process by Eurocan was able to achieve post-treatment TCLP results for arsenic below TCLP criteria of 5 mg/l. Treatment costs for this process are high, about four times as high as the anticipated cost associated with standard soil cement treatment.

Treatability testing for cement and lime stabilization of sludge was performed for a former process pond at Asarco's lead smelter in East Helena, Montana (Hydrometrics, 1995a). Treatment was achieved that successfully passed TCLP criteria using cement/lime combinations at a 30 percent additive ratio. Phosphate addition to the cement, either in the form of phosphoric acid or fertilizer, has been shown to dramatically reduce lead mobility in soils, reducing leachate lead concentration by two orders of magnitude (Hydrometrics, 1996a). One drawback is that arsenic is mobilized as a result of phosphate addition.

In general, stabilization of wastes containing arsenic and other metals, depends on the site-specific soil matrix. Consequently, prior to implementation of a particular method, pilot

studies are required in order to verify the effectiveness of the treatment technology. Pozzolan treatment costs typically range from $50 to $200 per ton of soil.

4.2.1.4 Thermal Destruction

Thermal destruction processes do not destroy metals, but they can potentially immobilize metals. These technologies generally are more costly than other potential treatment alternatives because of high energy costs. Many of the processes, such as flame reactor or plasma torch vitrification, are still in the development phase, and the practicability of these technologies has not yet been completely determined. The use of a blast furnace has been effective for soil treatment and disposal, and is a viable option at an active smelter site such as the Asarco El Paso Smelter site.

4.2.1.5 Vitrification Stabilization

Vitrification is a process that uses either electrical current or fueled oxidation systems to fuse soils into a vitrified block. Laboratory and pilot scale field testings indicate that the treatment is effective in reducing soil metal leachability; however, this process requires large energy inputs and is still in the development phase.

4.2.2 Groundwater

As discussed in Section 1.2.4, the aquifer underlying the Plant is composed primarily of interbedded and mixed sand, gravels, boulders, and bedrock. Water is derived from the Rio Grande and considered separate from the Hueco Bolson and Mesilla Bolson regional aquifers. In some cases, such as the floodplain of historical Smeltertown, finer grained sediments (silts and clays) exist. Groundwater flow direction is from the east-northeast to the west-southwest. As groundwater approaches the Rio Grande, the direction changes to a southerly route, which approximates the direction of the Rio Grande flow. Depth to groundwater is dependent on location within the Plant. The depth of groundwater at the Plant is 40 to 60 feet below ground surface (bgs), depending on the elevation of the Plant above the floodplain (30 feet to 50 feet). On the Rio Grande floodplain (historical Smeltertown), the depth to groundwater is approximately 10 feet bgs.

Groundwater in the regional Hueco Bolson aquifer, a source of drinking water for the City of El Paso upgradient of the plant, occurs in both the fluvial deposits and the underlying lacustrine deposits. The primary source of drinking water for the region is extracted from the poorly sorted, irregularly stratified fluvial deposits which outcrop over most of east El Paso and range from 400 feet to 1300 feet thick. The deposits consist of unconsolidated sand lenses alternating with gravel, silt, and clay.

Elevated concentrations of arsenic and other metals in groundwater underlying the Plant were observed during remedial investigation groundwater monitoring events. Arsenic, and in some cases, cadmium, lead, and selenium exceed drinking water MCLs. Dissolved arsenic (the primary constituent of concern), concentrations in the groundwater range from 0.005 mg/l to 315 mg/l. As discussed in Section 2.3, elevated concentrations of metals in the groundwater appear to coincide with areas of elevated metals in soils, pond sediments, and other source areas/materials

Metal concentrations in the groundwater generally decrease by two or more orders of magnitude within a few hundred feet downgradient of the source areas. The rapid decrease in concentrations of metals suggest geochemical attenuation may be controlling horizontal metal migration in the groundwater system.

4.2.2.1 Chemical Treatment of Groundwater (Pump and Treat)

Metals can be removed from groundwater by adjusting the pH to form an insoluble precipitate that settles to the bottom of a treatment vessel. Calcium hydroxide (lime), sodium hydroxide (caustic soda), and to a lesser extent, magnesium hydroxide, are used singly or in combination to achieve the desired pH adjustment. Sulfide polishing is sometimes used as a third step, since the solubility of metal sulfides is substantially less than the solubility of metal hydroxides (Hydrometrics, 1993). Filtration of the treated water is usually required after hydroxide and/or sulfide solution to achieve treatment standards.

