From: Natalia.Raykhman@CH2M.com
To: DHONT, JEFF
Subject: Residential Sampling Strategy
Date: Monday, December 9, 2013 7:47:31 PM
Attachments: General Field Approach for Residential Risk_CH2MHILL.docx
Figure 1_Residential_Sampling.pdf
FIG2a_ResidentialProgram_EPC-AS_E-size.pdf
FIG2b_ResidentialProgram_EPC-PB_E-size.pdf
Figure3_Sample Locations_Bioaccesibility.pdf

Hi Jeff,
Here is the residential strategy memo and figures. Please let me know if you have questions and or would like to discuss.
Best Regards
Natasha

Scope and Field Approach for Residential Risk-Based Sampling
Planned 2013/2014 Field Event

Iron King/Humboldt Smelter Superfund Site

Written by Region 9 and Intended for ERT as Fieldwork Agent

The *primary objective* of the residential investigation is to obtain sufficient data for EPA to calculate either an *area-based* or a *yard-specific* risk due to site-related contamination in yards *located within the area of potential site impact*, or APSI. The APSI is a physical boundary outside which we do not need to conduct further residential investigation. Based on RI work to date, yards outside the APSI do not need sampling for risk purposes because the IKHS Site has not affected those areas –even though natural levels of arsenic, in particular, can be elevated in those areas. The APSI has been determined independently and prior to this field effort.

Yards located *inside* the APSI require additional characterization to assess whether they contain contamination above background levels, and/or levels that would pose a health risk. This document presents a general guideline and instructions for characterization of these yards, before a reliable decision on cleanup can be made. The APSI and the yards designated for additional sampling are shown on the attached map (Figure 1).

Figure 1 shows two primary categories of yards designated for sampling within the APSI, including:

(1) Yards requiring yard-specific risk characterization (see targeted parcels for risk assessment), including previously sampled yards (shaded in pink) and new yards (shaded in brown); *and*

(2) Yards located within an area designated for an area-based risk screening (see areas committed to risk assessment screening shaded in purple and blue); although these yards are believed to have lower chance of contamination, they may need to be further sampled for full yard-specific risk characterization if determined in the field based on the screening information.

A secondary objective of residential sampling includes collecting a statistically-defensible number of soil samples for laboratory in-vitro analysis, which measures the bioaccessibility related to the metals in the soils.

1. Yard-Specific Risk Characterization

The objective of yard-specific characterization is to collect a sufficient population of soil data that will allow us to compute an upper-confidence limit (UCL) and estimate the risk that is posed by *that yard.* The new yards designated for this type of sampling are shown in "brown" color on Figure 1. These yards weren't sampled during previous field activities, but are located generally adjacent to the previously sampled yards, and/or are close enough to the site-related sources that area-based screening is not considered appropriate.

In addition to new yards, some of the yards sampled in 2009/2010 may also require additional sampling to address data gaps. Previous sampling performed at these yards typically included collection of 9 surface samples and 1 deep (1-foot below ground [bgs]) sample for a total of 10 within each yard. However, this density of sampling may not be sufficient for larger yards. Large yards may require more than 10 samples in order to obtain sufficient coverage.

Also, some of the samples collected during previous investigations have incorrect coordinates and cannot be properly located; and/or appear to be at locations outside the yard boundaries. The previously sampled yards where sample locations are suspected to be erroneous (i.e., samples located outside the yard boundaries) may also need supplemental sampling. This specifically applies to yards with potentially erroneous sampling locations, which have reported UCLs for the constituents of concern (COCs), such as arsenic and lead, above the risk standards.

The general guidelines and instructions for additional yard-specific risk characterization are presented below for both (a) new yards; and (b) selected previously sampled yards.

1.1 Sampling of New Yards

- Ten (10) samples (nine on surface and one subsurface <2 ft bgs) should be collected at each new yard that is smaller than/or equal to 0.75 acre. The samples should be spread across the yard, with some weighting around the house or play/use areas.

- An additional 5 samples (with a total of 15) should be collected at yards larger than 0.75 acre, but smaller than 3 acres. Ten of the 15 samples should be focused around use areas near the house or play areas, and the other 5 evenly spread across the remainder of the property.

- An additional 10 samples (with a total of 20) should be collected at yards larger than 3 acres. Ten of the 20 samples should be focused around use areas near the house or play areas, and the other 10 evenly spread across the remainder of the property

- For cases described in each of the 3 preceeding bullets, a minimum of 10 samples will be placed around existing homes, within an area of about 0.75 acres. This will allow for roughly equivalent risk analysis for current residences across all properties.

