TECHNICAL MEMORANDUM

Update on Corrective Measures Study Activities at the Former ASARCO East Helena Facility

PREPARED FOR: U.S. Environmental Protection Agency

Montana Environmental Trust Group, LLC, Trustee of the Montana Environmental Custodial Trust

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The Montana Environmental Trust Group, LLC, Trustee of the Montana Environmental Custodial Trust (Custodial Trust), submits this technical memorandum (TM) to satisfy the conditions cited in the U.S. Environmental Protection Agency (USEPA) conditional approval letter dated August 28, 2015, for the *Final Former ASARCO East Helena Facility Corrective Measures Study Work Plan* (Final CMS WP; CH2M HILL, 2015). Specifically, Condition 4 of the approval letter requests that a TM be prepared to provide an update on the results of key Corrective Measures Study (CMS) evaluations conducted in 2014 and 2015 at the former Smelter site (Facility). Condition 4 requests the following information:

- Summary of remedy evaluations
- Summary of source area investigations (SAIs)
- Summary of groundwater modeling
- Updates to Figure 6-1, Organizational Chart

In accordance with Condition 4, this TM summarizes the results of the remedy evaluations, SAIs, and groundwater modeling used during CMS implementation to guide decision processes for ongoing interim measures (IMs) design and construction and to support the development of recommendations for the final remedy at the Facility. The scope and results of key CMS evaluations are summarized in this TM, and will be documented more fully in a CMS Report, in accordance with the First Modification (Dreher et al., 2012).

Section 1.0 of this TM provides an overview of the CMS process and describes how the ongoing SAIs, evaluations, and associated modeling, together with the current IMs construction, are consistent with that process (Figure 1). Section 2.0 describes the key remedy screening and subsequent remedy evaluation phases. Section 3.0 describes the SAIs. Section 4.0 describes the groundwater modeling that supports remedy evaluation, and Section 5.0 lists the references cited in text. An updated version of Figure 6-1, Organizational Chart, is provided in the attachment.

1.0 Overview of Corrective Measures Study Process

As stated in the First Modification, "…the primary purpose of a CMS is to investigate and evaluate potential alternative remedies to protect human health and the environment from the release or potential release of hazardous waste or hazardous constituents from the Facility…" The Final CMS WP identifies the primary CMS goals as follows:

- Meet requirements of the First Modification to the 1998 Resource Conservation and Recovery Act (RCRA) Consent Decree (Dreher et al., 2012) and all other applicable regulatory and USEPA guidance, including an evaluation of each action, or combination of actions, following the factors set forth in the *Advanced Notice of Proposed Rule-Making* (USEPA, 1996).

- Analyze potential actions with consideration of known risks to actual or potential receptors.
- Include in the evaluation potential actions that will create the greatest net environmental benefit and which are compatible with expected future use, considering the finite Custodial Trust funds.

The Final CMS WP also documents the preliminary conceptual site models (CSMs) for the former ASARCO properties, including the Facility and parcels surrounding the former Smelter site. The preliminary CSMs comprised the first step in identifying and integrating existing contaminant fate and transport information about the CMS properties.

1.1 Initial Interrelated Interim Measures

As part of the CMS process described in the Final CMS WP, three interrelated, ongoing IMs were identified—Source Removal, South Plant Hydraulic Control (SPHC), and Evapotranspiration (ET) Cover System. These IMs were first documented in the *Former ASARCO East Helena Facility Interim Measures Work Plan–Conceptual Overview of Proposed Interim Measures and Details of 2012 Activities* (CH2M HILL, 2012) approved by USEPA on August 28, 2012. The IMs were designed as interrelated corrective measures that work together to eliminate the potential for human and ecological receptors, prevent stormwater and groundwater from direct contact with onsite surface soils containing high concentrations of inorganic contaminants, and significantly reduce the mobilization of contaminant mass across the former Smelter site.

The three interrelated IMs are summarized as follows:

- **Source Removal IM**. The removal of contaminated soil from the Tito Park Area (TPA) was completed as part of the Source Removal IM in 2014. A second removal action is planned for 2016, to remove approximately 14,000 cubic yards of contaminated soil beneath the former Acid Plant Area. The soil is contaminated with arsenic and selenium at concentrations exceeding respective USEPA industrial soil regional screening levels and present an ongoing source of contamination to groundwater.
- **SPHC IM**. The SPHC IM is designed primarily to lower groundwater levels at the south end of the former Smelter site, taking over 1,000,000 tons of contaminated soil out of direct contact with groundwater and reducing contaminant mass loading to groundwater by an estimated 40 to 80 percent (depending on constituent). Construction of the SPHC IM started in 2011 with the dewatering of Upper Lake. Construction of the Prickly Pear Creek (PPC) Bypass was completed in October 2013 and the realignment of PPC started in 2015.
- **ET Cover System IM**. Implementation of the ET Cover System IM started in 2014 with construction of the Interim Cover System 1 (ICS 1) to protectively manage contaminated soils excavated from the TPA (as part of the Source Removal IM) within the USEPA-approved Area of Contamination. The ICS 1 formed the foundation for the western portion of the ET Cover, and the final layers of the ET Cover were placed in this area in 2015. Construction of the ET Cover System IM will continue in 2016 to manage contaminated soils excavated as part of the PPC realignment. Completion is scheduled for late 2016.

The performance of the interrelated IMs is evaluated by the ongoing Corrective Action Monitoring Program. Since 2012, the Custodial Trust has collected groundwater elevation and quality data to assess IM effectiveness. These data continue to be collected and are also used to inform the ongoing evaluations and modeling efforts conducted as part of the CMS.

1.2 Ongoing Remedy Evaluations

During the construction of the interrelated IMs, CMS evaluations are continuing at areas identified as remaining source areas (i.e., those areas with the highest potential for unacceptable risk; Figure 2). Key uncertainties in each preliminary CSM for these areas were noted in the Final CMS WP and used to inform the remedy evaluations, SAIs, and modeling described in this TM. By addressing these areas, contaminant exposure and migration pathways will be controlled or significantly reduced. The results of the remedy evaluations, SAIs, and groundwater modeling will be used to support the Custodial Trust's proposal for final corrective measures at the Facility. As described in Sections VI and X of the First Modification, this information will be presented in the CMS Report and submitted to USEPA for review and approval.

2.0 Remedy Evaluations

CMS remedy evaluations started in 2011 and included preliminary evaluations of the potential for lowering groundwater elevations at the south end of the former Smelter site by implementing the Upper Lake Drawdown test and concurrent groundwater monitoring. The remedy evaluation results were used to develop and propose the initial interrelated IMs. CMS evaluations continued in 2012 and 2013 with source area evaluations and modeling using Mining Visualization System software. In 2014 and 2015, CMS evaluations described in this TM were conducted to assess the potential effects of source area corrective measures on downgradient groundwater quality and evaluate their feasibility, including estimates of the associated implementation costs. A phased approach was used for the 2014 and 2015 CMS evaluations described in the following sections.

2.1 Phase 1 Remedy Screening Evaluation

The first phase of the remedy screening evaluation focused on screening potential alternatives. The objective was to identify and screen corrective measures and groundwater remedies most applicable to the remaining source areas at the Facility. Potential remedies were screened following USEPA RCRA corrective action guidance (USEPA, 1994; USEPA, 2000). The screening process considered information gathered on the performance of the ongoing interrelated IMs. Institutional controls and long-term monitored natural attenuation were considered, as well.

Existing information was reviewed to determine which known source areas were expected to have the most significant effect on groundwater quality, and to identify the potential remedies and technologies that might be suitable for those source areas. As a result, 4 areas and 17 remedial alternatives were identified for the screening evaluation (Table 1). Specific alternative evaluations for the former Acid Plant and Slag Pile were deferred. The remedial alternatives were screened using RCRA corrective action evaluation criteria: effectiveness, implementability, and cost. The following three areas were determined to be the primary sources of contamination to groundwater:

- West Selenium source area
- North Plant Arsenic source area
- Former Speiss-Dross source area

Remedies for the on- and offsite focus areas where site-related contaminants of concern have been identified at concentrations exceeding USEPA maximum contaminant levels (MCLs), referred to as the Affected Groundwater Area, were also considered in the screening evaluation. Preliminary results from the 2014 SAI data (Section 3.1) were used to establish an understanding of primary source areas/dimensions, depth to key subsurface features, groundwater quality, and geochemistry in the Affected Groundwater Area.