To achieve removal of arsenic to low concentrations, one and sometimes two modifications to the hydroxide precipitation step are required. If arsenic is in the insoluble phase (As (V)), it can be precipitated as $FeAsO_4$ and coprecipitated with ferric hydroxide if sufficient ferric ions are added to the treated solutions and the pH is subsequently increased to form an insoluble precipitate. Iron is commonly added, using ferric chloride or ferric sulfate, the correct dosage being determined by laboratory testing. If arsenic exists as the soluble As(III) phase, an oxidizing agent (typically hydrogen peroxide) must be added to oxidize the As(III) to As(V) before the hydroxide precipitation step. Arsenic has been consistently removed to a concentration of 0.015 mg/l in a 100 gpm treatment plant using this process (Hydrometrics, 1996).

Chemical treatment requires the construction and operation of treatment plants. The capital required to construct a plant with a capacity to treat 100 gpm ranges from $4.2 million to $7 million (Modrow, 1995). The cost to operate and maintain a 100 gpm plant ranges from $200,000 to $300,000 per year (Modrow, 1995). Handling, storage and shipping of solid materials range from $200 to $400 per ton.

4.2.2.2 Groundwater Isolation/Containment

Subsurface barriers are designed to isolate or contain contaminated groundwater. A number of different technologies exist, including installation of extraction/injection wells, interception and infiltration trenches, slurry or clay walls, grout curtains, and concrete walls. In a general sense, construction of barriers is extremely costly, and there are numerous technical limitations associated with their effectiveness.

Groundwater Extraction and Injection Wells

Groundwater pumping techniques involve the active manipulation and management of groundwater in order to contain or remove a plume or to adjust groundwater levels to prevent formation of a plume. Extraction and injection wells are often used to manage contaminated groundwater. The selection of the appropriate well type depends on the depth of contamination and on the hydrologic and geologic characteristics of the aquifer.

Extraction wells, or a combination of extraction and injection wells, can be used when the objective is plume containment or removal. Use of extraction wells alone is best suited to situations whereby contaminants are miscible and move readily with water; whereby the hydraulic gradient is steep and hydraulic conductivity high; and where quick removal is not necessary. Extraction wells are frequently used in combination with slurry walls to prevent groundwater from moving over the wall and to minimize leachate contacting and degrading the wall. Slurry walls also reduce the amount of contaminated water that requires removal, so that costs and pumping time are reduced.

A combination of extraction wells and injection wells is frequently used in containment or removal when the hydraulic gradient is relatively flat and hydraulic conductivities are only moderate. One problem with extraction/injection well systems is stagnation zones. The size of the stagnation zone is directly related to the amount of overlap between adjacent radii of influence; the greater the overlaps, the smaller the dead spots will be. Another problem is that injection wells can suffer from many operational problems, including air locks and needs for frequent maintenance and well rehabilitation.

Installation costs for extraction wells and injection wells are approximately $30 per vertical linear foot. Operation and maintenance costs for these wells are typically approximately $120 per day per well.

Interception and Infiltration Trenches

Interception trenches can be excavated to control groundwater gradients and collect contaminated waters for containment or treatment. Application is best suited for low permeability unconsolidated materials. Infiltration trenches can be used in much the same way as infiltration wells. Gradient can be controlled in combination with interception trenches. Infiltration trenches also are potentially useful for disposal of treated waters. Construction costs for an interception or infiltration trench are approximately $8 per square foot.

Slurry Walls

Slurry walls are the most common subsurface barriers because they are a relatively inexpensive means of vastly reducing groundwater flow in unconsolidated materials. The term "slurry wall" can be applied to a variety of barriers. Slurry walls are all constructed in a vertical trench that is excavated under a slurry. This slurry, usually a mixture of bentonite and water, acts essentially like a drilling fluid. It hydraulically shores the trench to prevent collapse, and, at the same time, forms a filter cake on the trench walls to prevent high fluid losses into the surrounding ground.

Slurry wall types are differentiated by the materials used to backfill the slurry trench. Most commonly, an engineered-soil mixture is blended with the bentonite slurry and placed in the trench to form a soil-bentonite (SB) slurry wall. In some cases, the trench is excavated under a slurry of Portland cement, bentonite and water, and this mixture is left in the trench to harden into a cement-bentonite (CB) slurry wall. In the rare case requiring great strength of a subsurface barrier, precast or cast-in-place concrete panels are constructed in the trench to form a diaphragm wall. The construction cost for a slurry wall is approximately $40 per square foot.

Grout Curtains

Grout curtains are subsurface barriers created in unconsolidated materials by pressure injection. Grout barriers can be many times more costly than slurry walls and are generally incapable of attaining truly low permeabilities in unconsolidated materials. Recent field testing of two chemical grouts revealed significant problems in forming a continuous grout barrier due to noncoalescence of grout pods in adjacent holes and grout shrinkage. Furthermore, conventional injection grouting is incapable of forming a reliable barrier in medium sands, and grout curtains are rarely used for groundwater control in unconsolidated materials is desired.