- If a "hot spot" (i.e., sample with elevated concentrations of arsenic and/or lead) is identified during sampling, additional samples may be required to identify the extent of this hot spot. This sampling may include (1) a localized increase in sample density within a yard (e.g., within 50 feet of the hot spot and/or based on visual observations), (2) the possibility of crossing parcel boundaries if the hot spot is located near the boundary and is unbounded by other offsite samples, and/or (3) the

possibility of separating the hot spot and areas adjacent to or around it into separate risk management areas, which will mean collecting sufficient (i.e., 10) number of samples in both low- and high-concentration areas so a separate UCL could be calculated for these areas. Based on the calculated risk-based concentrations, the action levels that trigger high spot determinations are recommended to be above 200 mg/kg for arsenic, and above 400 mg/kg for lead.

1.2 Additional Sampling of Previously Sampled Yards

- Similar to sampling strategy at the new yards, an additional 5 samples (with a total of 15) should be collected at the previously sampled yards larger than 0.75 acre, but smaller than 3 acres. An additional 10 samples (with a total of 20) should be collected at the previously sampled yards larger than 3 acres. If previous sampling at larger parcels did not occur near the current residence such that there are 10 samples within about 0.75 acres around the home, new samples should be added to attain this requirement. A total of 54 previously sampled yards with an area greater than 0.75 acres were identified. Table 1 presents a list of these yards and the area for each yard. The sampling strategy pertaining to delineation of hot spots at these yards should also be similar to that described for new yards.

- A number of previously sampled yards require an additional evaluation and potential sampling because these yards have 3 or more samples with locations suspected to be erroneous (i.e., samples located outside the yard boundaries), and also have UCLs for either arsenic and lead or both above the risk standards. Figures 2a and 2b show all previously sampled yards color-coded by UCL for arsenic and lead respectively, as well as locations of samples collected previously at these yards (based on available coordinates). The yards above-risk standards UCLs, and selected for additional evaluation and potential sampling based on suspected erroneous sample locations, are listed in Table 2. Please note that yards OFS128, OFS215, OFS264 require additional sampling because of both large area and elevated UCLs.

2. Area-based Risk Screening

The focus of the area-based screening sampling is to provide a more generalized assessment of whether contamination may exist at the parcels/yards located typically on the periphery of the APSI, where impacts from source areas are less likely and may not be sufficient to warrant sampling every single yard with 10 samples. Area-based risk screening will collect a population of soil data that will allow us to evaluate an upper-confidence limit (UCL) for a defined *area* that incorporates multiple yards (10-40 yards). These areas are designated by letters A though J on Figure 1.

The samples will be collected from a subset of yards within the defined area. If the UCL (risk) for the area is low, then the area will be screened out - meaning any yards not sampled yet in the area will not need to be sampled; and the yards that were sampled will not need to be further sampled. Subsequently, yard-specific risks will not be calculated for defined areas screened out.

If an area has a UCL high enough that it cannot be screened out, then field crews will return to that area and sample the yards that were not previously sampled during the screening step to achieve full yard-specific characterization, *and* also collect *more* samples in yards that were previously sampled during the screening step so as to achieve full yard-specific characterization in accordance with the methodology described in Section 1.

The decision as to whether an area is screened in- or out- will be made as close as feasible to real time by Region 9. While field crews move to screen the next area, the data from the last area will be evaluated. It will be essential that data from the yard are passed along in an electronic format that will allow the Region and its contractor to perform statistics on the area as well as plot results and assess visual trends so that this evaluation can be timely.

Figure 1 also shows parcels located within the areas designated for screening. These parcels are shaded Blue and Purple. Within each area, the purple-shaded parcels are the primary parcels designated for sampling. The number shown on the parcel (see Figure 1) is the number of samples that should be collected on that particular parcel to serve the area-specific screening purpose. ***If no number appears, the number of samples is two (2).***

The blue-shaded parcels within the areas designated for screening are "replacement parcels" that should be sampled in the event that access cannot be obtained for one or more of the primary parcels (i.e., purple-shaded parcels). The number of samples collected from these replacement parcels should be the same as originally planned for the primary parcels that are being replaced. ***If no number is shown on Figure 1 for the blue parcel that is being replaced, the maximum number of samples to be collected from the replacement parcel is two (2).***

As an example, if access cannot be obtained for a primary parcel (shaded purple) on which 6 samples are identified, the same 6 samples could be collected from adjacent replacement parcels (shaded blue) where access *can* be obtained. If the surrounding replacement parcels have each 3 samples prescribed on Figure 1, then both of these parcels have to be sampled to replace 6 samples from the primary parcel, for which access could not be obtained. It would *not* be acceptable, however, to put all 6 samples on just on one of the replacement parcels.

