FINAL

Data Summary Report for the Supplemental Geophysical Survey Work Conducted at the L-Bar Site near Chewelah, Washington

October 2012

Prepared for

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Prepared by

CH2MHILL

Contents

Acronyms/Abbreviations

CAP	Cleanup Action Plan
CMP	Compliance Monitoring Program
Ecology	Washington State Department of Ecology
FD	Field Duplicate
FS	Feasibility Study
HDPE	High Density Polyethylene
Mag. Pile	Magnesite Residue Pile
MRL	Method Reporting Limit
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
PW	Production Well
QA	Quality Assessment
QC	Quality Control
RA	Risk Assessment
RI	Remedial Investigation
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SCCD	Stevens County Conservation District
SOPs	Standard Operating Procedures
SRM	Standard Reference Material
SWBU	Shallow
TMDLs	Total Maximum Daily Loads
WAC	Washington Administrative Cod

1.0 Introduction

This data summary report presents the key findings from a supplemental geophysical survey conducted at the L-Bar site in June 2012. Data needs regarding this work were discussed during a team coordination meeting with representatives from the Washington State Department of Ecology (Ecology), Northwest Alloys, Stevens County Conservation District, and CH2M HILL on October 20, 2011. The technical basis and need to conduct this work are described in the *L-Bar Site Compliance Monitoring and Data Evaluation Report, 1996-2010* (CH2M HILL, 2011). Ecology acknowledged and authorized the supplemental geophysical survey work as part of their recent *Periodic Review of the L-Bar Site* (Ecology, 2012).

This data summary report serves as the Task 3 deliverable as described in the scope of work between Alcoa and CH2M HILL (PO No. 190060971) titled, *Scope of Work and Fee Estimate for Environmental Consulting, Supplemental Site Characterization Work, and Regulatory Support Services conducted in 2012 at the L-Bar Site near Chewelah, Washington* (dated February 15, 2012). As described in the scope of work (and as coordinated with Alcoa), it is assumed that the results and key findings from the site investigation work, as outlined in this data summary report, will be presented and discussed with Ecology to help determine if supplemental cleanup actions (i.e., source removal) are needed at the site.

1.1 Purpose and Objectives

A supplemental geophysical survey was conducted at the L-Bar site to determine if suspected areas of elevated conductivity could be identified and delineated in a focused area of interest near the southeastern corner of the Magnesite Residue Pile (MRP) (shown in Figure 1). Consistent with prior work at the site, and in alignment with the current understanding of site conditions as established in the *L-Bar Phase I Remedial Investigation Final Report* (CH2M HILL 1998), elevated conductivity can be correlated to the presence of source materials such as Flux Bar (FB) or Flux Bar residue (FBR). Leaching of FB/FBR source materials over time is the source of elevated conductivity, chloride, and ammonia in shallow groundwater at the site. More specifically, elevated concentrations of these indicator constituents are persistent in shallow groundwater beneath the MRP, and most notably, increasing concentrations have been observed at well SA-10 during the active remediation period (2000 to 2004), and a continuation of increasing trends over the past 7 years following the source removal actions.

To help guide this work, a *Geophysical Survey Work Plan* (hereafter referred to as 'the Work Plan') was developed by CH2M HILL in cooperation with Northwest Alloys, and reviewed/approved by Ecology in advance of the work in May 2012. The Work Plan outlined the investigation objectives, data needs, site description/background, equipment, approach, methods, operational procedures, quality control, and the reporting associated with the geophysical survey as presented herein.

1.2 Background and Project Understanding

The L-Bar site is located approximately 2 miles south of Chewelah, Washington, on the west side of US Hwy 395 (shown in Figure 1). The site has extensive site history and is currently in the post-remediation monitoring phase of groundwater remediation under the Model Toxics Control Act (MTCA) Agreed Order program as administered by Ecology. Ecology's recent *Periodic Site Review for L-Bar Site* (Ecology, 2012) provides a thorough and current summary of site details such as the site history; regulatory background; nature and extent of contamination; interim-actions; remedial actions; environmental conditions in surface water and groundwater; and post-remediation monitoring. This information is not reiterated in this memorandum (nor was it included in the *Work Plan*), but was considered as part of the technical planning process in support of conducting the geophysical survey. The following information has been summarized in this section within the context of understanding the rationale to conduct the survey, and to assist with interpretation of the recent survey results (herein).

Recent observations as described in the *L-Bar Site Compliance Monitoring Program Data Evaluation Report, 1996-2010* (CH2M HILL 2011) identified a focused area of interest in the southeast corner of the MRP due to the monitoring results from well SA-10. One of the conclusions from this data report, in contrast to the characteristics of other compliance wells throughout the site, noted increasing concentrations in shallow groundwater at well SA-10 for the primary contaminants of concern (i.e., chloride and ammonia). For example, chloride concentrations have increased from levels less than 2,000 mg/L in 1999, to recent concentrations in excess of 10,000 mg/L in 2010; and similar increases for ammonia have been observed with concentrations below 400 mg/L in 1999, increasing to recent concentrations of approximately 1,000 mg/L in 2010. These increasing concentrations are in contrast to the characteristics observed in wells adjacent to SA-10 installed atop the MRP further to the west (i.e., SA-11 and SA-14), which show a characteristic spike in the late 1990's coincident with source removal actions, and subsequent significant declines during the post-remedial action monitoring period (following source removal actions). However, the elevated concentrations and increasing trends at well SA-10 led to the hypothesis that potential residual source materials within the MRP may be the cause. The significant increase in ammonia at SA-10 may suggest a flux bar residue source rather than residual flux bar leachate that was flushed out of the MRP, because ammonia in the unsaturated MRP is more likely to oxidize to nitrate.

The approach for the focused geophysical survey work and interpretation of results rely upon a basic understanding of several key site features which include the following:

1. Characteristics of the Magnesite Residue Pile (MRP) and source materials,
2. Source removal actions and source areas, and
3. Groundwater flow direction.

Details of these three items are summarized below.

1.2.1 Magnesite Residue Pile and Source Materials

This section provides an important distinction between the MRP (existing stockpile) and the former source materials (which have since been removed, as described in Section 3.2).

The MRP is an above-grade stockpile that sits roughly 25 to 30 feet high atop the native alluvium fine-grained soils as part of the Colville River valley floodplain. The MRP covers nearly 17 acres of the southwest quadrant of the L-Bar property. The former property owners, Northwest Magnesite Company, originally processed and stockpiled vast quantities of magnesite ore at the site (which constitutes the present-day MRP, as illustrated in Figure 1). As described in the *L-Bar Site Feasibility Study Report* (CH2M HILL 1999), the contaminants of primary concern related to the MRP materials include sulfate, and five trace metals (arsenic, boron, cadmium, copper, and selenium).

Magnesite ore processing was discontinued in 1967, and the facilities were later converted in the mid-1970's to recover magnesium from a magnesium processing byproduct commonly referred to as 'flux bar' (FB). FB was produced at the Northwest Alloys magnesium plant near Addy, Washington, and sold to the site owners. From 1986 to 1991, the site was owned and operated by L-Bar Products, Inc., a subsidiary of Reserve Oil and Minerals Corporation. L-Bar processed the FB blocks by crushing the raw flux bars and screening the crushed materials to recover metallic magnesium granules. The remaining non-metallic crushed and screened material is called "flux bar residue," or FBR.

As described in the *L-Bar Site Feasibility Study Report* (CH2M HILL 1999), the contaminants of primary concern related to FB/FBR include four inorganic constituents (chloride, ammonia, TDS, and nitrate) and three metals (barium, manganese, and iron). Elevated levels of chloride, ammonia, and conductance in shallow groundwater are most notably correlated with the leaching of FB/FBR source materials. Approximately 50,000 tons of FB or FBR were stockpiled at the site from 1977 to 1983 (and have since been removed). Materials stored on top of the MRP were predominantly weathered FB, whereas the materials located in the "Covered Pile" area (shown in Figure 1) were predominantly FBR.

In summary, the composition of the MRP materials were characterized during the remedial investigation (RI) effort and were demonstrated to not contribute elevated levels for the contaminants of primary concern that are associated with the leaching with FB/FBR materials (most notably chloride, ammonia, etc). Thus, current impacts observed at well SA-10 for chloride and ammonia are not attributed to potential influence from the existing MRP materials; but rather, appear to be caused from residual FB/FBR that was not fully identified (nor removed) during the prior source removal actions (as described in Section 3.2 below).

1.2.2 Source Removal Actions and Removal Areas

In cooperation with Ecology, the Selected Remedy for the site was source removal (of the FB/FBR materials) with natural attenuation and monitoring. Details of the feasibility study are detailed in a report titled *L-Bar Cleanup Levels Development and Feasibility Study Report* (CH2M HILL, 1999). Source removal activities were conducted from approximately 1997 to 2004, and the activities were guided by the Ecology-approved *L-Bar Material Removal and Compliance Monitoring Work Plan* (CH2M HILL, 2001).

The primary remedial actions/source removal activities included the following (areas shown in Figure 1):

- In 1997, removal of source materials consisting of FB and FBR in the area shown as the 'South Perimeter Removal Action.'
- From 1997 to 1999, removal of source materials consisting of FB and FBR from atop the MRP.
- From 2000 to 2004, removal of the covered FBR pile (referred to as the "Covered Pile") and materials stored in on-site plant buildings.
- In 2003, closure of the Main Ditch and removal of the high density polyethylene (HDPE) barrier wall along the western and northern perimeter of the Covered Pile.

Details of these and other remedial actions were documented in two previous reports: the *Interim Action Source Removal Summary Report – Magnesite Residue Pile, L-Bar Site* (CH2M HILL, 2001b), and the *Source Removal Summary Report – Covered Pile and Plant Buildings, L-Bar Site* (CH2M HILL, 2004). Noteworthy details of these former source removal actions in the vicinity of the MRP [per the aforementioned reports] are described below as they pertain to the recent geophysical survey work (herein).

Attachment A is a copy of the *Interim Action Source Removal Summary Report – Magnesite Residue Pile, L-Bar Site* (CH2M HILL, 2001b), including Table 1 [MRP Materials Removal Estimates], Figure 1 [FB/FBR Removal Areas], and Figure 2 [FB Piles and Removal Estimates]. As described in this report, the approach for source removal consisted of an initial inventory of FB/FBR materials performed by Cascade Earth Sciences (CES), which was conducted by way of laboratory analysis of the materials from Piles A-G [as shown in the figures at the end of Attachment A]. As the various piles were removed, the materials were screened visually and in some cases, chemically to help classify them as FB/FBR and distinguish them from underlying MRP. The screening process was conducted to help determine excavation limits and remove as much FB/FBR as practical, while minimizing the removal of underlying MRP materials.

The source areas designated as "Pile F" (including the South Perimeter Piles) and "Pile A" are in close proximity to the focused area of interest for the recent geophysical survey, and are of primary interest for the characteristics observed at well SA-10. Other source areas identified as "Piles B and G" may also be of interest to the recent study as they are the next closest piles to well SA-10, however, given their more distant location and considering the groundwater flow direction (described in the next section), these areas are considered lower priority in comparison to the areas designated as Piles F and A. As such, noteworthy details of the nearest piles (A and F) are summarized below as interpreted from the summary report (included in Attachment A):

Pile A – This pile is an elongate feature located between the access road to get atop the MRP and the southeastern margin of the MRP along the upper reach of the Main Ditch (behind former plant buildings). Well SA-10 is located along the southern margin of Pile A. The total quantity of FB/FBR removed from Pile A area was estimated at 20,000 tons. Post-removal confirmational sampling for chloride was conducted in the removal areas and confirmed that the FB/FBR had been removed to levels below the remedial action screening threshold level for chloride (established at 5,000 ppm).

Pile F – There were five (5) discrete sub-piles designated as 'Pile F' as shown in the figures at the end of Attachment A; three of which were along the southern flanks (slope) of the MRP, one area along the L-Bar property between the Sanitary Lagoon and the MRP, and the remaining area designated as the 'South Perimeter FB/FBR Piles' located along the south-central perimeter of the MRP. The total quantity of source material removed for the five areas designated as Pile F was estimated at 16,223 tons of FB/FBR, which was significantly greater than the initial estimated volumes estimated by CES. As noted in the source removal report, the additional FB/FBR material was found buried in paper bags and plastic "super sacks" and had been covered with MRP materials and road base gravel. In addition, portions of Pile F were found to be less weathered and therefore had higher ammonia content and heat generating characteristics. As described in the report, a major portion of Pile F was located in a deep bowl-shaped depression near the south center of the MRP; a thin polyethylene liner was identified at the interface between FB/FBR and underlying MRP. This bowl-shaped depression had nearly vertical walls, and after removal, the area was re-contoured. Post-removal confirmational field screening was conducted in areas to the east, northeast, and north of well SA-10 (i.e., in support of the Pile A and G removal areas); however, there was no mention of post-removal screening or confirmational sampling in the removal areas designated for Pile F. The removal actions for Pile F were chronologically first in sequence; and all subsequent removal areas included a discussion on post-removal verification methods (such as a visual or confirmational sampling approach, etc).

In summary, a review of the prior source removal efforts revealed the following noteworthy findings, including:

1. the actual source removal volumes for the five areas designated as Pile F was much greater than initially estimated from the original inventory by CES,
2. the FB/FBR materials from Pile F were found to be of relatively higher ammonia content in contrast to the other removal areas, and
3. there was no mention of any post-removal visual screening process and/or confirmational sampling for the removal areas in Pile F areas (which is in contrast to the other removal areas, which noted that either a visual method was deemed adequate, or confirmational chloride testing was performed to verify that all materials had been removed to the screening level).