Four alternatives were considered for the West Selenium source area. All four alternatives were retained for further evaluation (Table 1). Source removal was recommended for further study using groundwater modeling (see Section 4); the remaining alternatives were evaluated during the second phase, as described in Section 2.2.

Five alternatives were considered for the North Plant Arsenic source area. Of those five alternatives, only three were retained for further evaluation (Table 1), as described in Section 2.2.

None of the four alternatives for the former Speiss-Dross source area, other than construction of the interrelated IMs, was recommended (Table 1). In particular, source removal was not justified because of the effectiveness of the existing slurry wall.

Remedial alternatives considered for the Affected Groundwater Area included a baseline condition consisting of the ongoing interrelated IMs, implementation of the proposed controlled groundwater area, and monitored natural attenuation (Table 1). The baseline condition alternatives were included for comparison as they were assumed to be implemented regardless of additional groundwater remedy alternatives. Because the offsite arsenic and selenium plumes extended nearly 0.5 and 2 miles, respectively, evaluated options were not cost effective. The remedy screening evaluation concluded that focusing on control of the remaining source areas responsible for generating the groundwater plumes could provide more effective long-term control.

The Phase 1 screening evaluation recommendations, along with preliminary results of the 2014 SAI, were used to guide the recommendations for the Phase 2 remedy screening evaluations presented in Section 2.2.

2.2 Phase 2 Remedy Screening Evaluation

The first phase of remedy screening recommended further evaluation of four corrective measures (remedies) at the West Selenium source area and three corrective measures at the North Plant Arsenic source area (Table 1). The second phase of evaluations was initiated in December 2014 and included a more detailed preliminary design and costing approach (actual rough order of magnitude Class 4 Estimates [Association for the Advancement of Cost Engineering, 2005]) and effectiveness evaluation performed on the selected remedies (Table 2). An individual evaluation of each remedy for the two source areas was completed using evaluation logic based on guidance from USEPA (USEPA, 1994; USEPA, 2000) and seven balancing evaluation criteria:

- Long-term Effectiveness and Permanence
- Toxicity, Mobility, and Volume Reduction
- Short-term Effectiveness
- Implementability
- Cost
- Community Acceptance
- State Acceptance

The first five criteria are technical in focus and were used in the evaluation. The last two criteria are nontechnical and intended for consideration based on beneficiary and community input on future CMS reporting, and from beneficiary technical meetings and public meetings supporting the CMS remedy implementation process. The alternatives for each source area were evaluated in comparison to each other using a ranking system developed around the five technical evaluation criteria. The results are summarized in Table 2.

The results of the second phase of evaluations identified preferred remedy alternatives (highest ranked with respect to the criteria noted above) and provided recommendations for additional field data needed to support the selection of remedies for the West Selenium and North Plant Arsenic source areas. As shown in Table 2, additional data and further modeling were recommended to assess whether source removal or a slurry wall could be recommended at the West Selenium source area and whether a slurry wall could be recommended at the North Plant Arsenic source area. Additional soil borings and testing for total and leachable metals concentration were proposed to support or verify the potential alternatives for each source area. The additional information, collected as part of the 2015 SAI (described in Section 3.2), was used to assist in refining the transient groundwater flow simulations, calibrating the model, and reducing uncertainty in model predictions.

3.0 Source Area Investigations

Supplemental soil and groundwater quality data were collected in 2014 and 2015 from the remaining source areas to refine the overall understanding of conditions and the CSM in support of ongoing CMS evaluations. These SAIs were conducted based on data needs identified during the remedy evaluations (described in Section 2.0) and ongoing groundwater monitoring and modeling results.

3.1 2014 Source Area Investigation

The 2014 SAI was conducted to further characterize the occurrence and distribution of contaminants in the West Selenium and North Plant Arsenic source areas (Figure 2), support ongoing development of the groundwater flow and contaminant transport model, and evaluate groundwater remedies. A total of eight soil borings were completed within these areas as shown in Figure 3. Two of the borings in the West Selenium source area were completed as monitoring wells (Figure 3).

West Selenium Source Area. In the West Selenium source area, six soil borings (Figure 3) were completed during the SAI and 33 soil samples were collected and analyzed, as summarized in Table 3. The results indicate the following:

- The estimated areal extent of source material ranges from about 0.25 to 0.75 acre, with a vertical saturated thickness of about 3 to 7 feet, and a depth below ground surface of 40 to 45 feet.
- Total metals concentrations indicate selenium and cadmium are enriched relative to background.
- Elevated cadmium concentrations at borings EHSB-1, EHSB-6, and EHSB-7 (Figure 3) are a signature of the former Acid Plant process water circuit, indicating that the area is recharged by groundwater from the former Acid Plant Area (consistent with current and historical potentiometric data).
- Leachability tests showed that the highest leachate concentrations of selenium (up to 33 milligrams per liter [mg/L]) were derived from unsaturated zone soils; however, the apparent lack of infiltration in this area (due to the former asphalt/concrete cover and the current Interim Cover of the ET Cover System) suggests that unsaturated zone soils are not a significant current source of selenium loading to groundwater.
- Saturated zone soils generated leachate concentrations up to 9.3 mg/L; these concentrations and the relatively high leachability for selenium (25 to 44 percent of the total selenium mass in the samples was removed via leaching) indicates that the saturated soils are most likely the source of current selenium loading to groundwater.
- Total and leachable arsenic concentrations in the source area soil samples are low, suggesting a limited potential for remobilization of arsenic from soils under changing redox conditions in groundwater.

North Plant Arsenic Source Area. In the North Plant Arsenic source area, two soil borings were completed for this SAI as shown in Figure 3, and nine samples were collected and analyzed as summarized in Table 3. The results of the 2014 SAI and previous investigations indicate the following:

- The active source area may be up to 450 feet or more in length (north-south along the arsenic groundwater plume axis) and 150 to 250 feet in width, with the extent defined by groundwater geochemical conditions as well as soil arsenic concentrations.
- Saturated thickness ranges from 10 to 15 feet with the depth to groundwater at 30 to 35 feet.
- Based on total metals testing, arsenic and zinc are enriched in the North Plant Arsenic source area soils.
- Leachability testing showed that the unsaturated zone soils are not believed to be a current significant source of arsenic loading to groundwater; however, saturated zone soils are capable of

generating leachate concentrations similar to local groundwater concentrations and are likely the source of the arsenic plume.

- Total arsenic concentrations in saturated soils were lower in 2014 compared to samples collected in adjacent borings in 1986, possibly indicating release of arsenic from saturated zone soils over time and supporting the conclusion that saturated zone soils are an ongoing source of arsenic loading to groundwater.
- The combined selenium leaching results from 2014 SAI borings EHSB-8, EHSB-9, and similar information collected during the Phase II RCRA Facility Investigation (Phase II RFI; GSI Water Solutions, Inc., 2014), indicate that selenium remobilization under changing geochemical conditions is possible in this source area, and will be considered when evaluating potential groundwater remedies.

The data collected during the 2014 SAI resulted in estimates of West Selenium and North Plant Arsenic source area dimensions (as described above) and an improved understanding of the current relationship between leachable arsenic and selenium in soils and the groundwater plumes; however, the data collected did not fully define a potential localized high concentration soil source in the West Selenium Area, or the potential northward extent of the North Plant Arsenic area. Therefore, the 2014 SAI Report noted that additional investigation would be needed in both the West Selenium and North Plant Arsenic source areas before selection, design, and implementation of any potential groundwater remedies.

The highest total metals concentrations at soil borings in both the West Selenium and North Plant Arsenic source areas were encountered in unsaturated soils within 1 or 2 feet above the current water table. Although currently above the saturated zone, these soils would have been within the saturated zone and therefore in direct contact with groundwater, contributing to contaminant loading before the November 2011 initiation of the SPHC IM. This confirms that the SPHC IM has removed some of the high contaminant concentration soils from contact with groundwater. The potential effects of these recent hydrologic changes on local groundwater quality will take time to be fully realized, and will continue to be monitored to measure the performance of the IMs.

3.2 2015 Source Area Investigation

In order to complete CMS evaluations for the West Selenium, North Plant Arsenic, former Acid Plant, and Speiss-Dross (Figure 2) source areas, a 2015 SAI was implemented, including sampling and analysis of soil and groundwater from each area as summarized in Table 4. In addition, one pumping test was conducted at the Speiss-Dross source area to evaluate the integrity of the Speiss-Dross slurry wall. Boring locations for each source area were selected based on the 2014 SAI results, monitoring well network data, Phase II RFI data, and observed distribution of arsenic and selenium (October 2014) in groundwater.