The rationale for the location and number of samples defined for the area-based screening is discussed below. This rationale should also be considered for any required field adjustments.

- Samples should be located to allow for good aerial coverage throughout the area being characterized;

- Sampling density should not be increased at any given parcel, as it could cause a bias in results and skew the statistics, if conditions at that property are not representative of the rest of the area;

- Up to a reasonable maximum, placing multiple samples on one property when appropriate will reduce the number of access agreements that must be obtained to complete the screening assessment.

- The number of samples collected for an area should allow for statistical significance.

3. Bioaccessibility Samples

A number of bioaccessibility samples have already been collected at the site to date (See Figure 3). Therefore, it is recommended that only 20 additional samples for bioaccessibility analysis be collected (vs. 30 included in the Data Gap Report). Ten (10) samples should be collected at the Main Tailings Pile (MTP), and another 10 samples should be collected in residential areas. No additional bioaccessibility samples are required in the Gulch areas because we have sufficient number of samples for these areas collected during previous investigations.

- Bioaccesibility samples in residential areas should be collected at locations which provide sufficient coverage of the residential area;

- These locations should also be selected based on the results of the previous or on-going sampling. Specifically, the samples for bioaccessibility analysis should be collected in areas where concentration of arsenic exceeds 200 mg/kg, but can range upward to levels above 1,000 mg/kg if encountered.

4. Other Considerations

Planning

ERT should plan first to access the targeted primary parcels (shaded purple) for an area-based screening and parcels designated for the yard-specific screening (shaded tan). If access cannot be obtained at some of the purple parcels, or there is an issue at a purple parcel property making sampling difficult, there is flexibility and an alternate parcel can be chosen provided that the number of samples transferred to any given parcel does not exceed its maximum.

It is assumed that it may be best to conduct the screening sampling first; this way the total number of yards undergoing full yard-specific characterization can be known before that work begins. However, other approaches can be considered if appropriate.

Modes of Potential Contamination; Variability and "Hot Spots"

This risk-based sampling scheme is specific to an assumed fate/transport mechanism of ***historical aerial deposition*** of wind-blown particulates from one of the site-related sources, among which are tailings piles, dross piles, and smelter stack emissions. However, there are phenomena *other than aerial deposition* that, at any given location, could have resulted in localized areas with higher contamination. We will not necessarily find all such occurrences, but they may come up during the effort. If they do, we will need to be able to adjust our sampling to ensure that the risk due to aerial dispersion can be calculated, separately from risk due to these other causes. These causes of "hot spots" could be:

1. Import of material not native to the yard, which could include imported landscaping or grading material. This material may have come from a quarry or borrow source nearby, but also can

actually consist of imported tailings from one of the smelting or mining sources (tailings can be acquired very cheaply).

2. Deposition of material due to operations along rail lines, loading areas, transport pathways, or other small operations in town in the days of the smelter (1900-1937) of which knowledge may have been lost or is no longer available.

3. Natural high concentration anomalies.

The levels of metals found in yards may be quite variable as there have been many decades since site operations within which soil may have been moved, mixed, regarded, blended with imported material, cut-filled, etc.

Hot spots from these phenomena do exist and have been identified in the neighborhood before. Therefore, the field crew will need to be aware of any signs or indications that buried or imported material is present. ***If a hotspot is identified, it will be necessary to shift focus and take additional samples to identify its localized extent (see discussion above).***

Need for Statistically-Based Sample Sets

The samples collected in each yard will be used in a statistical analysis to determine the exposure point concentration for a hypothetical receptor in the yard. *At least 9 surface soil samples and one one-foot sample are needed in each risk management area (RMA) for this purpose*. In most cases, the yard itself will be the RMA; however, there can be more than one RMA in a yard and the need for this can be determined in the field. *Each RMA must have a statistically-based number of samples to allow for risk calculation for that RMA.*