1.2.3 Groundwater Flow Direction

The uppermost groundwater-bearing zone at the site has been characterized as the 'shallow water bearing unit' (SWBU), which is a relatively thin unconfined water-bearing unit that is generally 1 to 3 feet thick and typically occurs at depths of 2 to 5 feet below ground surface. The SWBU consists of glaciolacustrine fine-grained sediments which have been characterized as very stiff to hard clayey silt with occasional lenses of silty sand and intermittent organic-rich layers. The SWBU is underlain by a clay aquiclude, which separates the uppermost SWBU from the deeper aquifers in the Colville River valley. In addition, an upward vertical hydraulic gradient from the deeper aquifer(s) to the upper SWBU also precludes any vertical migration from the SWBU.

Figure 2 is a groundwater flow map for the SWBU using the April 2010 groundwater data (seasonal highs) [as presented in the recent *L-Bar Site Compliance Monitoring and Data Evaluation Report* 1996-2010 (CH2M HILL 2011)]. Groundwater in the SWBU generally flows to the north-northwest toward the Colville River, which forms the northern property and hydraulic boundary of the site. Near the southern end of the MRP, the inferred groundwater elevation contours yield a radial pattern based on the groundwater levels from wells P-12, P-13, P-09, and the three SA wells. There is a possible groundwater divide near the southern end of the MRP. It is hypothesized that the apparent radial pattern of the groundwater flow in this area is likely caused by recharge through the MRP and discharge to the nearby West Ditch and the Main Ditch. This hydraulic interpretation suggests groundwater flow is to the northeast in the vicinity of well SA-10, and to the west near the southwest corner of the MRP. Due to limited observation points, however, there is some uncertainty in the localized groundwater flow direction of the SWBU in the immediate vicinity of well SA-10.

The water-quality trends and the groundwater flow direction in relation to well SA-10 was (and is) one of the fundamental factors considered as part of the supplemental geophysical survey approach. The fundamental hypothesis for the focused investigation was that source materials may remain in areas up or cross-gradient from well SA-10 in the unsaturated portions of the MRP. This assumption on groundwater flow/transport, coupled with the understanding of where former source materials were identified (per Section 3.2 above), suggests a relatively focused (limited) area of interest with respect to where potential residual source materials may be present to cause the elevated concentrations and increasing trends observed at well SA-10.

2.0 Geophysical Survey Results and Interpretation

As noted earlier, a *Work Plan* was developed by CH2M HILL to guide the geophysical survey in cooperation with Northwest Alloys, and was approved by Ecology in late May 2012. Under contract with CH2M HILL, Zonge International Incorporation (hereafter Zonge) conducted the geophysical survey over a 2-day period on June 19 and 20, 2012. CH2M HILL's project manager was on-site during the 2-day investigation. Zonge (formerly Northwest Geophysical Associates, Inc.) has over 24 years of experience with conducting geophysical surveys, and performed an electromagnetic (EM) terrain conductivity survey at the L-Bar site in support of the RI work in 1995. The EM survey performed in June 2012 was found to meet the study objectives as outlined in the *Work Plan,* and supportive of future management decisions to determine if follow-on source removal actions may be warranted.

Attachment B includes the *Geophysical Survey Data Report* from Zonge, which was reviewed by CH2M HILL's geophysicist and project manager. The report from Zonge describes the geophysical survey methods, results, and data quality control (with accompanying tables, figures, and appendices). Attachment C includes site photographs taken during the June 2012 geophysical survey. CH2M HILL's interpretation of key findings from the geophysical survey results is provided below.

The geophysical survey identified several anomalous areas of elevated conductivity within the MRP which warrant discussion relative of whether they might represent residual FB/FBR and might be the cause for conditions observed at well SA-10. Per the figures in Attachment B, the key areas of the MRP are delineated as A, B, C, M, and NW to facilitate discussion and interpretation. In addition, the geophysical survey identified elevated EM responses in areas immediately south of, and east of the MRP, delineated as SP (south perimeter) and EP (east perimeter). Areas delineated as SP and EP are located at the toe of, and just off of the MRP to the south and east. A discussion of these areas is presented in the sections below.

2.1 Magnesite Residue Pile (MPR) Area

Key findings for the areas atop the MPR are summarized below:

- The anomalous area noted as A, and to a lesser degree B, showed elevated conductivity readings most notably in the EM31 dataset, which indicates a conductive zone may be present at relatively shallow depths less than 15 to 20 feet. The EM34 data, which provides a greater depth of exploration in comparison to the EM31 method, also showed similar areas of elevated conductivity in a broader zone as noted by areas A, B, and C. Areas A and B are in a similar location as the former source removal areas of Pile F (described above), and may support that residual FB or FBR is present in this location.
- The anomalous area identified as M is inferred to be a metal-like feature/object due to the transition from positive to negative response over a small area and the appearance of the anomaly in the in-phase response data; and given these responses, is not believed to represent residual FB/FBR.
- The area to the northwest of the survey near well SA-11 (labeled NW) also showed an anomalously elevated response, and this location is correlated to the previous source removal actions delineated as Pile B and/or Pile C (as summarized in the Attachment A source removal report). Anomalous readings in the vicinity of the NW area could represent residual FB/FBR associated with former Piles B and/or Pile C, however, given the groundwater flow direction in this area, this area is not the likely cause for the increasing levels of chloride or ammonia at well SA-10.
- Comparing the EM-34 10m data in the horizontal dipole phase versus the vertical dipole results reveals an elevated response within the general vicinity of areas A, B, and C, which is generally comparable to the areas identified from the EM31 survey. TheEM34 results are similar to the EM31 results because the EM34, in its horizontal dipole orientation, has a comparably, albeit slight increased, effective survey depth compared to the EM31. The EM34 vertical dipole results also depict a comparable elevated response at area A, but a

noticeably different elevated feature extending from area A eastward in a tortuous path to the vicinity of well SA-10. Because there is a significant increase in effective survey depth with the EM34 in vertical dipole orientation, it seems likely that the elevated responses could be indicative of source materials leaching into groundwater in the vicinity of area A, and then migrating downgradient under preferential groundwater flow from within the SWBU to the east or northeast toward well SA-10.

2.2 South Perimeter (SP) and East Perimeter (EP) Areas

Areas identified as SP and EP showed the highest EM31 response for the 2012 EM study. These areas are off of the MRP and the depth to groundwater in these areas is estimated at approximately 2 feet bgs. In addition, based on an understanding of the source areas (as part of the planning for this EM survey), areas off of the MRP generally represent locations in which source materials were not formerly stockpiled, with the exception of the southeastern-most pile (Pile F) located between the Sewage Lagoon and the MRP (as illustrated on Figure 2).

The EM31 conductivity response from the EP and SP areas (generally shown as dark red, purple, and dark blue coloring per Attachment B, Figure 2) was in the range of about 100 to 190 mS/m. These results are interpreted as "conductive soils and/or metallic-like response." The high electrical conductivity from these areas are likely enhanced due to clay rich soils and shallow groundwater since the depth of exploration for EM31 is on the order of 15 to 20 feet bgs, and the depth to saturation/groundwater in these areas off the MPR is estimated at approximately 2 ft bgs.

Prior EM survey results performed by NGA in 1995 at the site were conducted in broad areas of the site, and only a limited portion of which overlapped with the EM survey areas performed in June 2012. These 1995 EM survey results/mapping efforts are included in Attachment D. For the 1995 survey, only a single EM31 line was run along the southern margin of the MRP, which generally showed EM conductivity in the range of 90 to 130 mS/m (light green to light yellow color), except for the anomalous readings of about 190 to 320 mS/m (orange to purple color) in areas just to the northwest of the Sanitary Lagoon. Given the timing of this study, these elevated results likely represented the FB/FBR materials of Pile F (which had not yet been removed at this time). The differences in the responses between the 1995 and 2012 surveys are relatively insignificant in interpreting EM31 data and are likely attributable to potential changes in surface and shallow subsurface conditions over 17 years, and the fact that the 1995 survey was conducted in the horizontal dipole mode versus the 2012 vertical dipole EM31 survey. The horizontal dipole survey would have overall less influence from the subsurface at depth.

The EM31 in-phase responses (Attachment B, Figure 5) depict conditions consistent with a metallic-like response in the EP and SP areas. This effect is more pronounced and widespread in the surveyed portion of the EP area compared to the SP area. As noted in the data report from Zonge (Attachment B), the high EM31 in-phase response as noted by subarea "M1" is indicative of a buried metallic conductor, such as a culvert, pipe, reinforced concrete, or buried cable. The elevated EM31 in-phase response (metallic-like) may be a result of a localized increase in the mineral content of surface materials covering these portions of the site. For example, the calciner kilns of the magnesite plant were fired with coal, coal is conductive and often contains metallic sulfides. A layer of waste coal spread in this area may account of the EM-31 response in this area. Because of the elevated response in the EM31 in-phase data, it seems likely that the responses from these portions of the site beyond the MPR toe are not solely attributable to effects of groundwater saturation versus unsaturated conditions. Regardless of the cause, the areas delineated as EP and SP showed an anomalous response in both the EM31 conductivity and in-phase response data that should be considered for future potential actions.

3.0 Summary and Recommendations

The EM survey was completed in accordance with the Ecology-approved *Work Plan*, and achieved the intended objectives to further characterize the site-conditions in the focused area of interest near well SA-10. It is believed that the EM survey results have identified a candidate area (or areas) of interest (most notably 'Area A' and 'Area B' as shown in Attachment B) which most likely represents residual FB or FBR source material within the MRP that was not fully identified and/or removed during prior source removal actions. If this is the case, these residual source materials are likely causing the increasing concentration trends in shallow groundwater for indicator constituents at well SA-10.

The following data needs have been identified to compliment the EM survey results (herein), to fill data gaps, and to move forward in the most cost-effective manner to properly identify and subsequently mitigate the increasing concentration levels at well SA-10. The following list identifies the data gaps/uncertainty, along with the recommended supplemental site investigation activities to address each of data gaps/uncertainty:

1. Given the limited number of groundwater monitoring points near well SA-10, there is some uncertainty in the groundwater flow direction and/or hydraulic relationship between well SA-10 and the nearby 'Main Ditch' (which was closed in 2003 by backfilling with coarse-grained fill materials). To gain a better understanding of groundwater flow direction of the SWBU in this area, installation of two additional (temporary) piezometers is recommended near well SA-10; one located to the east near the former Main Ditch, and another due south well SA-10 just off of the MRP. Two new groundwater monitoring points, along with existing well SA-10 are believed to be sufficient to characterize the direction of groundwater flow in this area. Since the depth to groundwater is estimated at roughly 2 ft bgs in these areas, a cost-effective option in support of this recommendation could be to install the temporary shallow piezometers using a hand-auger.
2. The EM survey results identified areas EP (east perimeter) and SP (south perimeter) as "conductive soils and/or metallic-like response". As described earlier, the elevated EM31 conductivity response in these areas could be enhanced due to clay-rich soils and/or shallow groundwater. However, the source of the elevated EM31 inphase response (i.e., metallic-like response) in the EP and SP areas is not readily known and cannot be determined from the geophysical data. To better understand what the near-surface soils/materials are in these areas, it is recommended to conduct in-situ soils-testing using electrical conductance (EC) as a cost-effective indicator constituent. The general approach would be to establish a sampling grid to determine sampling locations in the SP and EP areas, collect 'grab' samples of near-surface soils/materials (either via shovel or hand-auger to shallow depths of 6 to 12 inches below existing grade), and perform in-situ testing of EC on the samples after they have been prepared into an amended paste (such as 10 grams of sample mixed with 50 mL of deionized water). EC results would be obtained from a typical hand-held conductivity meter (such as a YSI Model 63 which is routinely used for groundwater sampling). If the results from the EC field testing are significantly elevated, supplemental sampling and soils testing to quantify chloride and/or ammonia concentrations could be performed.
3. It is interpreted that the EM survey results identified areas A, B, and perhaps C as locations in which former FB or FBR may be present in the MRP. In an attempt to further understand these potential source areas and/or whether these areas represent true FB or residual FBR, it is recommended to perform soil vapor sampling in these areas of the MRP. Vapor sampling could be conducted in a cost-effective manner by using ammonia as the indicator vapor, and perform the vapor sampling by installing shallow drive points in the MRP to be used as vapor sampling 'wells'. The vapor sampling wellpoints could be installed to shallow depths of roughly 3 to 5 feet bgs in the MRP areas of interest (such as near area A, B, and C). Vapor sampling could then be conducted at each wellpoint by exerting a vacuum (via small diameter sampling tube) to withdraw the vapors, and quantifying the ammonia vapor concentrations by using a simple field-screening meter (such as a Draeger Pump with colormetric detection tubes). If significantly elevated ammonia vapors are identified, this may be

supportive of the presence of FB or FBR materials, which could help to guide and optimize potential future removal actions.

These recommendations would be coordinated with and approved through Ecology, and conducted in a manner consistent with the selected remedy for the site under the MTCA cleanup program. A detailed *Work Plan* would be prepared and submitted to Ecology for review and approval prior to moving ahead with these types of recommendations.