West Selenium Source Area. In the West Selenium source area, seven borings were drilled in 2015 as shown in Figure 4, with two of the borings completed as monitoring wells. Leach testing of 2015 West Selenium source area soil samples showed results consistent with the 2014 SAI results, indicating that selenium in the area is highly leachable in both unsaturated and saturated soils. Based on both the 2014 and 2015 SAI results, soils generating the highest leachate selenium concentrations are located near well DH-8 (Figure 4). Results of the investigation indicated the following:

- The estimated selenium mass in the unsaturated zone is approximately three to seven times higher than in the saturated zone; however, there is no identified mechanism for transport of this mass to groundwater.
- Saturated zone soils appear to be the primary contributor of selenium loading to groundwater; however:

  - There is not sufficient mass within the saturated zone soils to fully account for the nature and extent of the downgradient selenium plume.
  - The area of saturated zone soils is limited in lateral extent based on both groundwater plume geometry and soil analytical results for total and leachable selenium.
- Groundwater levels and selenium concentrations are currently decreasing, based on trends observed throughout 2015. Given the limited total selenium mass present and the observed highly leachable nature of the total selenium, the groundwater trends suggest that the saturated zone source contributing to the plume may be decreasing over time.

North Plant Arsenic Source Area. The North Plant Arsenic 2015 SAI consisted of two soil borings completed within the City of East Helena, in the area historically impacted by the groundwater arsenic plume, as shown in Figure 5. Samples were analyzed as summarized in Table 4. Laboratory testing was designed to estimate remaining arsenic adsorptive capacity and evaluate groundwater model assumptions regarding the effect of a potential remedial action on the downgradient arsenic plume. Batch adsorption tests were conducted on soils with varying total arsenic concentrations using site groundwater with different dissolved concentrations, to investigate arsenic adsorption under a variety of conditions. The data indicate the following:

- Arsenic partitioning to soils from groundwater (adsorption or coprecipitation) has occurred as total soil arsenic concentrations have generally increased since the mid-1980s. Total arsenic concentrations remain lower downgradient of the source area than typical upgradient soils, suggesting additional adsorption capacity may exist in this area.
- Total metals analysis indicated that all selenium and cadmium concentrations were below detection limits.
- Batch adsorption testing showed that downgradient soil samples adsorbed arsenic, with most data showing good fits to Langmuir-type adsorption isotherms, similar to previous adsorption data collected from both on- and off-plant areas. Arsenic adsorption constants derived from these isotherms confirmed values used in the groundwater fate and transport model for the Facility.

As described further in Section 4.0 (Groundwater Modeling), these data are used in ongoing predictive groundwater modeling designed to assess the potential benefits of a remedial action in this area.

Former Acid Plant Source Area. The former Acid Plant 2015 SAI consisted of four soil borings with two of the borings completed as monitoring wells as shown in Figure 6. Results of the investigation indicate the following:

- Groundwater in the area is encountered approximately 20 feet below ground surface, generally 5 feet lower than groundwater levels measured prior to implementation of the SPHC IM.
- Results were consistent with previous investigations, showing total arsenic, cadmium, and selenium concentrations in soil above background concentrations as a result of historical plant activities. Average total arsenic, cadmium, and selenium concentrations were the highest of any of the four source areas evaluated in 2015.
- The leachability study indicated that cadmium in soils in this area is highly leachable, with total concentrations up to 857 milligrams per kilogram (mg/kg) in saturated soil, average leachate concentrations of 19.3 mg/L, and maximum leachate concentrations of 120 mg/L. Groundwater cadmium concentrations of 2 to 4 mg/L are observed in some wells indicating leaching of cadmium to groundwater.
- Groundwater arsenic concentrations were observed to increase through the former Acid Plant settling pond, with no apparent arsenic groundwater concentration increase beneath the High Density Sludge water treatment building immediately north of the former settling pond (Figure 6).

Upgradient of the former settling pond and equipment wash building, arsenic concentrations are about 5 mg/L. Concentrations increase to about 15 mg/L as groundwater migrates through the former settling pond area.

On the basis of the information indicating the accessibility of the source mass in the settling pond area, potential for ongoing arsenic and cadmium loading, and potential future selenium loading if groundwater geochemical conditions change in the future, a soil removal action in this area is proposed as an IM before completion of the ET Cover System IM. Additional details of the proposed source removal are presented in the final *Addendum to Former ASARCO East Helena Facility Interim Measures Work Plan—2015 and 2016* (CH2M HILL, 2016). The addendum is scheduled for completion in the first quarter of 2016.

Speiss-Dross Source Area. The Speiss-Dross 2015 SAI consisted of two soil borings (Figure 6), completion of one soil boring as a monitoring well, and a pump test. Soil samples were analyzed as summarized in Table 4. Key results of this SAI are as follows:

- Total arsenic and selenium concentrations in soil were similar to concentration ranges observed in 2014 North Plant Arsenic SAI samples (note that the North Plant Arsenic source area is located immediately downgradient of the Speiss-Dross area).
- Total cadmium concentrations in soil were low (fewer than 1 to 4 mg/kg) in the boring north of the slurry wall, but relatively high in the boring west of the slurry wall (in the former Speiss Handling area) at 2 to 780 mg/kg. Higher cadmium concentrations in the Speiss Handling area are likely due to historical groundwater flow from the former Acid Plant, as cadmium is an indicator of impacts from the former Acid Plant.
- Arsenic and cadmium concentrations in groundwater collected from a borehole west of the slurry wall (former Speiss Handling area) exceed respective MCLs, but are low compared to upgradient (former Acid Plant) concentrations, and downgradient concentrations (arsenic only); therefore, the former Speiss Handling area does not appear to be a significant source of arsenic loading to groundwater.
- Selenium leaching behavior in samples from the boring north of the slurry wall were consistent with historical results, showing that, although current groundwater selenium concentrations are low in this area (likely due to reducing geochemical conditions), leachable selenium is present in saturated zone soils, and the potential exists for selenium remobilization if groundwater conditions become more oxidizing in the future.

Pump test results indicate relatively low hydraulic conductivity and transmissivity within the slurry wall. The low hydraulic conductivity limits flux of groundwater and contaminants. Although some flux and leakage through the wall is known to occur as evidenced by water level fluctuations of slurry wall wells, the potential impact from leakage on downgradient water levels and water quality appears to be minimal. These impacts are being further evaluated in 2016 through additional pump testing and contaminant transport modeling (described further in Section 4.0). A detailed summary of the 2015 SAI activities and results will be presented in the CMS Report.

4.0 Groundwater Modeling

Groundwater modeling supports the CMS remedy evaluations by predicting the effects of the IMs and select remedy alternatives. The modeling results have predicted how implementation of the IMs and potential corrective measures may change groundwater mass, plume concentrations, and plume extent. The modeling conducted since 2014 builds on previous modeling by AMEC in 2012 and by NewFields in 2013 and 2014.

4.1 Modeling Inputs

The computer codes used in the modeling include MODFLOW, MODPATH, and MT3D. MODFLOW is a three-dimensional, finite difference numerical model used to simulate groundwater flow conditions laterally and with movement between defined layers. MODPATH is used with MODFLOW to provide particle tracking and MT3D is used for simulating solute transport. The model domain consists of approximately 44 square miles, encompassing the Facility. The model is bounded to the south by the southern-most boundary of the Trust property along PPC), to the west by Tenmile Creek, to the east by the Spokane Bench Fault, and to the north by Lake Helena (Figure 7). Fate and transport modeling of two chemical parameters, selenium and arsenic, was conducted using solute transport simulations that account for advection, dispersion, and parameter-specific adsorption and retardation factors. The solute transport modeling used these criteria to approximate anticipated conditions and did not include more complex geochemical interactions such as redox, degradation, or biological activity.

The groundwater flow modeling and predictive fate and transport simulations (steady-state flow regime) for selenium and arsenic focused on West Selenium, North Plant Arsenic, former Acid Plant, and Speiss-Dross source areas based on historical process knowledge of source material generation, extensive site groundwater monitoring to date, and previous as well as ongoing evaluations of site conditions. The model inputs were refined with the SAI results. Transient flow conditions were used with the fate and transport model to help define the time frame for changes in groundwater concentrations based on the different remedy alternatives evaluated.