Approach Steps for Each Yard

1. **Learn from Owner**. If possible, the owner should be approached and asked whether he has brought any fill material into the property, and what its depth is, and what its source was. Also, whether there has been construction or grading anywhere. *All information gleaned should be logged*.
2. **Reconnaissance.** A short reconnaissance of the yard should be performed. Driveways, depressions, differences in the color of soils, vegetation, staining, indications of fill, indications of renovations and house additions, etc. should be noted.
3. **Identify the Risk Management Area**. In yards without suspected or actual hot spots (e.g. imported contaminated material such as fill), an effort should be made to identify the area of the yard that covers where someone living at the address may routinely spend their time over the course of many years. In most cases, the samples will be taken throughout the active yard area. *If there are play areas for children*, ensure that these areas are adequately covered by samples. If necessary, increase the number of samples to ensure this coverage.
4. It may be appropriate to increase the density of samples somewhat in the areas most likely to be occupied by people over many years.
5. **Consider Whether to Split Risk Management Area**. If a yard is particularly large, it may be that more than one RMA should be calculated. For instance, the area around the house with a play area and fence may be far more likely to have human occupancy over the years than an area in the far

rear of the yard that is covered with briars and bushes. *Make sure that there are 10 samples taken in each area which may ultimately become a risk management area*. It may also be appropriate to split a risk management area if there is a localized hot spot in the yard (see below).

6. **Avoid Certain Materials**. Fresh potting soil or mulch in flower beds, gravel, locations under concrete, sand bedding under driveways, or soils immediately adjacent to a house foundation probably should in most cases be avoided as sample targets as they may be biased low. Native soil below potting soil or gravel may be appropriate as a target, especially if the cover could be easily removed.
7. **Check Visually for Tailings**. Prior to laying out sample locations, an examination should be made for any material that has a yellowish or orangish cast as this may contain tailings (although many native soils do display high iron content and can mimic tailings appearance). If this material is identified, it should be investigated by digging carefully into it to see whether further tailings become more apparent. At least one deeper sample should be collected in any such material as well as at least one surface sample initially.
8. **Check for Suspected Hot Spots**. A hot spot means a location where imported contaminated material may have been placed. A suspected hot spot should be identified if:
    a. There is bright yellowish or orangish material, or a fine, flat silvery gray material, --either with a uniform particle size –or dark red/orange staining;
    b. A single sample point exceeds 200 mg/kg for arsenic or 400 mg/kg for lead;
    c. Direct information from an owner or neighbor suggests that affected fill or a former operation may be there.
9. At the location of a suspected hot spot, additional samples should be placed at somewhat higher density in the area of suspected hot spots to confirm whether they are actual hot spots; if high concentrations are repeated, the extent of the hot spot should be identified through a strategic spatial approach.
10. If the hot spot is relatively small with marked boundaries and does not cover much of the yard, it may be appropriate to consider it as its own risk management area, as otherwise it may skew the variability and data distribution that is used to calculate risk for the entire yard. *In such cases, make sure that there are at least 10 samples in the portion of the yard that is* **not** *within the hot spot*. This will allow the risk assessor to split the RMA later if it is appropriate.

Sampling, Logging

1. Part of every sample identifier will be a unique number that is specific to (can be cross-referenced one-to-one to) its GPS location. If more than one sample is collected from the same GPS location (such as at a different depth) then it should be identified by the same number with a dash or decimal extension, or similar approach. For example, sample 433.1 and 433.2 would be at the same GPS location but at different depths. A consistent approach to numbering should be taken throughout the program.
2. Calibrated GPS coordinates will be read and recorded for every sample location.
3. Unless otherwise specified, surface samples shall be collected from the top 2 inches of soil. If there is gravel, peat, cover bark, needles, detritus, sticks, or some other such material on top of where a sample must be collected, the top 2 inches of actual *soil* will be targeted.