4.0 References

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CH2M HILL. 1999. *L-Bar Site Feasibility Study Report.*

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CH2M HILL. 2001b. *Interim Action Source Removal Summary Report – Magnesite Residue Pile, L-Bar Site.*

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Figures

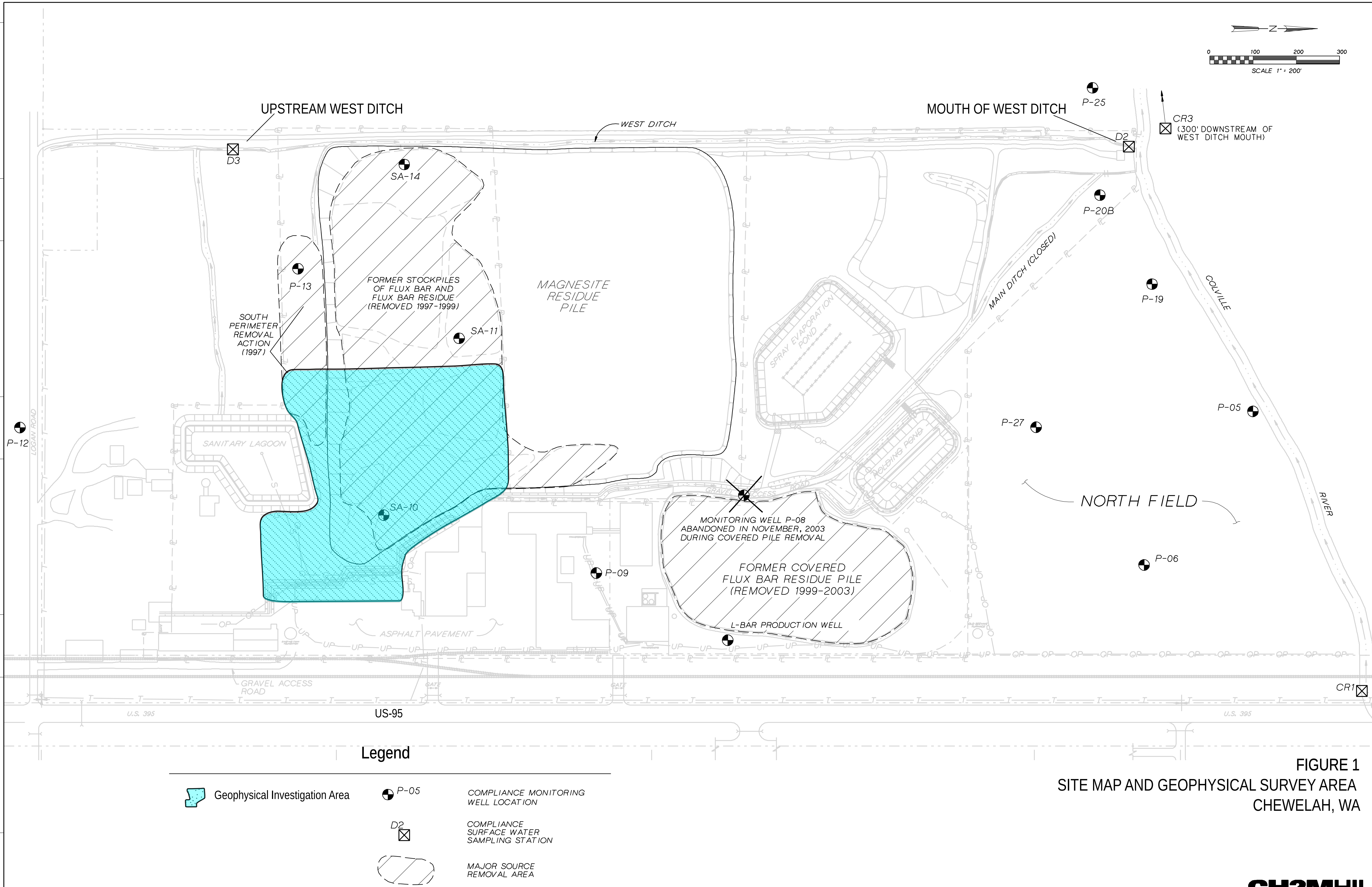
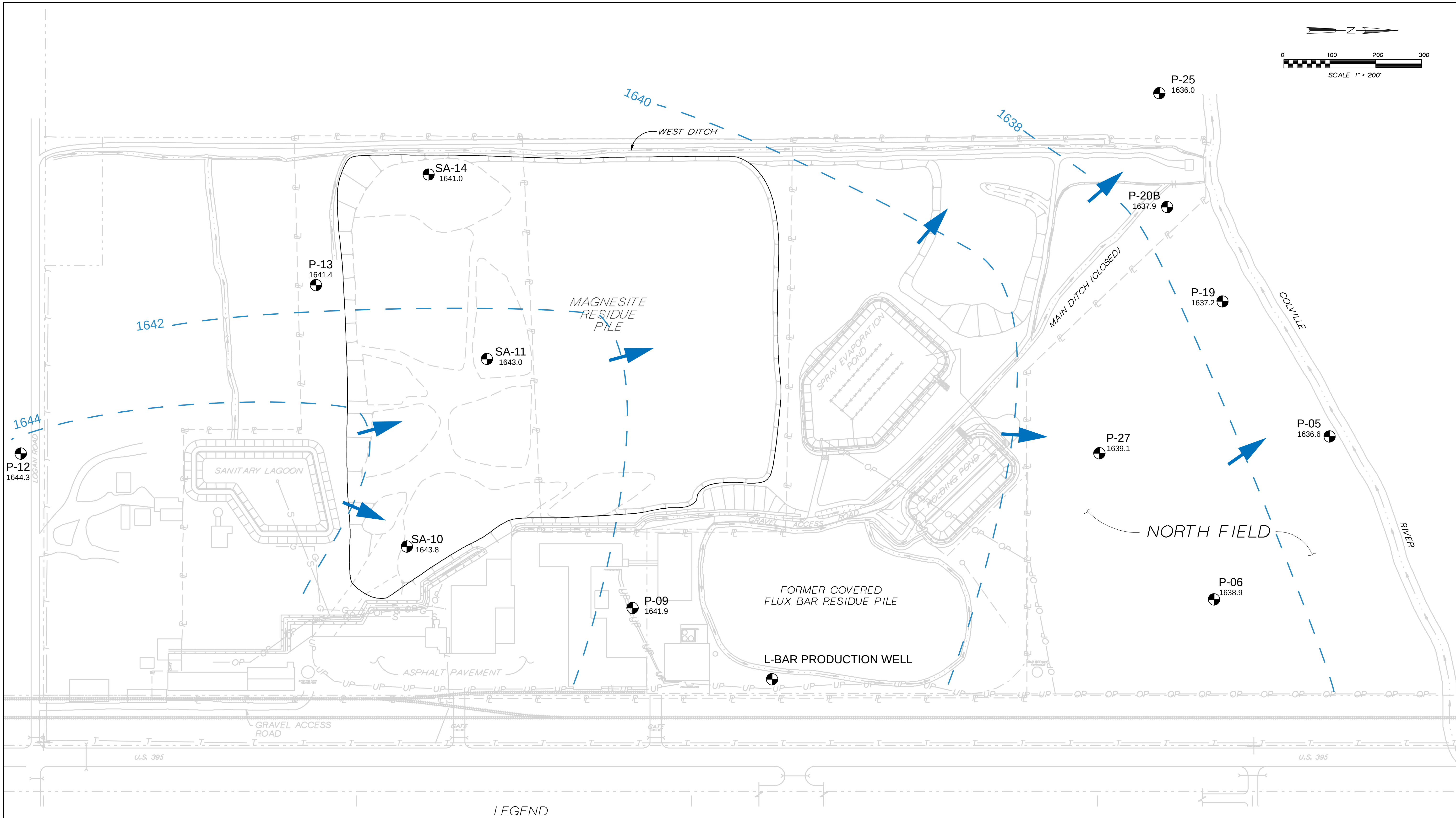


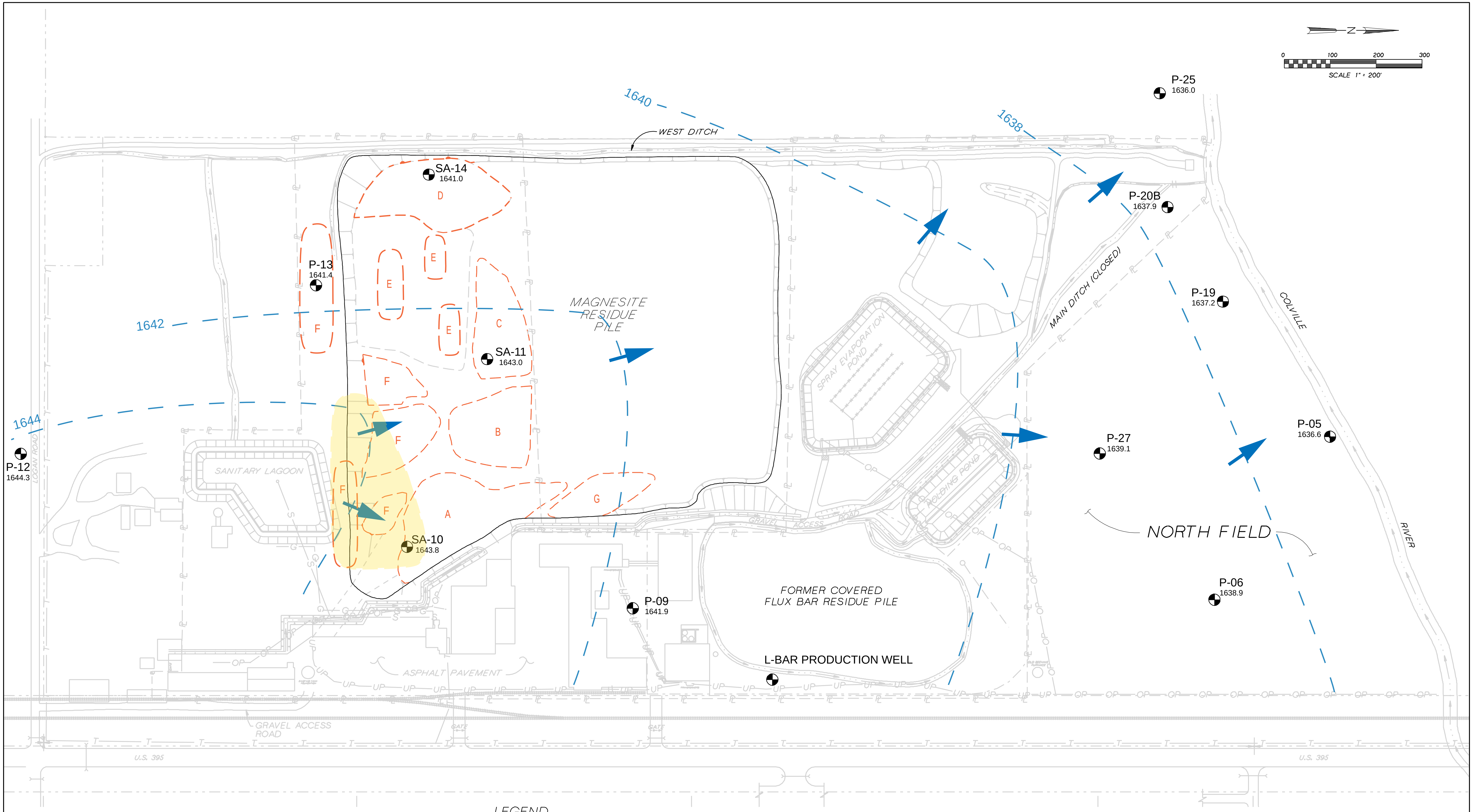
FIGURE 1
SITE MAP AND GEOPHYSICAL SURVEY AREA
CHEWELAH, WA



SOURCE: L-Bar Site - 2010 Compliance Monitoring Report

FIGURE 2
GROUNDWATER FLOW MAP
APRIL 2010 GROUNDWATER ELEVATIONS
CHEWELAH, WA

CH2MHILL



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COMPLIANCE MONITORING WELL LOCATION AND GROUNDWATER ELEVATION

APPROXIMATE GROUNDWATER ELEVATION CONTOUR AND INFERRED FLOW DIRECTION

Former FB/FBR Source Removal Areas

Area of Interest Up and Cross-Gradient from SA-10

FIGURE 3
FORMER SOURCE MATERIAL REMOVAL PILES AND FOCUSED AREAS OF INTEREST
CHEWELAH, WA

CH2MHILL

Attachment A

Background Information: *L-Bar Source Removal Summary Report Magnesite Residue Pile* (CH2M HILL 2001)

Interim Action Source Removal Summary Report
Magnesite Residue Pile-L-Bar Site, Chewelah, Washington

Prepared for
Northwest Alloys, Inc

Prepared by
CH2M Hill and Campbell Services Group

October 2001

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1.0 Introduction

1.1 Background

From May 1997 through December 1999 Northwest Alloys (NW Alloys) performed source removal actions to address a large quantity of exposed flux bar and flux bar residue (FB/FBR) at the L-Bar site (see Figure 1). The L-Bar Site is located on Highway 395 about 2 miles south of Chewelah, Washington. FB and FBR had been stockpiled by previous site owners/operators over portions of a relic mineral processing waste pile referred to as the *magnesite residue pile*. Concerns over the susceptibility of these FB/FBR materials to leaching and erosion prompted the Washington Department of Ecology to require that NW Alloys formulate a plan for the interim control, stabilization, reuse and/or disposal of these materials as part of the Remedial Investigation/Feasibility Study (RI/FS) project requirements. An Interim Action (IA) Work Plan was prepared in response to Agreed Order No. DE94TC-E104 for the L-Bar site. The IA Work Plan included specific provisions for characterization and/or management of on-site materials. Section 6 of the IA Work Plan (CH2M HILL, May 1995) presented a sampling and analysis plan for material on top of the magnesite [residue] pile. Included in this portion of the Work Plan was a description of the geometry and estimated volume of seven individual piles (Piles A through G) of weathered FB/FBR and soil/construction debris, which were the focus of the recent removal action (see Figure 2).