The groundwater modeling performed in 2012 and used for initial studies through 2014 employed an average, steady-state flow regime for fate and transport of arsenic and selenium in groundwater. Steady-state groundwater flow was used to evaluate the different remedy alternatives under the same flow conditions. The transient flow modeling conducted in 2015 was used to better evaluate the time required to reach the anticipated effectiveness (i.e., reduction in groundwater plume size or mass). Model sensitivity evaluations were performed by running scenarios on key modeling parameters to understand model variability and impacts to predicted plume mass and volume conditions. Modeling inputs for the following areas were used in the sensitivity evaluations for fate and transport modeling:

- West Selenium source area mass volume and loading conditions
- North Plant Arsenic source area hydraulic conductivity and source mass volume
- Downgradient offsite arsenic adsorption conditions
- Former Acid Plant source mass volume and groundwater conditions
- Source mass and hydraulic conditions in the Speiss-Dross slurry wall area

The Slag Pile source area will be further studied in upcoming evaluations.

4.2 Modeling of Selenium Remedy Alternatives

Fate and transport modeling of selenium was based on a revised CSM that was developed using the latest field data obtained during the 2014 and 2015 SAIs (described in Section 3.0) and groundwater monitoring through October 2015. The West Selenium source area groundwater was modeled using both finite and infinite source mass assumptions. Under a finite mass modeling scenario, as the plume develops and continues downstream, the source mass decreases. Under the infinite scenario, the plume generates and continues with no reduction in the source mass feeding the plume. The West Selenium source area was modeled under both scenarios as a sensitivity evaluation. Three predictive scenarios were modeled for the West Selenium source area: infinite mass under the controls of the ongoing IMs (SPHC and ET Cover System), finite mass under the ongoing IM controls, and a calibration comparison for an assumed 100 percent removal of West Selenium source area mass. The results for all three simulated scenarios show relative similar downgradient reductions in the selenium groundwater plume within approximately 3 years. These data indicate that reductions are due to the ongoing IMs with essentially no additional benefits observed from the implementation of additional remedies.

4.3 Modeling of Arsenic Remedy Alternatives

Fate and transport modeling of arsenic was conducted for three scenarios, One scenario was for the SPHC, ET Cover System, and TPA Source area removal IMs (ongoing IMs), and two scenarios were for the ongoing IMs with supplemental mass reduction from implementation of a remedy. One scenario assumed a 70 percent mass reduction from the former Acid Plant Area via excavation, and the other an additional 70 percent mass reduction from the North Plant Arsenic source area via containment. The results of the simulations were relatively similar to previously conducted prediction scenarios:

- The downgradient extent of the plume was not significantly reduced by implementing additional corrective measures.
- Mass reductions downgradient of the site (same size plume, but with lower concentrations) were relatively similar for the ongoing IMs as for additional source removal scenarios, with reductions predicted to occur within a relatively short 2- to 3-year time period.
- Predictive model results for the removal or containment of the North Plant Arsenic source area did indicate that the mass of arsenic would be reduced downgradient, but not at concentrations sufficient to reduce the plume size.
- Sensitivity modeling of offsite soil arsenic retardation capacity indicated that offsite mass reductions and plume size are relatively unaffected by changing offsite arsenic retardation assumptions (low or high).

The results of the modeling also provided information on estimated future groundwater concentrations and the estimated time to achieve them. Comparison of selenium predictive model results indicates that ongoing IMs prove effective under different CSMs, and should be observable within an approximate 3- to 5-year monitoring period upon completion of the ongoing IMs. Comparison of arsenic predictive model results confirm that although the remedy alternatives (in addition to ongoing IMs) will reduce offsite mass flux, they will have only minor impact on lowering offsite groundwater concentrations, and downgradient plume size will remain relatively constant over the 30-year simulation period.

5.0 References

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Tables

TABLE 1

Overview of Source Area Screening Evaluation

Update on Corrective Measures Study Activities at the Former ASARCO East Helena Facility

Remedy Screening Evaluation			
Source Area[1]	**Preliminary Alternative**	**Notes on Scoring**	**Recommended for Further Evaluation (Y/N)**
Affected Groundwater Area	Baseline action: includes planned IMs, CGWA, and MNA	Baseline action will be implemented regardless of recommendation of the evaluation. All other potential groundwater remedies and their associated costs are considered supplemental.	NA
	Pump and treat onsite and offsite groundwater	Not cost-effective.	N
	Pump and treat onsite groundwater	Not cost-effective.	N
	Pump and treat combined with slurry wall	Uncertain effects on downgradient plume stability and geometry and not cost effective.	N
West Selenium Area	Source Removal	Recommend using the groundwater flow model to determine effectiveness in comparison to other remedies. Moderate cost.	Y
	PRB, with funnel-and-gate system	Favorable effectiveness and implementability with low cost.	Y
	Slurry Wall (hydraulic enclosure of source area)	Slurry walls have been shown to be effective and appears to be cost-effective.	Y
	Focused pump and treat	Reasonably effective, and favorable implementability with potential for low cost.	Y
North Plant Site	Source Removal	Not cost-effective.	N
	PRB, with funnel-and-gate system	Effective, technology is readily available, reasonably cost-effective.	Y
	Slurry Wall (hydraulic enclosure of source area)	Slurry walls have been observed to be effective and appears to be cost-effective.	Y
	In-situ treatment (dosing of aquifer with Fe), to augment slurry wall	Can be effective if used in conjunction with slurry wall.	Y
	In-situ treatment (to augment slurry wall)	High costs and difficult to implement.	N
Former Speiss/Dross Area	No Further Action (includes existing slurry walls)	Already implemented, and is cost-effective.	NA
	Source Removal	Additional cost not justified when existing slurry wall appears generally to be effective.	N
	Expand slurry wall system to encompass former Speiss Storage and Handling Area	Technologies are available but high implementation factor due to technology being installed close to the Ore Storage Building.	N
	In-situ treatment (dosing of aquifer with Fe), to augment slurry wall	Would be effective with another technology such as a slurry wall, but not effective alone.	N

[1] Further investigation and evaluation of the former Acid Plant and Slag Pile areas was deferred.

Notes:

CBS = combined balancing score
CGWA = Controlled Groundwater Area
Fe = ferrous sulfate
IM = interim measure
NA = not applicable
O&M = operations and maintenance
PRB = permeable reactive barrier
Se = selenium

TABLE 2

Overview of Source Area Remedy Evaluations

Update on Corrective Measures Study Activities at the Former ASARCO East Helena Facility

		Phase II Remedy Evaluation	
Source Area	**Alternative - Carried Forward from Screening Evaluation**	**Notes on Scoring**	**Evaluation Results**
West Selenium Area	Source Removal	CBS of plus two (+2); would be more effective at reducing toxicity, mobility, or volume through treatment; with uncertainty of source capture and cost limiting the overall score.	Recommend supplemental data and additional modeling to support continued evaluation.
	PRB, with funnel-and-gate system	CBS of plus one (+1); a positive score for short-term effectiveness, but with lack of proven Se removal effectiveness and cost requirements for O&M limit the overall score.	Not evaluated further.
	Slurry Wall (hydraulic enclosure of source area)	Highest CBS of plus four (+4); long-term effectiveness and permanence, short-term effectiveness, implementability, and cost.	Recommend supplemental data and additional modeling to support continued evaluation.
	Focused pump and treat	Combined balancing score at neutral (0); negative scoring based on implementation with moderate cost effectiveness.	Not evaluated further.
North Plant Site	PRB, with funnel-and-gate system	CBS of negative one (-1); with positive score for short-term effectiveness, but negative scores on reduction in toxicity, mobility, or volume through treatment; the lack of significant contaminant mass and plume volume reduction and the cost limit the score.	Not evaluated further.
	Slurry Wall (hydraulic enclosure of source area)	CBS of plus two (+2); positive scores for short-term effectiveness and implementability; the lack of significant contaminant mass and plume volume reduction and contaminated groundwater that remains within the slurry wall long-term limits the score.	Recommend supplemental data and additional modeling to support continued evaluation.
	Slurry Wall Enclosure with In-situ treatment	CBS of plus three (+3); positive scores for reduction in toxicity, mobility, or volume through treatment, short-term effectiveness, and implementability. The remaining criteria were scored 0 (neutral).	To be considered based on evaluation results of previous alternative (Slurry Wall).