4. When samples are collected targeting depths greater than 2 inches, a consistent method will be used to prevent surface cross-contamination into the hole. This may involve a coring device. ***If*** a shovel is used:
    a. The shovel should be slowly and carefully advanced slightly below to the desired sampling depth. As much surface soil should be removed from the hole as practicable.
    b. The shovel should then be advanced in a downward slicing motion *along one side of the hole and not lifted back up* such that the shovel is still in the hole, and native material at the desired depth is exposed at the bottom of the hole on one side of the shovel blade.
    c. If any surface material falls into the hole, the shovel should be lifted very slightly, placed *over and in front of* the surface material (the surface material will be behind the shovel compared to the material to be sampled) and then placed back down so that again the material at the desired depth is exposed and adjacent to the shovel.
    d. While keeping the tip of the shovel fixed in position at the bottom of the hole, the shovel head should then be tilted back away from the exposed face to make room for a sampling scoop.
    e. The sampling scoop should be decontaminated if used in prior holes. This can be accomplished by wiping with a cloth soaked in distilled water and then dried.
    f. The scoop should then be used to scrape material off the side of hole at the desired depth. It should be transferred directly into a strong zip-lock baggie or jar. If some material falls into the hole, as long it is on top of the shovel blade, it can be retrieved. The baggie or jar should be immediately sealed.
    g. The hole should be refilled with the removed soil and any sod, cover, or plant material put back in place.
5. Care should be taken not to include stones, rocks, sticks, leaves or large colloids in samples.
6. Each baggie shall be labeled, at a minimum, with the sample number, yard number, address if available, date, time, and sampling team.
7. A separate field log with observations and notations for all samples (standard ERT software acceptable)

Sample Preparation and Analysis

1. All baggies shall be evaluated by XRF in the field for metals.
2. 20% of baggies will be analyzed by the laboratory for metals.
3. Ideally, 100% of baggies will be shipped to storage during/or at the conclusion of the study. The availability of this needs to be checked and discussed.
4. The XRF will be calibrated against standards for all metals of interest according to appropriate SOPs.
5. Each baggie will be prepared prior to XRF analysis to homogenize the sample.
    a. The sample will be thoroughly shaken/mixed back and forth while in the baggie for 15-30 seconds.

b. The baggie will be squeezed repeatedly between thumb and forefinger to break up any colloidal or semi-condolidated materials. Clays will be crushed, smeared, crumbled, and tumbled again within the bag to achieve as much mixing as is practicable.

6. Each baggie will be analyzed twice by the XRF. An “A” reading and a “B” reading for each sample ID will be recorded into the database and field notes. Each “shot”, or analysis, will be taken from a different side or end of the bag.

7. The baggie will be pressed firmly and flat against the XRF window, completely covering the window, and held stationary during the entire analysis time.

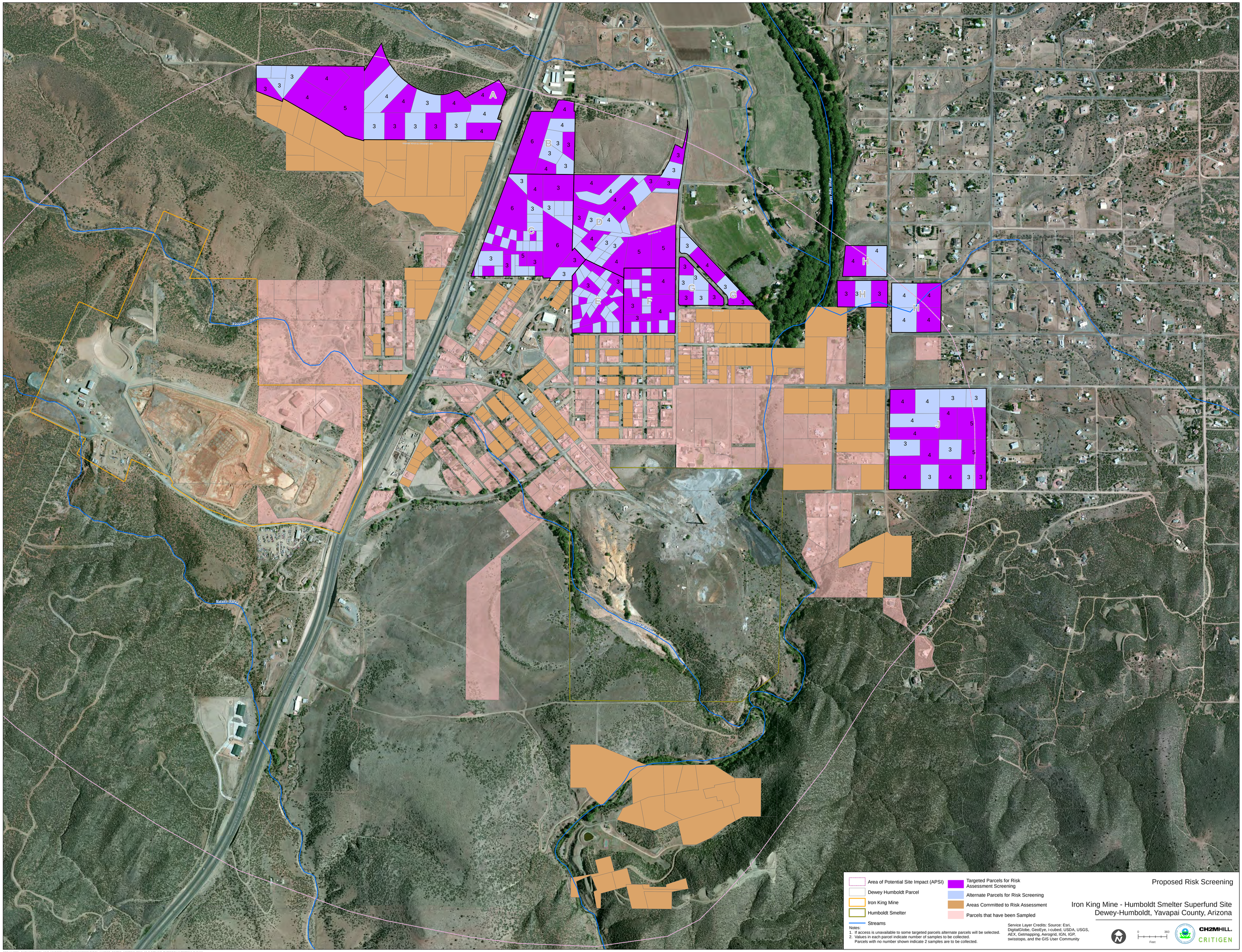
Table 1- Previously Sampled Yards larger than 0.75 acres