NW Alloys conducted RI activities at the L-Bar site during 1995 and 1996 in compliance with the terms of the Agreed Order. During 1995, IA material characterization activities also occurred (as originally described in the IA Work Plan), and included sampling and analysis of the FB/FBR materials stockpiled over the southern half of the magnesite residue pile. The RI and Material Characterization data confirmed that the FB/FBR source materials located on the magnesite residue pile were leaching ammonia, chloride and other source-related constituents into the magnesite materials, and were locally contributing to surface water and shallow groundwater quality impacts. In particular, it was concluded that FB/FBR material stored on the south side of the magnesite pile near ground level is a likely source of contamination of surface water in the south and west ditches.

NW Alloys developed an initial proposal to remove and dispose (off-site) of approximately 10,000 tons of the FB/FBR material. Removal of the FB/FBR was to be completed as an IA under the terms of Agreed Order No. DE94TC-E104. NW Alloys developed a management plan (*L-Bar Site Material Removal and Disposal Management Plan*, NW Alloys, October 1996) to direct the IA source removal activities and to address pertinent health and safety considerations, site controls and State Environmental Policy Act (SEPA) checklist requirements. The Department of Ecology also made source removal a conditional requirement of a land application project, which NW Alloys had proposed to the agency as an interim measure for management and control of on-site surface water.

2.0 General Procedures and Methodology

Section 2 presents a general overview of the core elements of the source removal process including:

- Material characterization and identification methods
- Equipment
- Excavation, handling and stockpiling procedures
- Control measures, and
- Health and Safety considerations

2.1 Material Identification, Sampling and Testing

2.1.1 FB and FBR Materials Identification

In most areas of the site, FB/FBR materials were stockpiled directly on the ground surface or on the surface of the magnesite residue pile. Cascade Earth Science (CES) performed a detailed inventory and analysis of site materials, including the FB/FBR materials stockpiled on the magnesite residue pile (*Interim Action Source Materials Characterization Report*, Draft, February 1996). Laboratory analysis of material samples from Piles A through G was performed as part of the material characterization, and included fertilizer properties, selected trace metals, and hazardous characteristics including a fish bioassay screening. During the IA Materials Characterization study, the areal extent of each FB/FBR/construction debris pile was determined, and coordinates were surveyed at several points around the perimeter of each pile. The CES data helped to further refine the areal extent and boundaries of each of the respective seven piles that were presented in an earlier (1993) aerial photogrammetric study performed by Northern Forests.

As shown in Figures 1 and 2, the FB/FBR in Piles A through G are located around the southern and eastern perimeter and on the top of the magnesite pile at the site. As the various piles were removed, the materials were screened visually and in some cases, chemically to classify them as primarily FB/FBR or magnesite residue. This screening was conducted to help determine excavation limits and remove as much of the FB/FBR as practical, while minimizing the removal of the underlying magnesite residual material.

Additional FB/FBR material, not previously assessed during the IA Materials Characterization Study, also was identified (and removed) during the course of the IA source removal. These materials were found along the southern margins of the magnesite residue pile, beyond the defined limits of Piles A through G. One source material stockpile was found buried near the northeast corner of the Sanitary Lagoon (see Figure 1 -- labeled as a sub-unit of Pile F). Most of this material had been buried under an access road, and was present in paper bags and plastic "supersacks" staged on wooden pallets. A clustered grouping of generally small, discrete piles of FB/FBR containing material also was

Chloride Field Screening Procedures & Data, and Figure B-1 for Confirmation Sample Locations around Piles A and G). Excavation was terminated in an area when the material confirmation samples indicated a chloride content below about 5,000 parts per million (ppm) or visual indications confirmed that the magnesite residue interface had been reached. The 5,000-ppm was a general remediation action guidance level, which was intended to provide a measure of safety from subsequent leaching of residuals from the soil/magnesite residue materials. Specifically, application of a MTCA clean up level that is 100 times the groundwater standard would result in a chloride soil clean up level of 25,000-ppm.

Confirmation samples generally were taken as hand or shovel grab samples from near the surface to about 12 inches in depth. Samples were labeled and stored in plastic zip lock bags and taken into the on-site laboratory for analysis by either CSG or NW Alloys personnel. Material samples were tested in the on-site laboratory using a chloride ion selective probe. Samples were prepared in slurry for testing by combining 10 grams of sample with 90 grams (approximately 90 milliliters) of distilled water. The ion probe was calibrated at the beginning of each test session with solutions of known chloride ion strength of 100, 1,000 and 10,000-ppm.

2.2 Equipment and Manpower

Most of the material removal activities were performed using equipment and personnel from the NW Alloys Addy plant. On-site work crews typically consisted of three to four NW Alloys personnel who were responsible for heavy equipment operation, site maintenance, and railcar covering and weighing. A CSG representative was also present to assist with field oversight, client/railroad coordination, and routine documentation.

FB/FBR materials were excavated using a Cat 120 excavator. The excavated FB/FBR materials typically were transported to a designated stockpile area on site using a Cat 950 front-end loader. The front-end loaders were also used to scoop the materials from the temporary stockpile locations and load them into gondola-type railcars (approximately 100 cubic yard [yd^3]capacity) for transport to a solid waste disposal facility. Occasionally, some FB/FBR materials were transported and loaded directly into the railroad cars (without intermediate stockpiling) when temporary stockpile inventories had been depleted, and/or operational conditions warranted. During later phases of the IA removal action, large haul trucks (two 10-yard capacity on-road trucks) were used to move the FB/FBR materials to a staging area prior to loading them into railcars.

A dragline was used to perform some of the source removal work from Piles A and G. Additional details of the dragline operations are discussed in later subsections.

2.3 Stockpiling

The majority of the FB/FBR materials removed to date were stockpiled by the previous owners/operators of the site on the top and side slopes of the magnesite residue pile. During the source removal process, temporary stockpiles were created to stage the excavated FB/FBR materials prior to loading them into railcars for transport. Temporary storage bunkers were created in the paved parking lot area (near the L-Bar office building) where source materials could potentially impact stormwater discharges, and routine inspection and maintenance of the stormwater drainage system (directing stormwater into the holding pond). These operational BMPs remained in force during the course of the IA Source Removal. Dikes, berms and/or covers were used to the extent possible to isolate the source material from precipitation and snowmelt, and to minimize the potential for leaching.

After the FB/FBR source material removal activities were completed, regrading of portions of the magnesite residue pile was performed to minimize the potential for ponding of stormwater and/or erosion. An area at the northeast corner of the magnesite residue pile also was regraded and bermed in 1996 to address a sizable erosional gully that was created along the side of the pile, through which stormwater was discharging directly into the Main Ditch.

2.5.3 Heat and Dust Control

Unweathered FB/FBR materials, when wetted or exposed to atmospheric moisture may generate heat. During the IA source removal, NW Alloys used controlled application of water and/or mixing of wet and dry materials to manage potential heat production. Thermo-couples and infrared heat sensing devices were used to assess and quantify the presence of reactive and unweathered FB/FBR materials – especially during the excavation and removal of materials from Piles A and F. Procedures (Appendix D) were developed (i.e., heat rise test) to assess the heat generating potential and characteristics of selected samples.

Once the materials had been mixed, and/or exposed to moisture, the materials were allowed to thermally equilibrate (in place) for several days prior to being transferred to temporary stockpile bunkers or buildings, or loaded directly into the railcars.

When source removal activities occurred during hot, dry weather conditions, (with Department of Ecology approval) water application was used for dust control purposes both in the excavation areas and on the heavy equipment haul routes. Water used for thermal equilibration and/or dust control purposes was applied at a controlled rate to minimize the potential for leaching of soluble components of the FB/FBR material.

2.6 Health & Safety Considerations

Air Monitoring

FB/FBR may produce ammonia when exposed to moisture. Ammonia is produced when magnesium nitride (Mg_3N_2), a constituent of FB/FBR, comes into contact with water or moisture in the air. Phosphine also may be produced, but generally at very low levels. Ammonia monitoring was conducted periodically during the source removal process (see Appendix E -- Air Quality Monitoring). Ammonia levels were monitored at the perimeter of the work area to measure any possible off-site air quality impacts. Ammonia also was monitored within the material excavation area to perform a qualitative assessment of potential worker exposure. Long-term (8-hour) Drager tubes were periodically placed around the particular work area undergoing excavation and at the railcar loading area.

3.0 Pile-Specific Removal Information and Details

In general, the methodology described in Section 2, was used to complete the IA source removal. However, some operational and procedural deviations/variations were necessary to address unique logistical, locational and/or material characteristic considerations at each of the respective piles. Section 3 presents pile-specific removal information and details. Photos taken at the L-Bar site during IA source removal activities are included in Appendix G.

Figure 2 shows the relative locations, approximate shapes, and actual quantities removed from each pile. Table 1 summarizes and compares the previous material quantity estimates (CES, 1996; Northern Forests, 1993) and the actual quantities removed during the IA source removal. The reasons for the differences in estimated and actual quantities are also discussed in Table 1. The general chronological sequence of the source pile removal was as follows:

- Pile F and South Perimeter piles (May 1997 – July 1997)
- Pile A (September 1997 – July 1998)
- Pile G (September 1997 – July 1998)
- Pile B (August 1998 – November 1998)
- Pile C (November 1998 – January 1999)
- Pile D (February 1999 – May 1999)
- Pile E (May 1999 – December 1999)

Table 1 indicates that the IA source material removal activities resulted in the removal of a greater tonnage of FB/FBR materials than originally estimated. The discrepancy between the preliminary tonnage estimates and actual final tonnage removed is believed to be based on five main considerations, including:

- Variations in material density and in-place moisture content of the source material from values reported in the 1996 material characterization report (CES, 1996).
- Unrecognized variations in the geometry of selected source piles, especially Piles A, F, and G, which draped over the sides of the magnesite residue pile that resulted in an under-estimation of the piles' thickness and areal extent.
- Water application requirements for dust and heat control, and the resulting increase in the moisture content (and tonnage) for the materials shipped to the landfill.
- FB/FBR material that had been buried by L-Bar along and under the access road that runs between the magnesite residue pile and the on-site sewage lagoon, which was not included in the original tonnage estimate for Pile F.

Subsequent excavation on Pile A was conducted using a dragline equipped with a one-third cubic yard bucket. The dragline excavated and stockpiled FB/FBR materials at the crest of the magnesite residue pile. The materials were then picked up with loaders and loaded into dump trucks or transferred directly by the loaders to the railcar loading area.

During excavation of Pile A source material, the excavation equipment had to work around groundwater monitoring well SA-11 (located within the Pile A area). Precautions were taken to protect the well to the extent possible during active source removal. Once the removal activities were completed the monitoring well was modified to comply with state well construction standards.

During the excavation work on Pile A, with the Department of Ecology's approval, water from the site evaporation pond was applied to the surface of the piles to aid in dust control and to thermally equilibrate materials prior to transfer to the railcars. NW Alloys met with representatives from the Department of Ecology on October 9, 1997 to review data from Pile A and to discuss procedures being used to monitor water application rates. Water application and soil moisture monitoring procedures and daily inspection monitoring results are presented in Appendix F.

A total of approximately 700,000 gallons of water from the site evaporation pond was applied for dust and heat control during the removal of Piles A and G. The water was applied with rotating spray nozzles. Water quantity was estimated by taking daily readings from a staff gauge located in the evaporation pond and calculating estimated volume by using the two-dimensional pond surface area and the depth of water in the pond measured by the staff gauge. The quantity of water applied to the pile was visually monitored and adjusted on a daily basis to assure that the water was infiltrating the FB/FBR materials and not running off the pile and into the site drainage ditches. Moisture probes were also used to confirm that excess filtration of applied water was not occurring.

The main site drainage ditch (Main Ditch) parallels the base of Piles A and G and separates them from the asphalt paved site access road. An 8-inch plastic sewer pipe was installed in the ditch in a section where the ditch was backfilled to facilitate heavy equipment access for source material removal from Pile A.

More intensive air monitoring was performed during excavation of source material from Pile A (and Pile G). A summary of air monitoring activities performed during the course of the source removal work (including Piles A&G) is presented in Appendix E.

Confirmation sampling in the areas where FB/FBR materials were removed at Pile A was conducted at three depth locations within the underlying magnesite pile after visual observations indicated completed removal. Samples were taken at depths of approximately 6 inches and 12 inches below ground surface over a relatively regular 50-foot grid pattern. Confirmation samples were tested at an on-site laboratory for chloride content. Results and sample locations are presented in Appendix B. After confirmation sampling confirmed that all FB/FBR material had been removed, the area was regraded to preclude precipitation runoff from the top of the pile and into the Main Ditch.

in Appendix A. The following paragraphs summarize any deviations from general procedures discussed in Section 2.

It was possible to easily distinguish the bottom boundary of the FB/FBR of Pile C from the underlying magnesite residue materials based on visual observation. Therefore, no post-removal confirmation samples were collected from Pile B for chloride field screening.

Removal of Pile C was conducted by excavation and transport of FB/FBR to the railcar loading area with Cat 950 loaders.

During excavation of Pile C source material, the excavation equipment had to work around groundwater monitoring well SA-11 (located within the Pile C area). Precautions were taken to protect the well to the extent possible during active source removal. Once the removal activities were completed the monitoring well was modified to comply with state well construction standards.