Notes:

CBS = combined balancing score

CGWA = Controlled Groundwater Area

Fe = ferrous sulfate

IM = interim measure

NA = not applicable

O&M = operations and maintenance

PRB = permeable reactive barrier

Se = selenium

TABLE 3

Overview of 2014 Source Area Investigation and Analyses Completed

Update on Corrective Measures Study Activities at the Former ASARCO East Helena Facility

Source Area	Number of Borings	Number of Wells Completed	Number of Soil Samples	Summary of Analyses
West Selenium	6	2	33	Soil leach testing Total metals (soil) Arsenic and selenium (groundwater) Mineralogical analysis
North Plant Arsenic	2	0	9	Soil leach testing Total metals (soil) Arsenic and selenium (groundwater) Mineralogical analysis

Note:

Leach Testing = synthetic precipitations leaching procedure and saturated paste analyses.

TABLE 4

Overview of 2015 Source Area Investigation and Analyses Completed

Update on Corrective Measures Study Activities at the Former ASARCO East Helena Facility

Source Area	Number of Borings	Number of Wells Completed	Number of Soil Samples	Summary of Analyses
West Selenium	7	2	43	Soil leach testing Total Metals (soil) Arsenic and selenium (groundwater)
North Plant Arsenic	2	0	16	Total metals (soil) Batch adsorption testing
Acid Plant	4	2	23	Soil leach testing Total metals (soil) Arsenic and selenium (groundwater)
Speiss-Dross Area	2	1	11	Soil leach testing Total metals (soil) Arsenic and selenium (groundwater)

Notes:

Leach Testing = synthetic precipitations leaching procedure and saturated paste analyses.

Intact Shelby tube soil cores were collected for potential geotechnical analysis at seven locations, as follows:

- Five locations in the West Selenium source area
- One location in the former Acid Plant source area
- One location in the Speiss-Dross source area

Figures

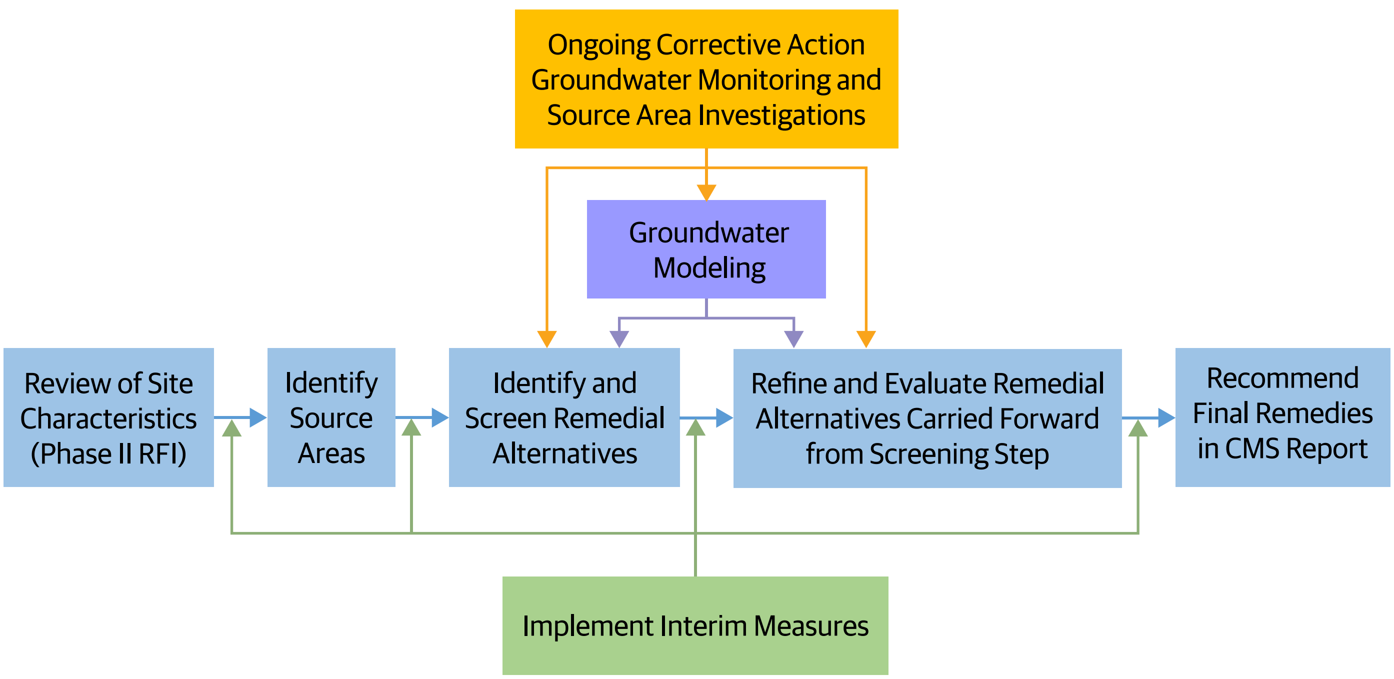

Figure 1
Corrective Measures Study Process Diagram
Update on Corrective Measures Study Activities
Former ASARCO East Helena Facility – East Helena, Montana

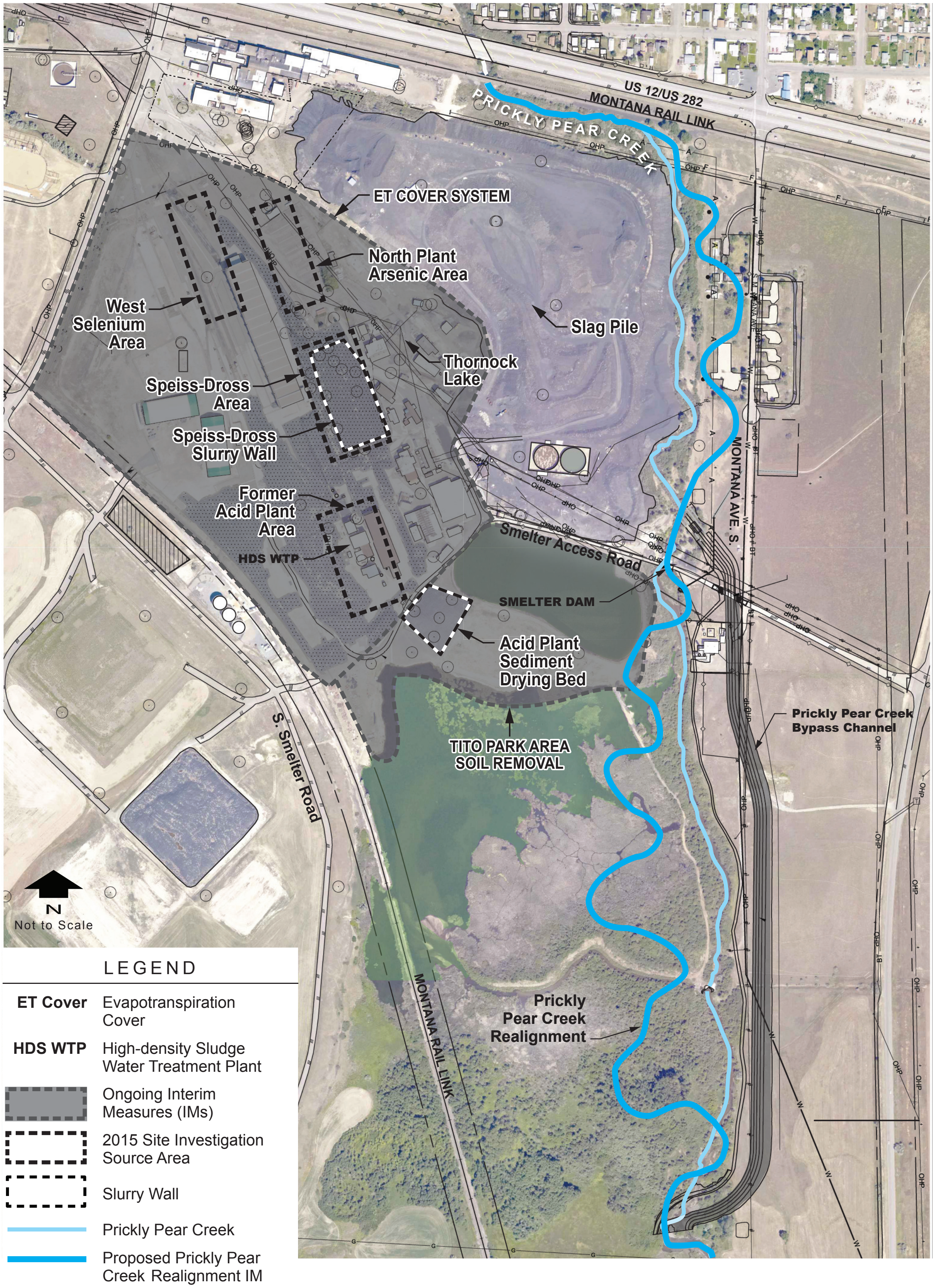

Figure 2
Sitewide Schematic with Interim Measures
Update on Corrective Measures Study Activities
Former ASARCO East Helena Facility – East Helena, Montana