Parcel ID	Acreage
O02	39.8
OFS264	22.72
OFS252	20.72
OFS167	8.74
OFS221	8.09
OFS105	7.36
OFS107	6.59
OFS250	5.41
OFS203	4.77
OFS237	4.46
OFS259	4.37
OFS191	3.4
OFS106	3.01
OFS266	2.76
OFS128	2.6
O19	2.6
OFS170	2.51
OFS126	2.49
OFS183	2.28
OFS253	2.19
OFS268	2.19
OFS160	2.1
OFS215	2.1
OFS242	2.06
OFS255	2.04
OFS200	2
OFS108	1.99
OFS185	1.94
OFS115	1.84
OFS109	1.77
OFS199	1.75
OFS150	1.68
OFS201	1.61
O07	1.49
OFS138	1.47
OFS224	1.43
OFS254	1.41

Parcel ID	Acreage
OFS225	1.36
OFS121	1.27
OFS261	1.19
OFS214	1.12
OFS125	0.95
OFS257	0.93
OFS226	0.92
OFS134	0.88
O08	0.88
OFS206	0.87
OFS260	0.86
OFSO16	0.86
OFS190	0.84
OFS123	0.81
OFS202	0.81
OFS154	0.77
OFS157	0.76

Table 2 – Previously Sampled Yards with Erroneous Sample Locations and Elevated UCLs

Yard ID	UCL	
	As	Pb
O11	45.94	882.9
OFS120	20.52	18100
OFS127	313	327.7
OFS128	633	397.9
OFS133	368.2	1655
OFS142	331	506.9
OFS147	155.3	126
OFS148	133.1	692.9
OFS162	101.5	668.5
OFS164	99.2	491.3
OFS181	69.85	503.8
OFS182	47.26	588.9
OFS208	817	576
OFS215	207.7	218.5
OFS222	85.53	9150
OFS223	253.1	296.2
OFS227	667	535
OFS230	54.93	1060
OFS233	51.92	416.8
OFS244	339	25.55
OFS264	417.9	255.7