3.4 Pile D

Material Quantities and Waste Designation

Removal of Pile D source materials began in February 1999 and was completed in May 1999. Piles B, C and D were similar in size, shape and composition and were located on top of the flat interior and south central part of the magnesite pile (Figures 1&2).

A total of 77 railcars (7,380 tons of FB/FBR) was removed from Pile D (see Table 1). The preliminary estimates indicated the presence of approximately 6,200 tons of source material for Pile D (Table 1). The estimated tonnage was close to the tonnage of source materials actually removed. Materials removed from Pile D were characterized and designated as non-dangerous solid waste. Materials from Pile D were heavily weathered and did not require application of water for dust suppression or heat control.

Removal Techniques and Methodology

In general, excavation and material removal techniques discussed in Section 2 were used for Pile D. Material characterization laboratory results for Pile D (and other piles) are included in Appendix A. The following paragraphs summarize any deviations from general procedures discussed in Section 2.

It was possible to easily distinguish the bottom boundary of the FB/FBR of Pile D from the underlying magnesite residue materials based on visual observation. Therefore, no post-removal confirmation samples were collected from Pile D for chloride field screening.

Removal of Pile D was conducted by excavation and transferring of FB/FBR to the railcar loading area with Cat 950 loaders.

During excavation of Pile D source material, the excavation equipment had to work around groundwater monitoring well SA-14 (located within the Pile D area). Precautions were taken to protect the well to the extent possible during active source removal. Once the removal activities were completed the monitoring well was modified to comply with state well construction standards.

All of the excavation and transport of the materials to the railcar loading area was accomplished with Cat 950 loaders.

3.6 Pile F

Material Quantities and Waste Designation

Removal of Pile F source materials began in May 1997 and was completed in July 1997. Pile F consisted of two discrete stockpiles (predominantly flux bar residue): the volumetrically larger pile located along the southern flank of the magnesite residue pile and the smaller pile located along the central edge of the magnesite residue pile near the slope crest (Figures 1&2). These were the first piles to be removed from the site.

163 railcars (16,223 tons of FB/FBR) were removed from these piles (see Table 1). Preliminary estimates indicated the presence of approximately 2,600 tons of source material for Pile F (Table 1). The tonnage discrepancy was due to the following:

- Pile F geometry was different than originally expected (i.e., the "grotto-area" was much larger than predicted)
- Requirements for water application during source removal added additional weight to the source materials
- The south perimeter piles were not included in the original FB/FBR tonnage estimates
- The material buried along and under the road between the magnesite residue pile and the sewage lagoon were not known to be present when original estimates were made.

Materials in Pile F demonstrated greater heat rise properties and greater amounts of water were applied to maintain heat and dust control.

In addition to the initial estimates of FB/FBR source material quantities in Pile F, an estimated 2,300 tons of additional source material was found buried in paper bags and plastic "super sacks" on pallets to the east of the main body of the Pile F (see Table 1 and Figure 1). This FB/FBR had been covered with magnesite residue material and road base gravel.

Several discrete piles of material visually appearing to contain FB/FBR were observed along the southern property line separating the L-Bar site from the adjacent "Wuesthoff" property. These piles were placed directly on the ground and were removed as part of the IA, concurrent with the removal of Pile F materials. The piles were removed in June 1997, and the estimated quantity was approximately twelve (12) railcars or 1,200 tons. The approximate locations of these "Miscellaneous South Perimeter FB Piles" are shown in Figures 1 and 2.

Materials removed from Pile F were characterized and designated as special waste. Results of the fish bioassay testing indicated that materials from Pile F were designated as special waste. These samples were collected directly from drilled boreholes prior to any transport, mixing with water/wet materials or storage. Portions of the FB/FBR source materials from Pile F were less weathered, and therefore had higher ammonia content and heat generating characteristics.

Appendix F. Samples were tested in the on-site laboratory for chloride content and results and sample locations are shown in Appendix B (see Figure B-1).

3.8 Other Source Material Areas

Approximately 4,500 tons of prilled flux bar stored on-site in the Butler Building was removed during the period from December 1997 through July 1998. This product was applied to fields in the Willamette Valley (Oregon) and Deer Park (Washington) areas as a fertilizer/liming agent. The product was shipped in covered semi-truck bottom dump trailers. Loading operations took place inside the Butler Building to minimize dust emissions during the loading process.

4.0 Summary

NW Alloys has completed the removal of all recognized FB/FBR from the top and sides of the magnesite residue pile, fulfilling the requirements for IA source removal as specified in Agreed Order No. DE94TC-E104. NW Alloys complied with the original requirement to remove 10,000 tons of FB/FBR materials, and completed the removal of all remaining source materials from the magnesite residue pile during an approximate 2.5-year period from May 1997 through December 1999. At completion, the IA source removal resulted in the removal and off-site disposal of approximately 67,000 tons of FB/FBR source materials. The actual tonnage of FB/FBR that was removed exceeded the original estimates by approximately a factor of 1.5. This tonnage variation resulted from (1) a greater than anticipated volume of material, (2) additional weight due to water application, and (3) quantities of material that were unknown at the time the original quantity estimates were developed.

Materials removed from the magnesite residue pile were characterized and designated into two categories: non-dangerous solid waste and special waste. Results of the fish bioassay testing indicated that materials from Piles F and some materials from Pile A were designated special wastes. The samples that designated as special wastes were taken directly from drilled borings prior to any transport, mixing with water/wet materials, or stockpiling. Consequently, these materials contained a higher ammonia content and displayed higher heat generating characteristics. All other materials designated as solid waste.

During the course of the IA source removal, NW Alloys developed methods and procedures for safe and efficient testing, excavation, management (heat and dust control), stockpiling, and loading of the FB/FBR materials. Knowledge gained and procedures developed during the IA removal have been applied to a test removal of the Covered FBR Pile and have been applied to the full-scale removal activities that began in 2001.

Specific Health & Safety procedures and considerations have been developed during the course of the IA source removal and these measures are being applied to the full-scale source removal action at the Covered FBR pile and source materials currently located in the site buildings.

5.0 References

Cascade Earth Sciences (CES), February 1996. *Interim Action Source Materials Characterization Report, Draft.*

CH2M HILL, CES, and Kessler, C., May 1995. *Interim Action Work Plan for L-Bar Site, in Chewelah, Washington* .

NW Alloys, October 1996. *L-Bar Site Material Removal and Disposal Management Plan.*

TABLE 1
Estimated Material Quantities Prior to Excavation, Actual Material Quantities Removed, and Reasons for the Differences
L-Bar Magnesite Residue Pile Source Removal

Pile #	Estimated Quantities [a] (tons)	Actual Quantities (tons)	Reason for Differences
A + G	8,904 (A) 966 (G)	25,907	Pile geometry differed from original expectations. Materials demonstrated greater heat rise properties and greater amounts of water was applied to maintain thermal and dust control.
B	7,225	6,835	-
C	6,410	6,579	-
D	6,200	7,380	-
E	11,601	3,980	Only a portion of the construction debris materials was found to contain FB/FBR residues at levels that required removal.
F	2,627	16,223	Approximately 2,300 tons of additional source material was found buried in paper bags and plastic "super sacks" on pellets to the east of the main body of Pile F. Materials demonstrated greater heat rise properties and greater amounts of water was applied to maintain thermal and dust control.
Total	**43,933**	**66,905**	-

[a] Estimated quantities were developed by Northern Forests using aerial survey techniques (digital terrain mapping).

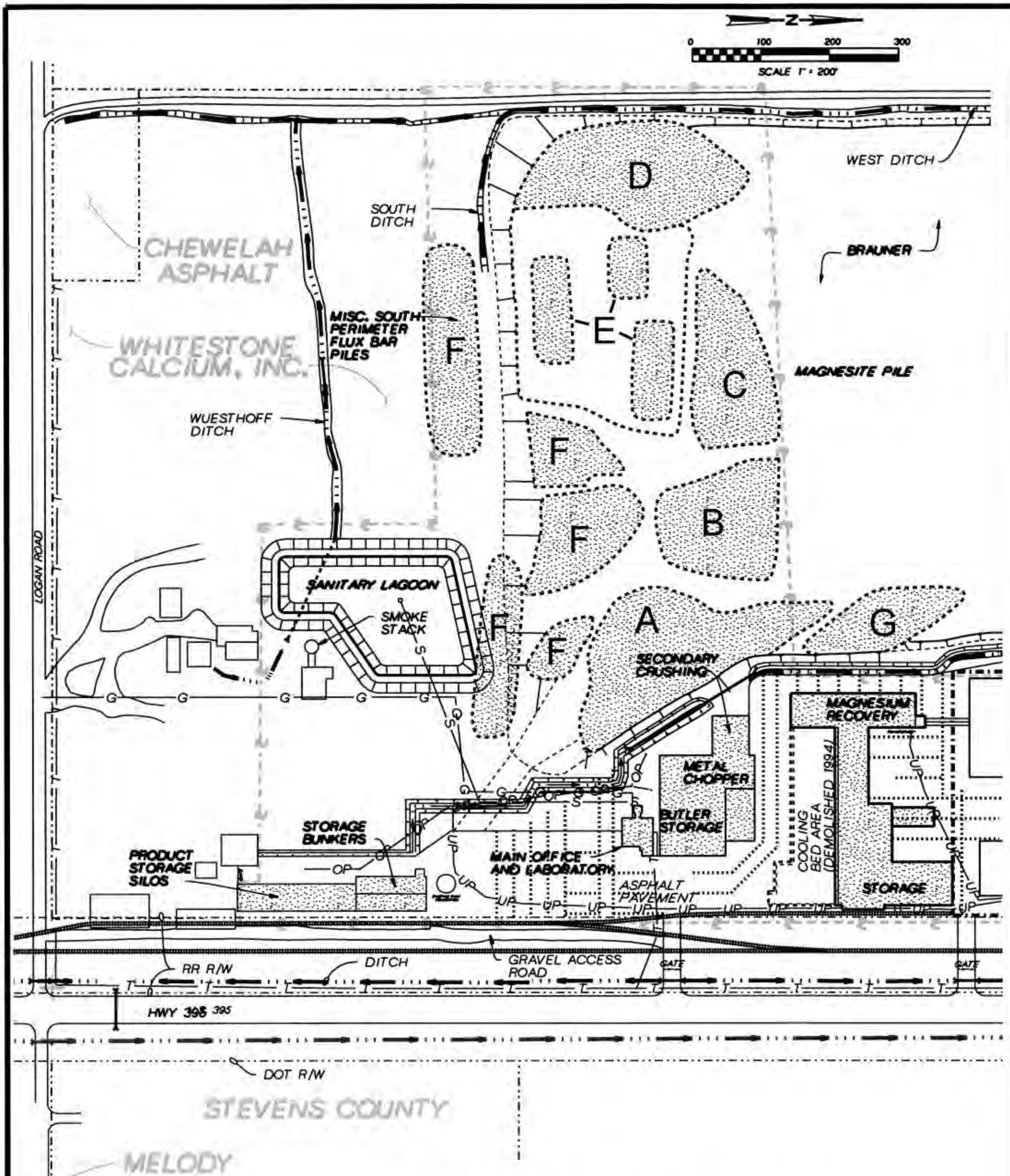

FIGURE 1
FLUX BAR/FLUX BAR RESIDUE
PILES REMOVED DURING
INTERIM ACTION SOURCE REMOVAL
LBAR SITE - CHEWELAH, WA

CH2M HILL

p10d003f2.dlv 01-NOV-2001 14:22:49 NDM npe 40465

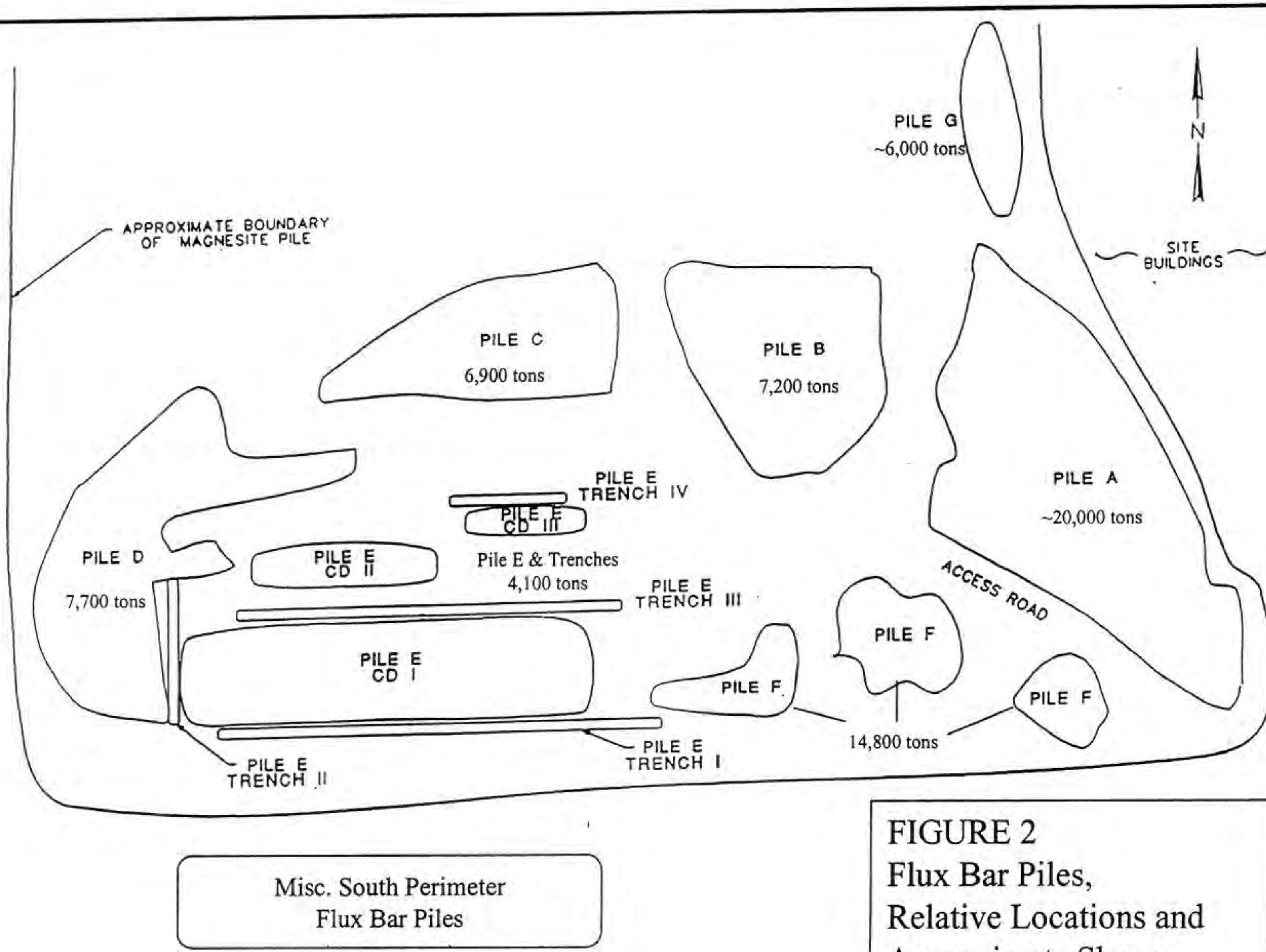

FIGURE 2
Flux Bar Piles,
Relative Locations and
Approximate Shapes
L-Bar Site, Chewelah, WA