ch2m

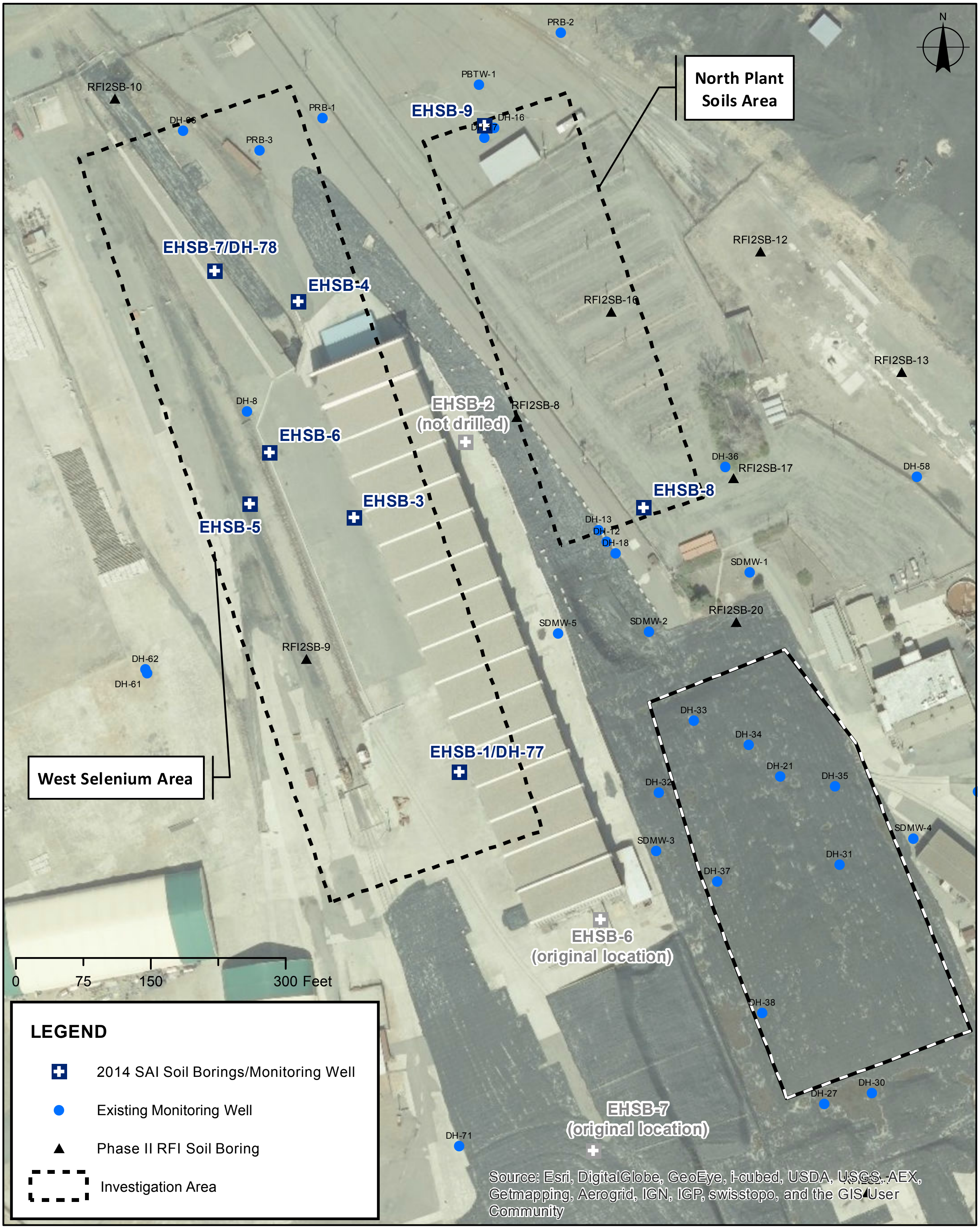

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Figure 3

2014 Soil Boring Locations – North Plant Soils Area and West Selenium Area

Update on Corrective Measures Study Activities

Former ASARCO East Helena Facility – East Helena, Montana

Hydrometrics, Inc
Consulting Scientists and Engineers

Note: This figure was prepared by Hydrometrics, Inc. in 2015.

ch2m

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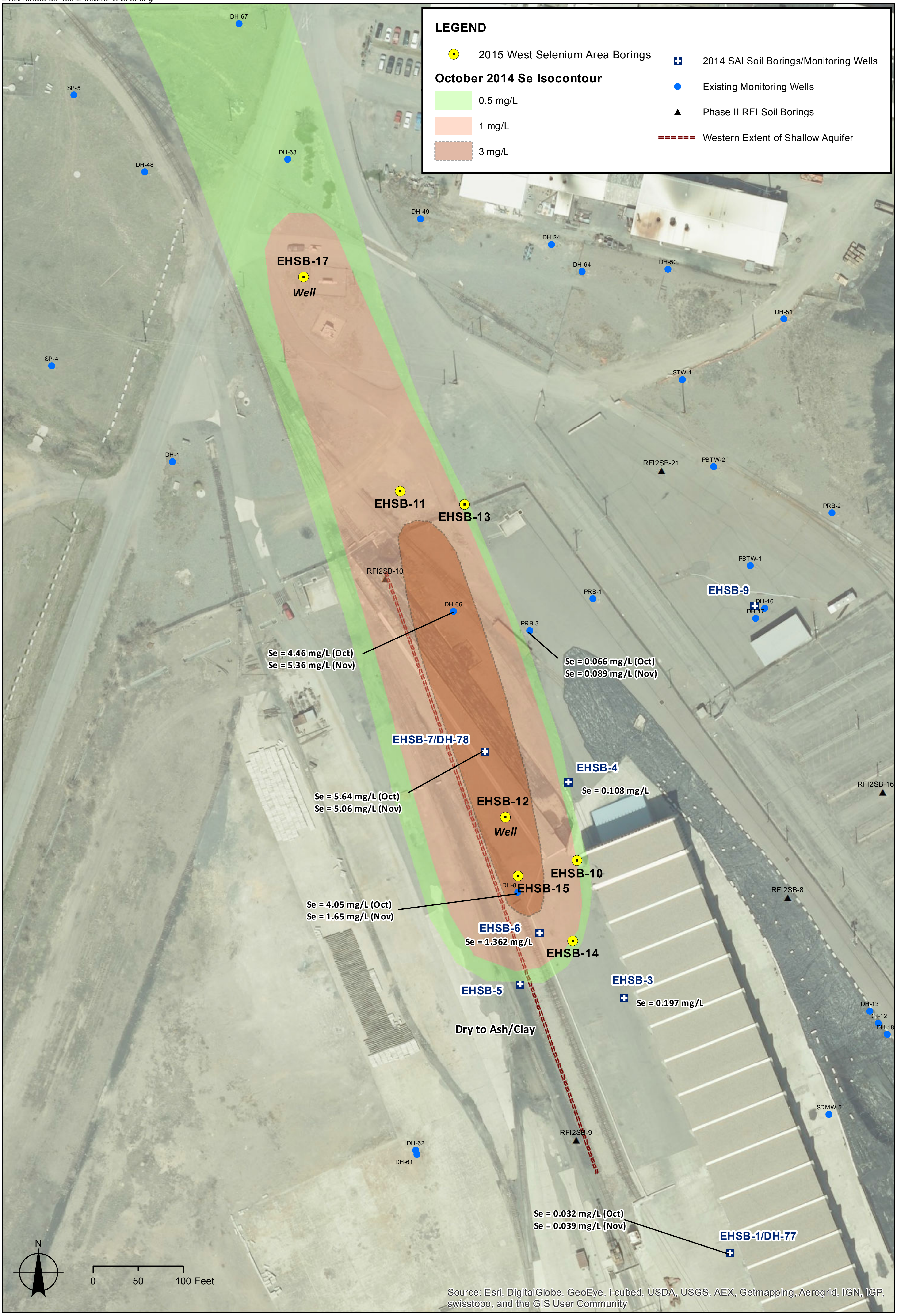

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NOTES:
Se values shown are either

(1) screening level groundwater concentrations (soil borings) or
(2) October and November 2014 concentrations (monitoring wells)

Hydrometrics, Inc
Consulting Scientists and Engineers

This figure was prepared by Hydrometrics, Inc. in 2015.