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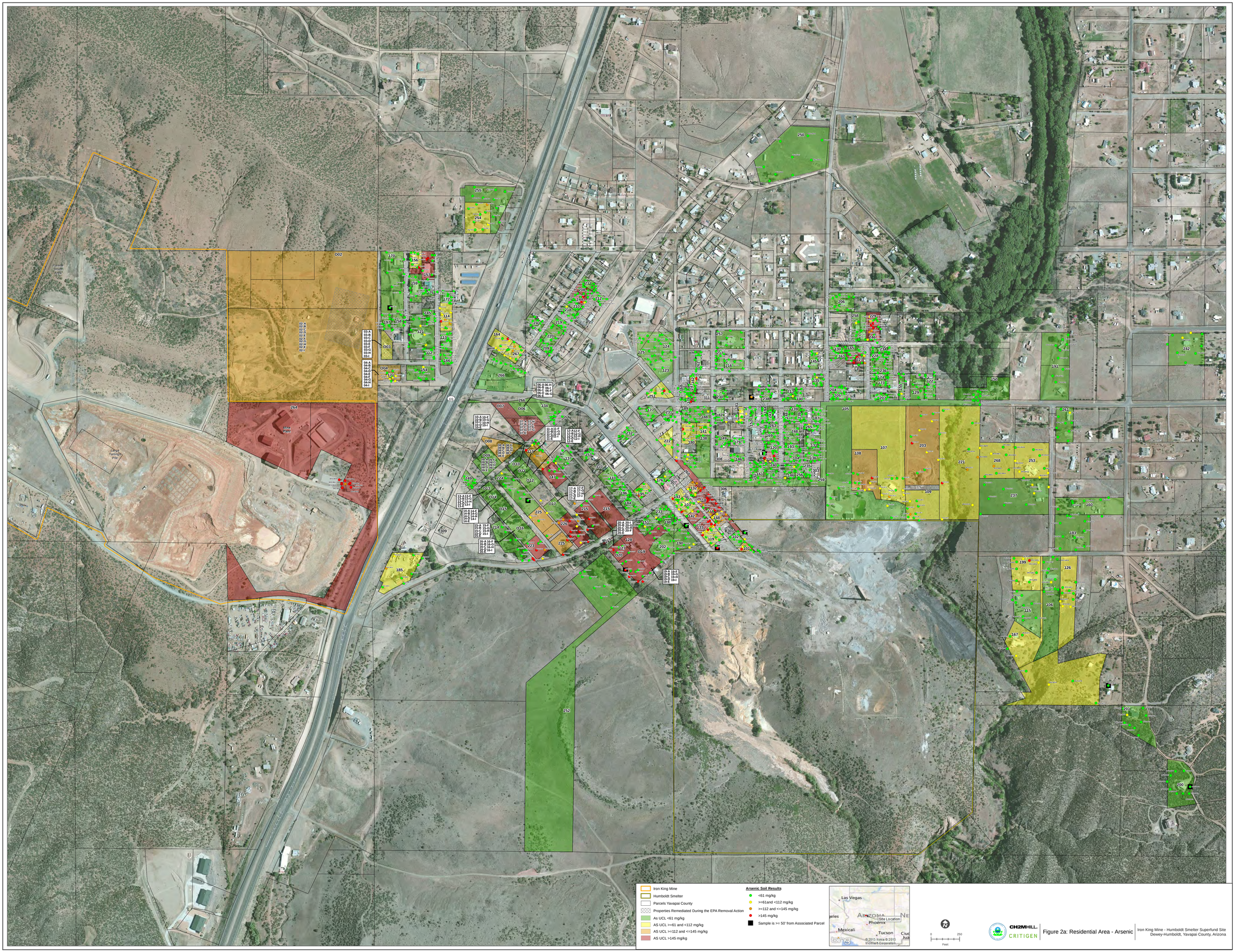

Figure 2a: Residential Area - Arsenic

Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

Former Drum Area

Large Tailings Pile

Mine Plant

Iron King Mine
Humboldt Smelter
Parcels Yavapai County
Properties Remediated During the EPA Removal Action
PB UCL < 35 mg/kg
PB UCL >=35 and <150 mg/kg
PB UCL >=150 and <400 mg/kg
PB UCL >400 mg/kg

Lead Soil Results
- < 35 mg/kg
- >=35 and <150 mg/kg
- >=150 and <400 mg/kg
- >=400 mg/kg
- Sample is >= 50' from Associated Parcel