CH2M HILL

Attachment B

Geophysical Survey Data Report from Zonge International, Inc.
(Zonge 2012)

Final Data Report

Geophysical Investigation

L-Bar Site, Chewelah, Washington

Prepared For

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Zonge Project # 12111
August 17, 2012

Final Data Report

Geophysical Investigation

L-Bar Site, Chewelah, Washington

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Geophysical Investigation

L-Bar Site, Chewelah, Washington

INTRODUCTION

This report conveys the results of a geophysical investigation which Zonge International, Inc. (Zonge), conducted at the L-Bar property south of Chewelah, Washington (Figure 1). The investigation utilized electromagnetic techniques to map areas of elevated conductivity which may be indicative of residual chloride from material stockpiles.

The objective of the survey was to map areas of elevated terrain conductivity which may occur on site due to Flux Bar and Flux Bar residue material remaining on the site. The area of concern includes the southeast portion of the Magnesite Residue Pile, up to 20 feet high, surrounding monitoring well SA-10. That monitoring well is reported to have elevated conductivity, chloride and ammonia levels. The groundwater flow direction in the vicinity of well SA-10 is to the northeast. The geophysical investigation was designed to identify possible source areas of former process materials which may be causing the elevated conductivity.

Zonge conducted this electromagnetic (EM) investigation survey utilizing the Geonics EM31 and EM34 terrain conductivity meters. These instruments both measure the electrical conductivity of the ground using electromagnetic induction, without ground contact. The EM31 has a depth of investigation of 15-20 feet, whereas the EM34 has a greater depth of investigation; up to 50 feet with the configuration used in this survey.

Apparent conductivity data plots are attached as Figures 2 through 5. Quality Control data and documentation are included as Appendix A of this report. An information sheet with a brief explanation of electromagnetic methods used in geophysics is included as Appendix B.

ELECTROMAGNETIC SURVEY

EM31 data were acquired over the area of concern on June 19, 2012 by a senior geophysicist and a geophysical technician from the Portland office of Zonge. Those data were processed to provide a preliminary field interpretation to assist with the determination of whether it would be necessary to collect EM34 data. From that preliminary interpretation it was judged, by the Zonge field geophysicist, the CH2M HILL field representative and a CH2M HILL geophysicist, that the near surface conductivity was sufficiently defined, but that data from the EM34, providing a greater depth of exploration, would also be a useful compliment to the EM31 data.

EM31 Data Acquisition

EM data were acquired using a Geonics EM31 terrain conductivity meter (SN: 9009001). Both quadrature (conductivity) and in-phase data were recorded. The instrument was run in the normal vertical dipole orientation. This instrument was run in the "continuous" sampling mode, recording the EM response at 0.2 second intervals (approximately 1 foot). Nominal line spacing was 15 feet. This data density was selected to adequately resolve conductivity features with expected dimensions of 50 feet or greater.

In the area south of the Magnesite Residue Pile, the initial data collected on north-south lines was clipped at values over 200 mS/m where the response overloaded the instrument. Those clipped data were removed from the dataset and data recollected, on east-west lines at a lower instrument gain (1000mS/m full scale range).

EM34 Data Acquisition

EM34 data were acquired on June 20, 2012. Data were collected with an Geonics EM34 (SN: 9820002) using a 10 meter coil spacing in both the vertical dipole and horizontal dipole modes. Data were acquired at a 30 foot station spacing on lines spaced 30 feet apart. Data were edited to remove data spikes where interference was suspected.

GPS Navigation

Location data were acquired concurrently with the EM31 and EM34 data using a Trimble AG132 (SN: 402374) Differential Global Positioning System (DGPS). That system provides visual feedback to the operator to assure that he is "on line" and that the survey area is covered uniformly. This system is a real time differential GPS system using the Omnistar satellite subscription service for the differential correction. The GPS system has "sub-meter" accuracy; hence positions are generally good to ±1-2 feet, but may be off by 2-3 feet.

Data Processing

EM31, EM34, and GPS data were transferred from the Allegro data logger and reformatted into ASCII xyz files, with UTM coordinates using the Geonics/Geomar programs Trackmaker 31 and DAT34. GeoSoft OASISmontaj™ data processing and analysis software was used to edit and grid the data and to create the maps for presentation. Data were gridded using a kriging algorithm with 1 foot and 10 foot grid cells for the EM31 and EM34 data respectively. Contour maps of apparent conductivity are included as Figures 2 through 4. A contour map of EM31 in-phase data is included as Figure 5.

RESULTS AND INTERPRETATION

The EM apparent conductivity plots are presented as Figures 2 through 4 with several features marked for discussion. Feature **A** is an area of elevated conductivity to the west and southwest of monitoring well SA-10. That conductivity high is most pronounced in the EM31 data, indicating that the conductive zone may be at depths less than 15-20 feet. Table 1 below provides relative depths of investigation for the three EM measurements acquired on this survey. Features **B** and **C** are less pronounced areas of elevated conductivity.

Instrument	Coil Separation	Orientation	Nominal Depth of Investigation
EM31	3.7 meters	VD	5.2 m (17 ft.)
EM34	10 meters	HD	6.8 m (22 ft.)
EM34	10 meters	VD	14.3 m (47 ft.)

"Nominal Depth of Investigation" – depth above which 67% of the signal originates in a uniform earth

HD – horizontal dipole

VD – Vertical Dipole

TABLE 1 – Nominal Depth of Investigation for EM31 and EM34

The EM34 10V data (10 meter separation, vertical dipole), Figure 4, which has the greatest depth of exploration, show broader areas (proximity of **A**, **B**, and **C**) of elevated conductivity. We interpret this to be caused by the groundwater carrying the conductive solutes. With EM34 data it is important to consider that the apparent conductivity is a weighted average conductivity of everything up to and beyond the depth of investigation (22 or 47 feet) with the weighting function decreasing with depth.

In areas on the south and east perimeters of the EM31 dataset (features **SP** & **EP**), the EM31 conductivities are greater than 100 mS/m on the. Those high conductivities are observed at the toe of, and away from the Magnesite Residue Pile. The high EM31 in-phase response (Figure 5) to the east of the Magnesite Residue Pile (**EP**) is indicative of a buried metallic conductor. These areas off of the Magnesite Residue Pile were not subjects of the current investigation and hence were not investigated further.

The EM31 data also shows an anomaly (feature **M**) 50 – 70 feet south of SA-10 which is indicative of buried metal. That anomaly is hatched on Figure 2. The rapid high/low variations are characteristic of metallic conductors. The EM34 data also showed signs of this response and we have edited several questionable EM34 data points out of the data set. This is particularly true of the vertical dipole (10V) data.

Two hundred to three hundred feet (200-300 feet) to the northwest of SA-10 and 100 to 200 feet east of SA-11 (feature **NW** on Figure 2) the EM31 revealed an area of higher conductivities. This area is hydraulically down and cross-gradient from SA-10 and hence was not considered a conductive feature which could be causing the characteristics observed at SA-10.

To conclude, this EM survey has produced a robust and consistent terrain conductivity dataset with three increasing depths of investigation. Those datasets showed areas of increased conductivity within the Magnesite Residue Pile which may be indicative of increased chloride concentrations.

FILE: Zonge LBar EM Rpt12.docx
Zonge Project: 12111

REVISION: A-23-JUL-12
DATE: JUNE 2012
FILE: SITE LOCATION.map
ZONGE PROJECT 12111

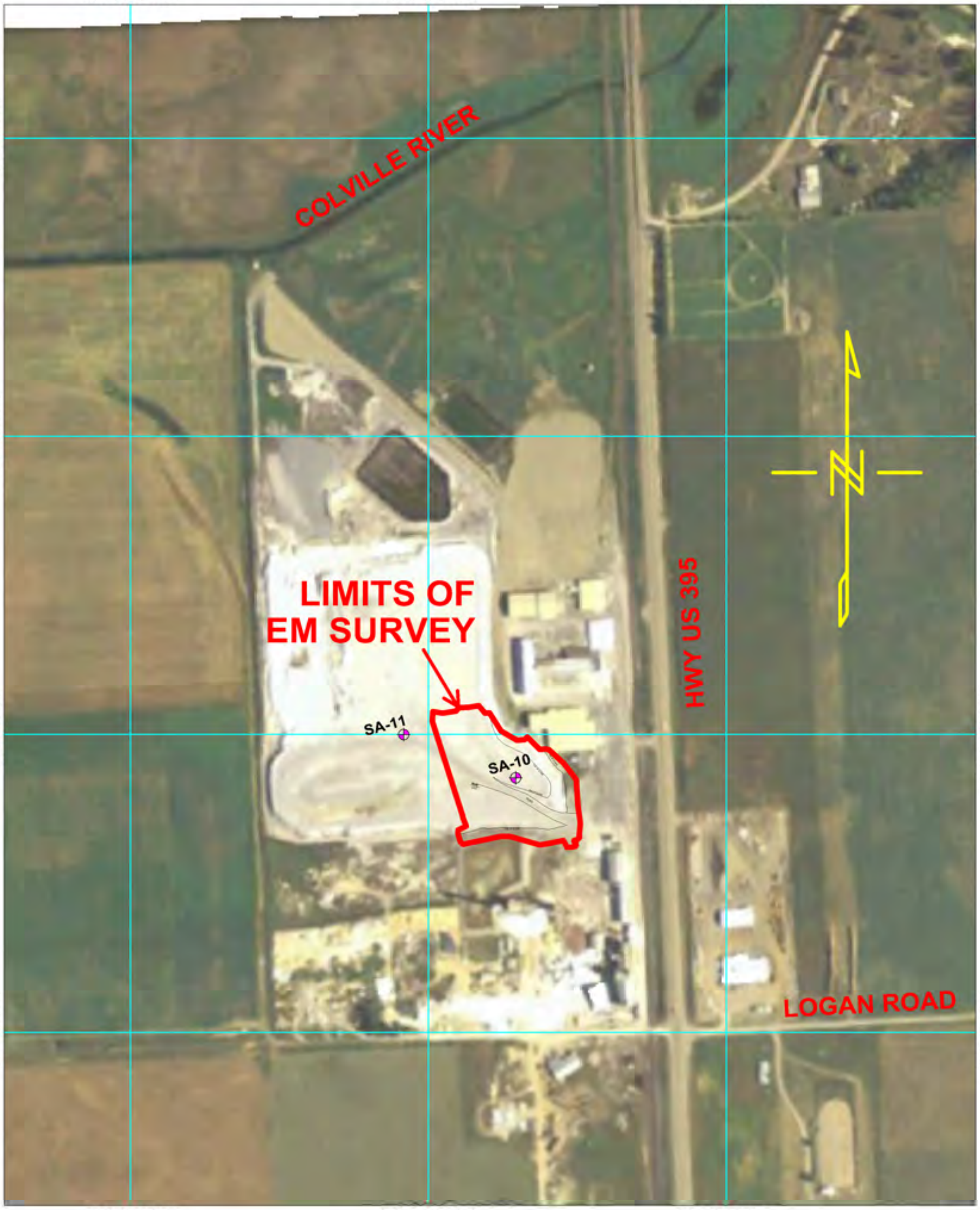


IMAGE FROM GOOGLE EARTH 7/31/2005
Copyright 2012 Google
Used with Permission from Google

Scale 1:7200

250 0 250 500

US survey foot

NAD83 / Washington North (ftUS)