Figure 4
2015 Soil Boring Locations – West Selenium Area
Update on Corrective Measures Study Activities
Former ASARCO East Helena Facility – East Helena, Montana

ch2m:

EN1204151006PDX 656187.54.02.02 12-09-15 gr

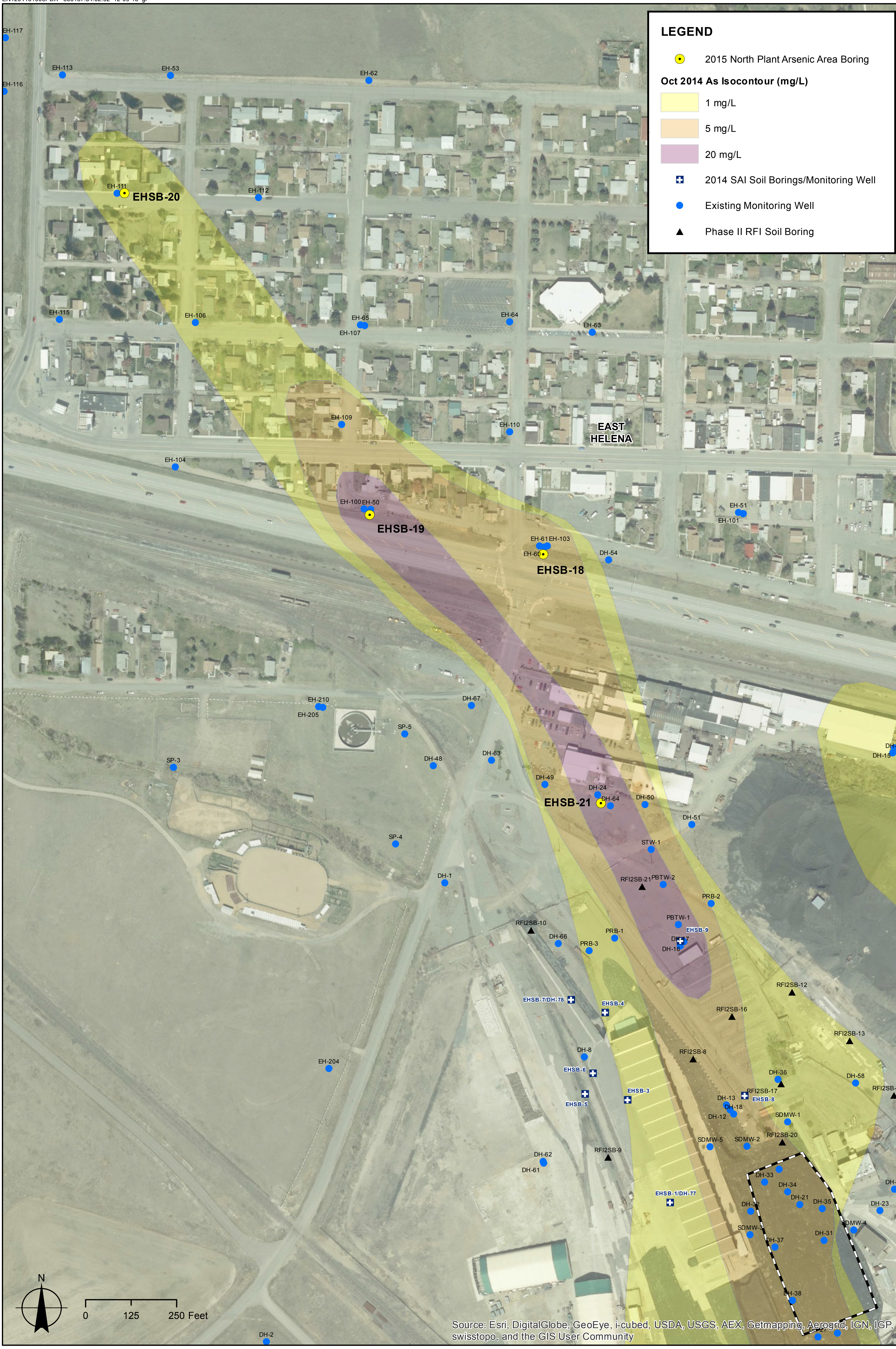

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Figure 5

2015 Soil Boring Locations – North Plant Arsenic Source Area

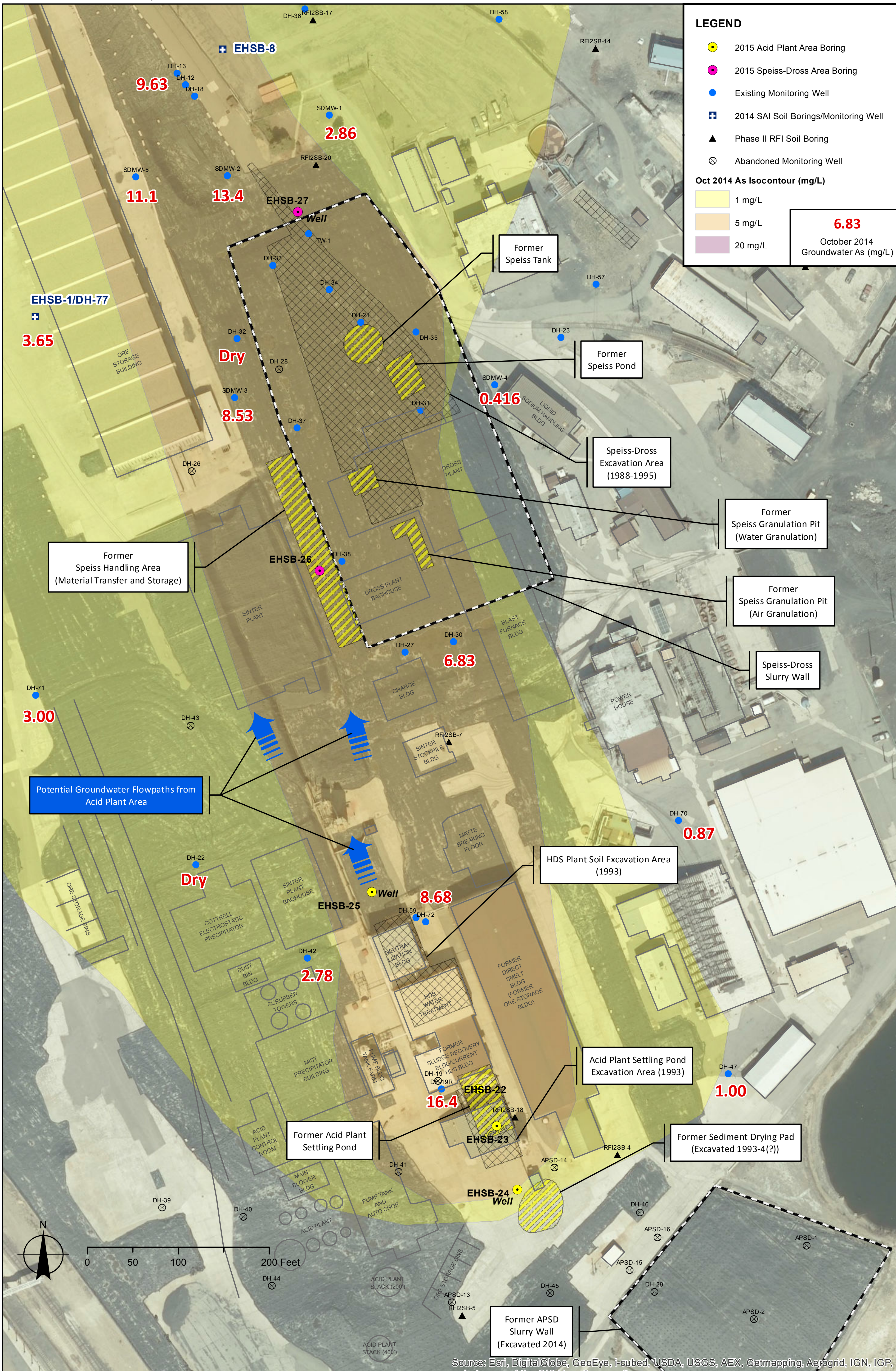
Update on Corrective Measures Study Activities

Former ASARCO East Helena Facility – East Helena, Montana

Hydrometrics, Inc
Consulting Scientists and Engineers

This figure was prepared by Hydrometrics, Inc. in 2015.

ch2m



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Hydrometrics, Inc
Consulting Scientists and Engineers

This figure was prepared by Hydrometrics, Inc. in 2015.