Las Vegas
Phoenix
Tucson
Mexicali
Site Location
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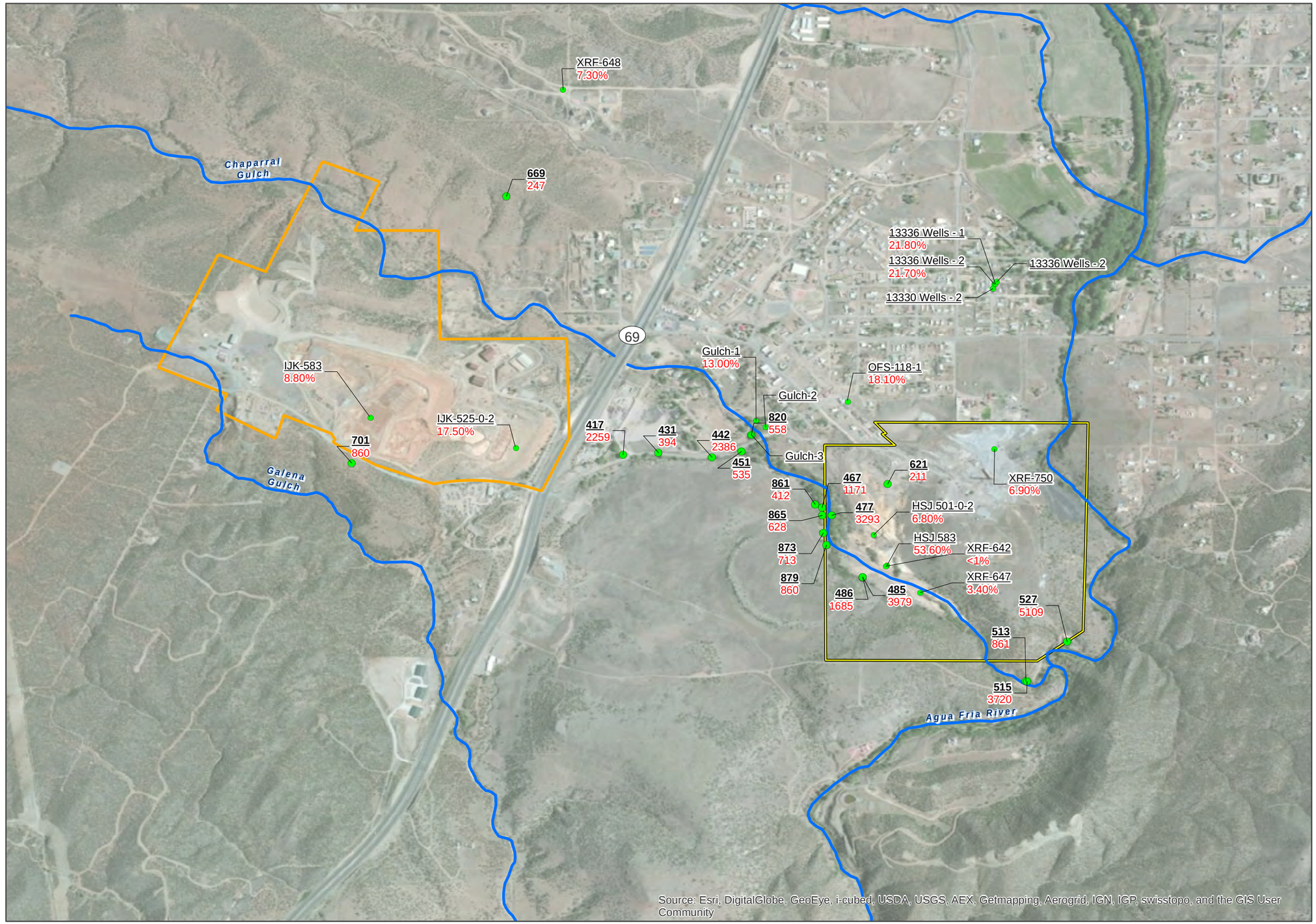
0 250
Feet

CH2MHILL. CRITIGEN

Figure 2b: Residential Area - Lead

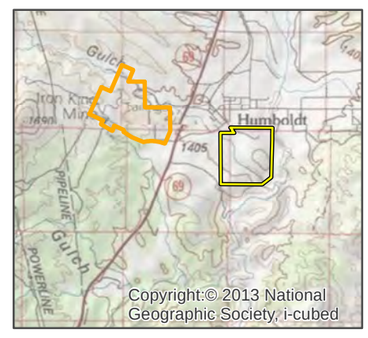
Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona



Iron King Mine
Humboldt Smelter
Streams
Sample Locations

N

0 1,200
Feet



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2013 Sample Locations - Arsenic

Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

BAO CAKEBREAD V:\USEPA_RACII\460650IRON_KING_MINE\GIS\MAPFILES\2013\MISC\SAMPLE LOCATIONS_BIOACCESIBILITY.MXD NBROWN11 11/26/2013 10:47:58 AM