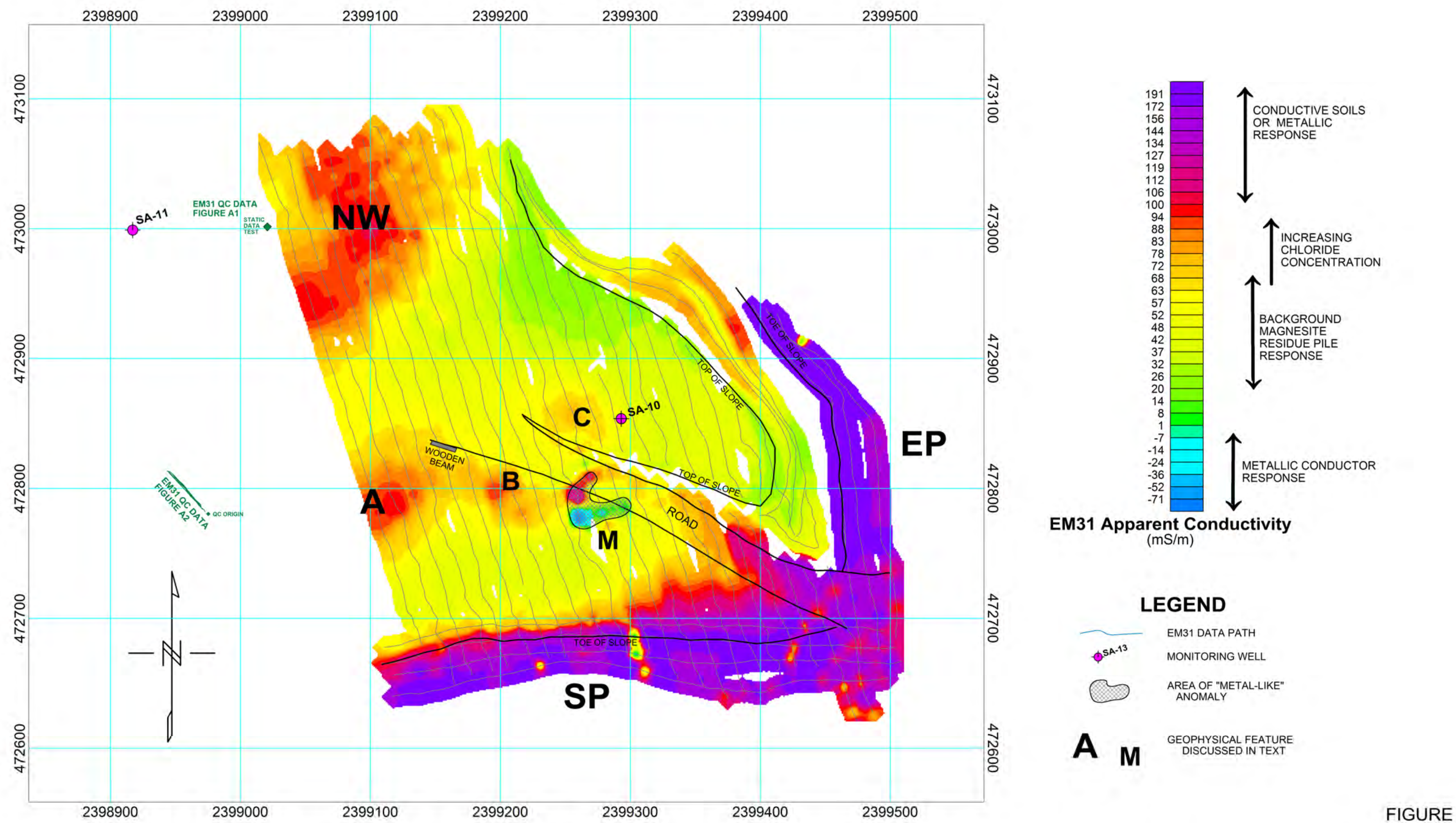
FIGURE 1

Prepared by: Zonge TRUSTED GEOPHYSICS

Prepared for: CH2MHILL

SITE LOCATION

Geophysical Investigation
L-Bar Property
Chewelah, Washington



REVISION: C-15-AUG-12

DATE: JUNE 2012

FILE: LBAR EM31.map

ZONGE PROJECT 12111

FIGURE 2

Scale 1:960

50 0 50 100 150

US survey foot

NAD83 / Washington North (ftUS)

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Zonge TRUSTED GEOPHYSICS

Prepared for:

CH2MHILL

EM31 APPARENT CONDUCTIVITY DATA PLOT

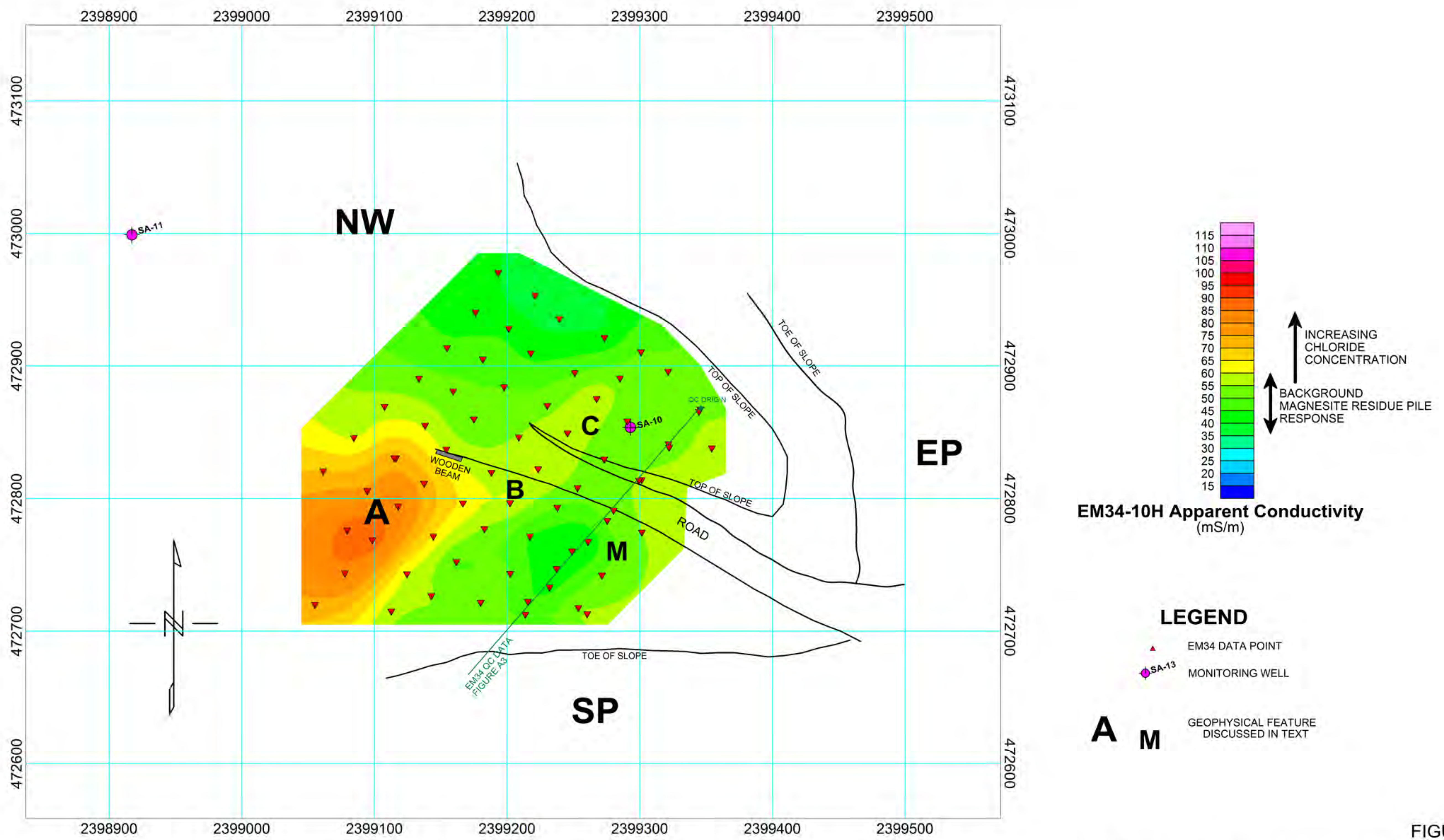
Geophysical Investigation
L-Bar Property
Chewelah, Washington

REVISION: C-15-AUG-12

DATE: JUNE 2012

FILE: LBAR EM34-10H.map

ZONGE PROJECT 12111



Scale 1:960

50 0 50 100 150

US survey foot

NAD83 / Washington North (ftUS)

FIGURE 3

EM34 10m HORIZONTAL DIPOLE APPARENT CONDUCTIVITY DATA PLOT

Geophysical Investigation
L-Bar Property
Chewelah, Washington

Prepared by:
Zonge
TRUSTED GEOPHYSICS.