Figure 6
2015 Soil Boring Locations – Former Acid Plant and Speiss-Dross Source Areas
Update on Corrective Measures Study Activities
Former ASARCO East Helena Facility – East Helena, Montana

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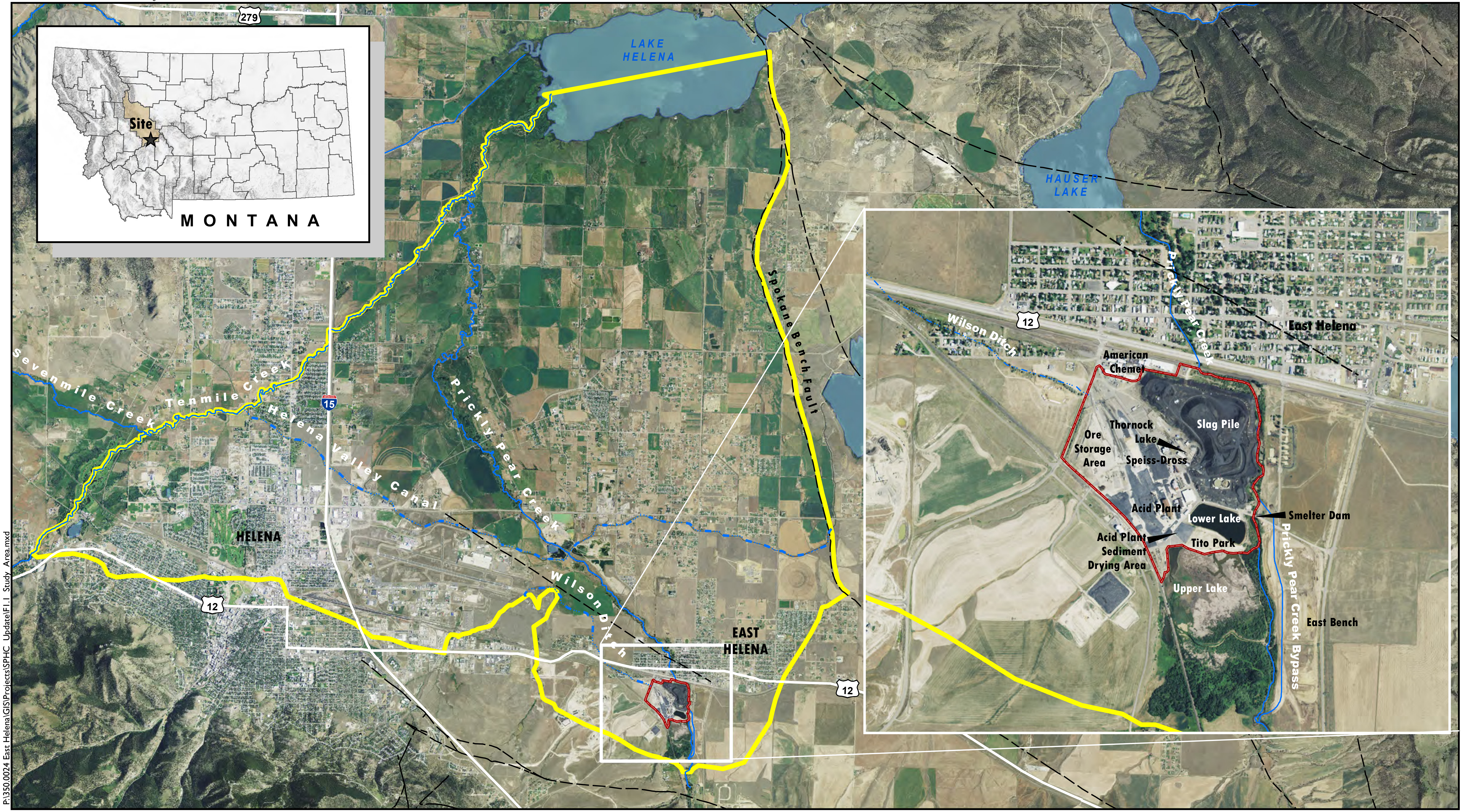

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Source: NAIP, 2013; METG, 2011

0 Feet 6,000

Fault
Ditch
Facility Boundary
Model Domain

NewFields

Note: This figure was prepared byNewFields in 2014.

Figure 7
Study Area and Facility Features with Model Domain
Update on Corrective Measures Study Activities
Former ASARCO East Helena Facility – East Helena, Montana

ch2m

Attachment
Updated Figure 6-1 Organizational Chart

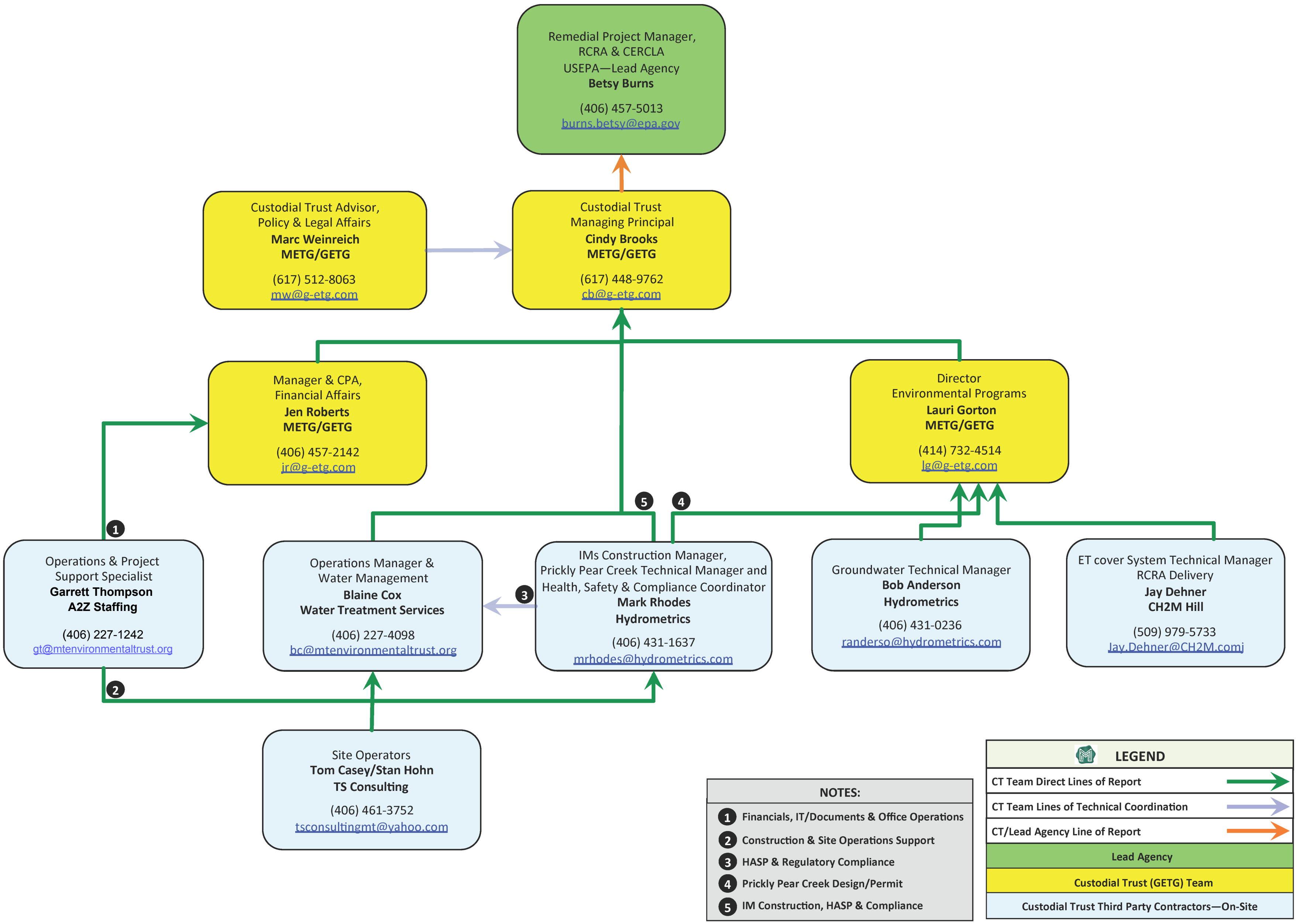

FIGURE 6-1
Corrective Measures Study Project Organization and Lines of Communication
Corrective Measures Study Work Plan
East Helena, Montana

CH2MHILL.