Grout curtains, like other barriers, can be applied to a site in various configurations. Circumferential placement offers the most complete containment but requires that grouting take place in contaminated groundwater downgradient of the source. Chemical reactors in groundwater can cause problems with grout set and durability, and this technique requires extensive compatibility testing during the feasibility study. Another limitation of grout curtains is gaps left in the curtain due to poor grout penetration. Construction costs for a grout curtain are approximately $50 per square foot.

Vibrating Beam

The vibrating beam method is not an injection technique usually used to install grout curtains, but instead is a way of placing grout to generate a wall. In this method, an I-beam is vibrated into the desired depth, then raised at a controlled rate. As the beam is raised, grout is pumped through a set of nozzles mounted in the beam's base, entering the newly formed cavity. When the cavity is completely filled, the beam is moved less than one beam width along the wall, leaving suitable overlap to ensure continuity. The construction cost for placing grout to generate a wall is approximately $14 to $25 per square foot depending on placement depth.

Concrete Walls

Concrete walls can be installed as vertical barriers to groundwater movement. The installation is similar to slurry wall construction, with the exception that concrete is used to displace the mud slurry used to hold the trench open. Concrete has a narrower range of chemical compatibility, and higher permeability than a conventional slurry wall. The construction cost for a concrete wall is approximately $50 per square foot.

Clay Walls

Clay walls can be installed as vertical barriers to groundwater movement. The installation is similar to slurry wall construction, with the exception that clay materials are used to displace the mud slurry used to hold the trench open. Construction costs for clay walls and slurry walls are similar.

4.2.2.3 Source Isolation/Removal

In recent years, attention to groundwater remediation technologies has been drawn away from large-scale manipulation of groundwater, such as pump and treat methods and plume barrier construction, because of the limited effectiveness and high cost of these processes. This is true for dissolved metals, such as arsenic, which are absorbed to aquifer materials and not easily removed from groundwater. If the source of contamination is removed or isolated, natural processes such as geochemical attenuation and dispersion can reduce contaminant concentrations. The time scale for natural processes to occur is highly variable and dependent on a number of site specific factors.

In reviewing options for soil and groundwater treatment, field implementation of physical methods, such as soil flushing or washing, are costly, with numerous technical difficulties being associated with them. Chemical neutralization and deep tilling are effective for surface soils, but smelter sites typically contain enriched metal concentrations at depth. There may be some limited applicability for limestone amendments or deep tilling at the Asarco El Paso site. Thermal destruction of lead and arsenic is not practical for the Asarco El Paso site. The construction of groundwater barriers could present many problems that are site and technique related. Site investigation results suggest that arsenic in the shallow alluvial aquifer is attenuated. Installation of barriers is likely a costly and unnecessary measure for plume containment. Groundwater removal and treatment, such as chemical hydrolysis and co-precipitation is an extremely expensive and difficult procedure. Future consideration of the aforementioned treatment options can probably be eliminated.

Of the methods discussed, source isolation/containment and chemical fixation/stabilization are probably the most rational to implement at the El Paso site in terms of cost, technical feasibility, and success at similar sites. The use of pavement and concrete caps and stormwater improvements that might be constructed in conjunction with site improvement projects could effectively isolate source materials from potential contact with surface water and eliminate leaching of arsenic and metals and percolation to groundwater.

In the case of groundwater, source removal via soil remediation, which either immobilizes arsenic and metals or removes them, thereby preventing their leaching into the groundwater, allows natural dilution and dispersion to occur. Source isolation or removal is by far the most reasonable method of remediating groundwater in terms of cost and implementabilty. In addition, natural processes following source isolation or removal would further reduce the potential for leaching of arsenic and metals, and for off-site impacts. If source materials are removed as part of a corrective action, on-site containment in an appropriately designed solid waste or RCRA compliant landfill would eliminate the need for expensive off-site transport.

4.3 IDENTIFICATION OF CORRECTIVE ACTION ALTERNATIVES

In this section of the report, corrective action technologies and process options reviewed in Section 4.2 are developed into Corrective Action Alternatives based on their potential to be effective and implementable at the Asarco El Paso site. Based on the results of the remedial investigation, and information presented in Section 4.2, groundwater does not appear to adversely impact surface water resources (American Canal and Rio Grande) and treatment of groundwater is not feasible. Therefore, Corrective Action Alternatives do not address groundwater. The following sections identify and describe applicable Corrective Action Alternatives.

4.3.1 Institutional Controls/Deed Restrictions

Institutional controls applicable to corrective action at the Asarco El Paso Smelter site include the following:

- Worker health and safety programs
- Deed restrictions

Through health and safety policies and programs currently in effect at the El Paso smelter, the potential for exposure and health hazards is significantly reduced. The health and safety program includes required OSHA training and medical monitoring of "Contact Intensive"