Prepared for:
CH2MHILL

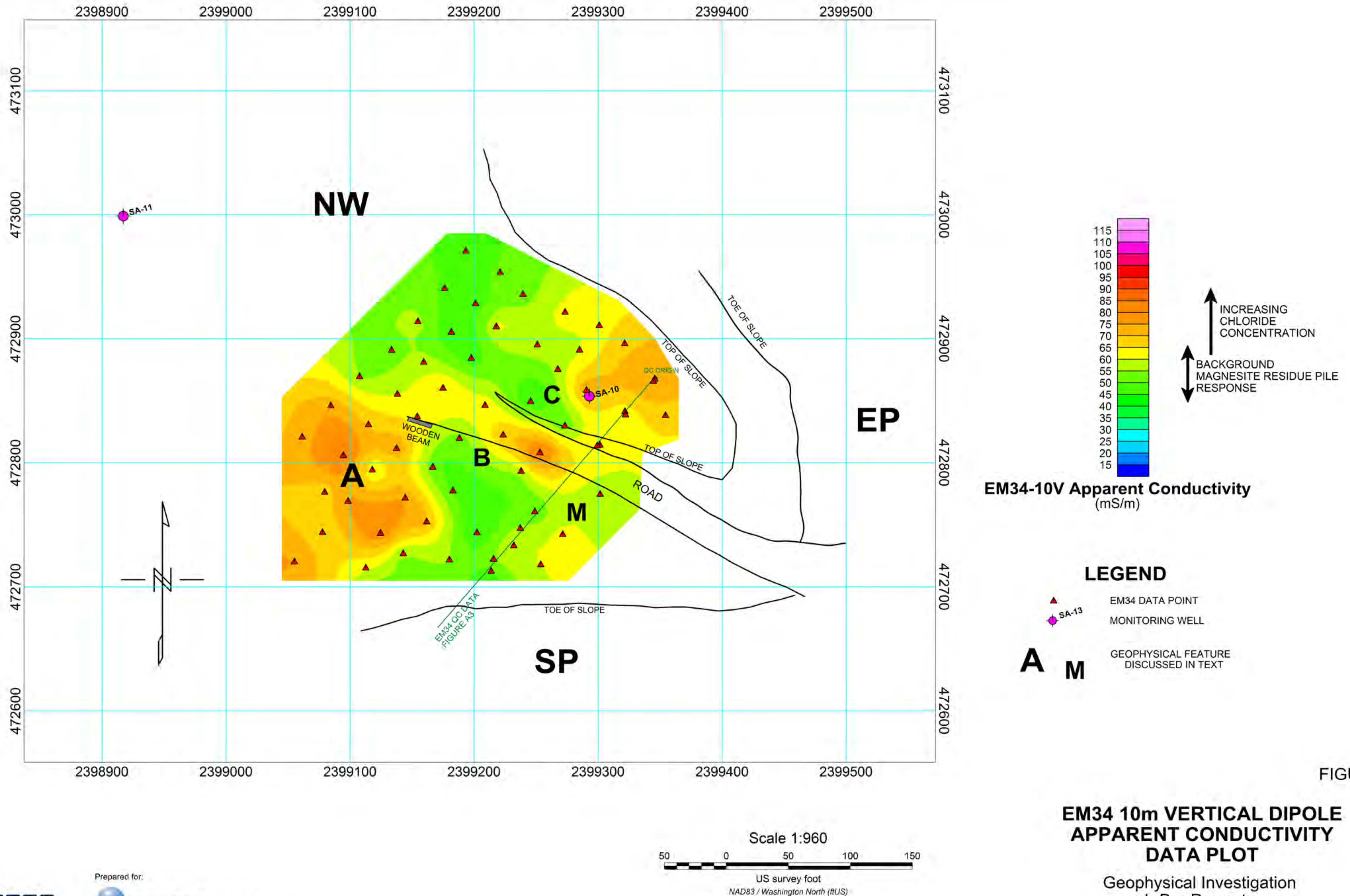


FIGURE 4

EM34 10m VERTICAL DIPOLE APPARENT CONDUCTIVITY DATA PLOT

Geophysical Investigation
L-Bar Property
Chewelah, Washington

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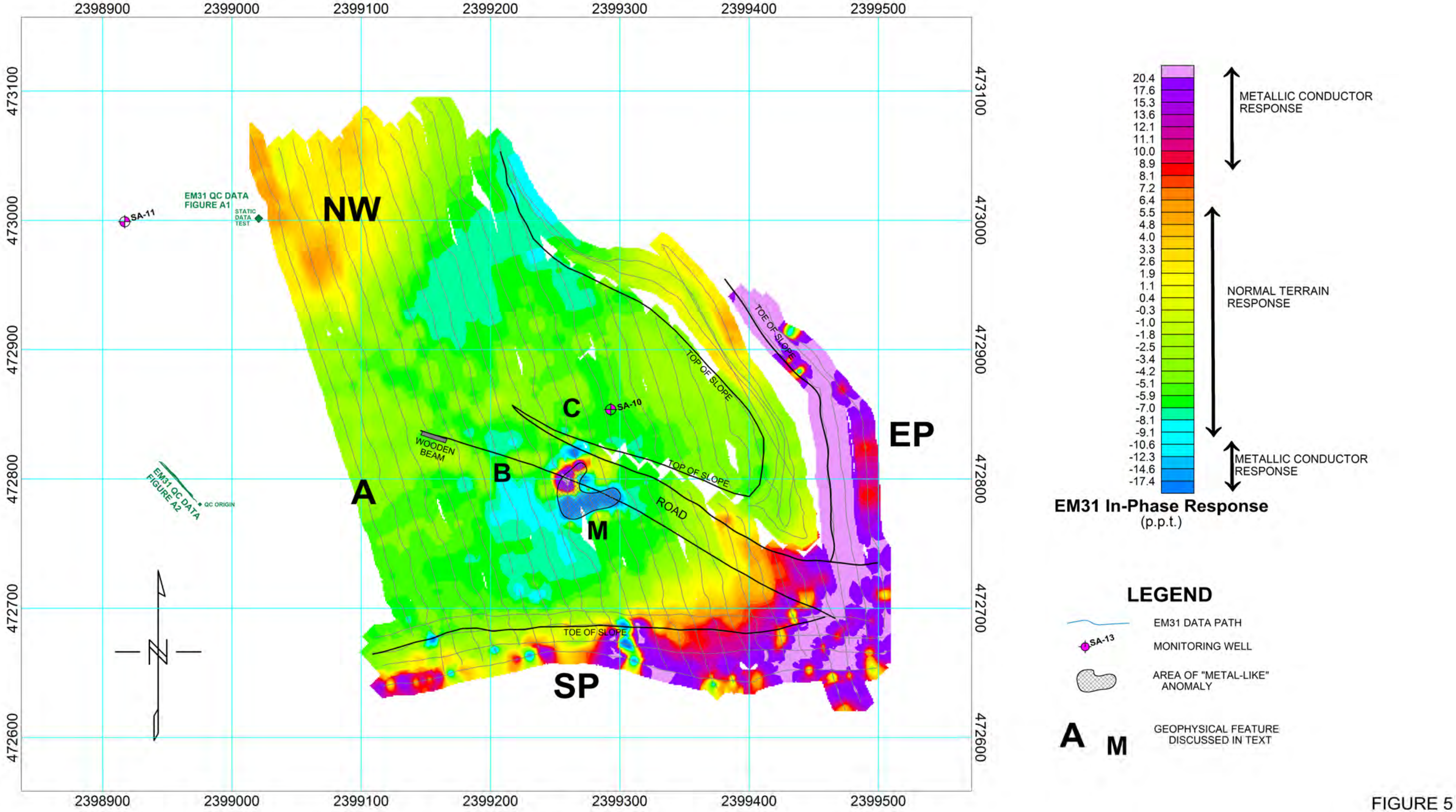
CH2MHILL



REVISION: C-15-AUG-12

DATE: JUNE 2012

FILE: LBAR EM31_I.map

ZONGE PROJECT 12111

FIGURE 5

Scale 1:960

50 0 50 100 150

US survey foot

NAD83 / Washington North (ftUS)

EM31 IN-PHASE RESPONSE DATA PLOT

Geophysical Investigation
L-Bar Property
Chewelah, Washington

Prepared by: Zonge TRUSTED GEOPHYSICS

Prepared for: CH2MHILL

Geophysical Investigation

L-Bar Site

Chewelah, Washington

APPENDIX A

Quality Control Data

Quality Control Data

This Appendix presents the Measurement Quality Objectives and Quality Control data and documentation for the electromagnetic investigation at the L-Bar facility. A copy of the field data log is included as an attachment to this Appendix.

- EM31 Warm-up and Functional Checks: The EM31 was allowed to warm up 10 minutes prior to acquiring data. The manufacturer recommended functional checks and adjustments we conducted including: battery check, compensation check/null, phase check/adjust, and sensitivity check.
- EM31 Static Background: Static background check was conducted prior to the survey, recording data at one location for a period of 1 minute. That data is shown in Figure A1, *EM31 Static Background Data Plot*.
- EM31 Dynamic Test: An EM31 dynamic test line was established in an area west of the survey area where pipes, rebar, and some scattered debris were present. The line was established crossing what was thought to be an isolated 2 inch pipe on the surface and partially buried. Three profiles were collected over the same line both before and after the EM31 survey. Data are presented in Figure A2, *EM31 Dynamic Test Data Plot*. Differences in the before and after data are thought to be due to minor variations in line position across the pipe and debris. While the site selected for this test turned out to have 2-D effects, no alternative sites with a singular anomalous feature were noted close the survey area.
- EM31 Repeat Data: The EM31 data collection took place over a period of less than four hours and hence none of the survey data were explicitly repeated. The test dataset, shown in Figure A2 serves as a repeat dataset with data from both prior to and after the survey.
- EM34 Warm-up and Functional Checks: The EM34 was allowed to warm up 15 minutes prior to acquiring data. The manufacturer recommended functional checks and adjustments we conducted including: battery check, mechanical meter null, null check, and sensitivity check.
- EM34 Repeat Data: Repeat EM34 data were collected on survey Line 2L (GPS designation). Plots of that data are presented in Figure A3, *EM34 Repeat Data Plot*.

Copies of the field notes are included following Figures A1-A3

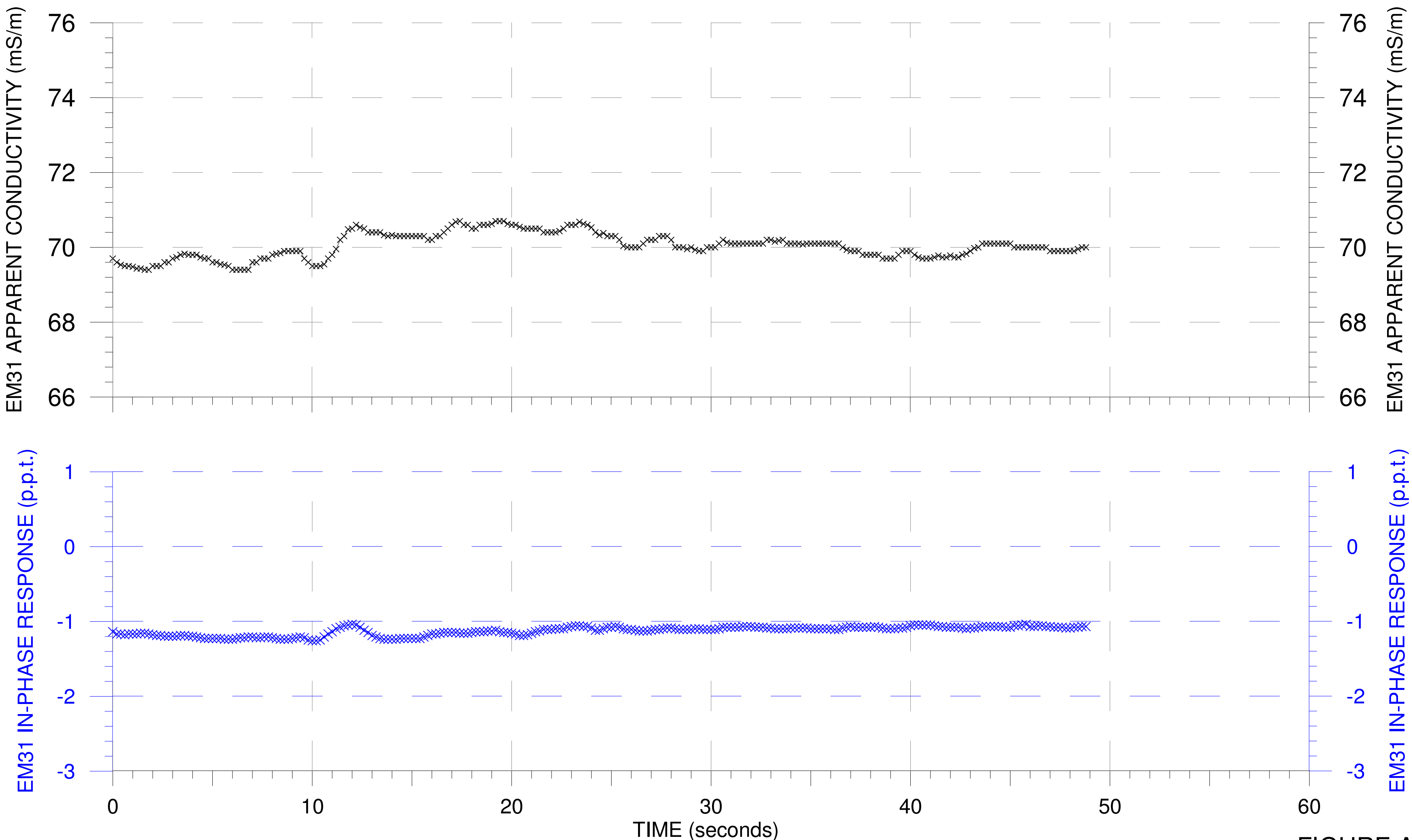


FIGURE A1

EM31 STATIC BACKGROUND DATA PLOT

Geophysical Investigation
L-Bar Property
Chewelah, Washington

Prepared by: Zonge TRUSTED GEOPHYSICS.

Prepared for: CH2MHILL

Zonge Project #: 12111 FILE: EM31 Ref Line.grf REVISION: B-15-AUG-2012

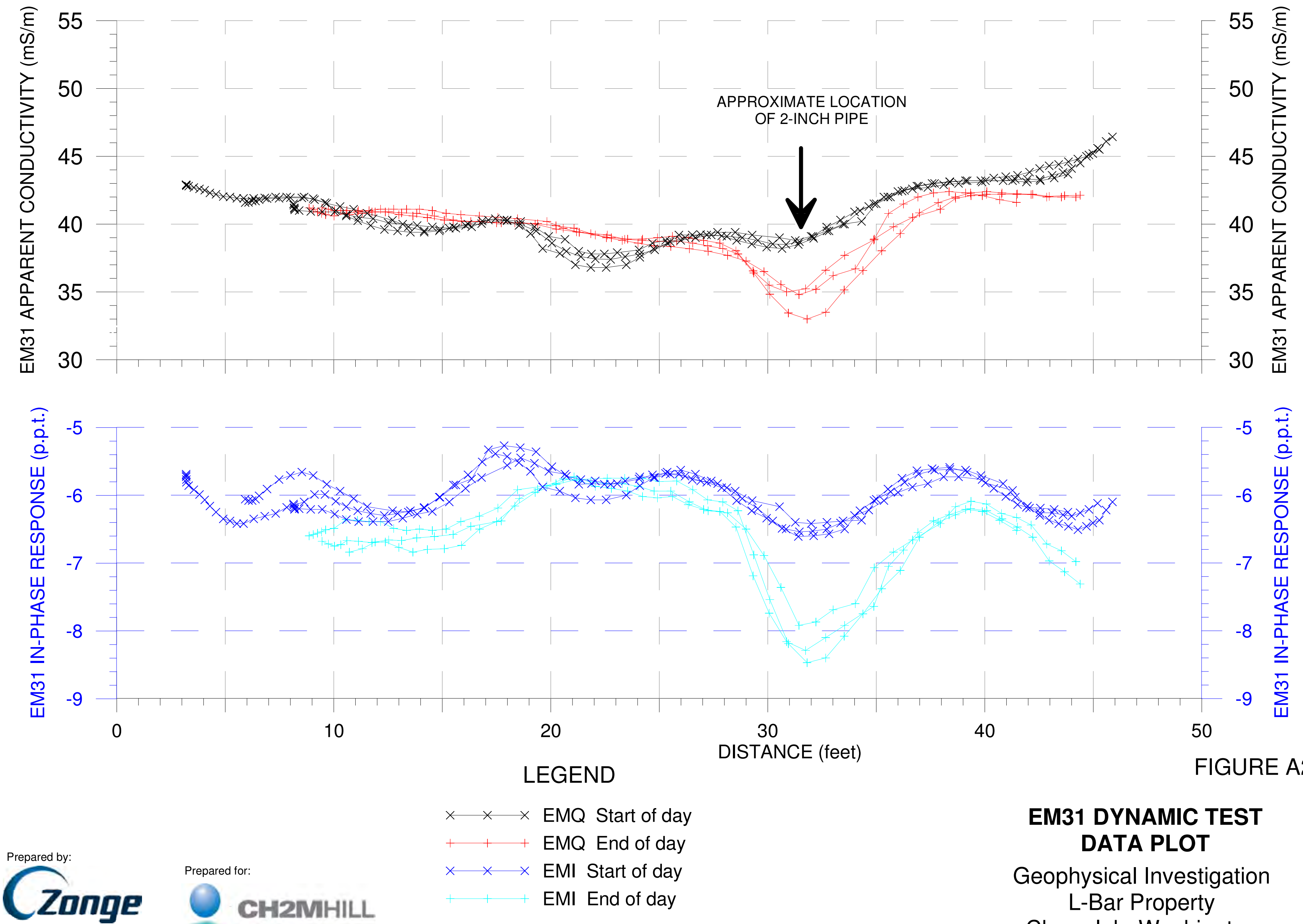


FIGURE A2

EM31 DYNAMIC TEST DATA PLOT

Geophysical Investigation
L-Bar Property
Chewelah, Washington

Prepared by: Zonge TRUSTED GEOPHYSICS.

Prepared for: CH2MHILL

Zonge Project #: 12111 FILE: EM34 L-2.grf REVISION: A-20-JULY-2012

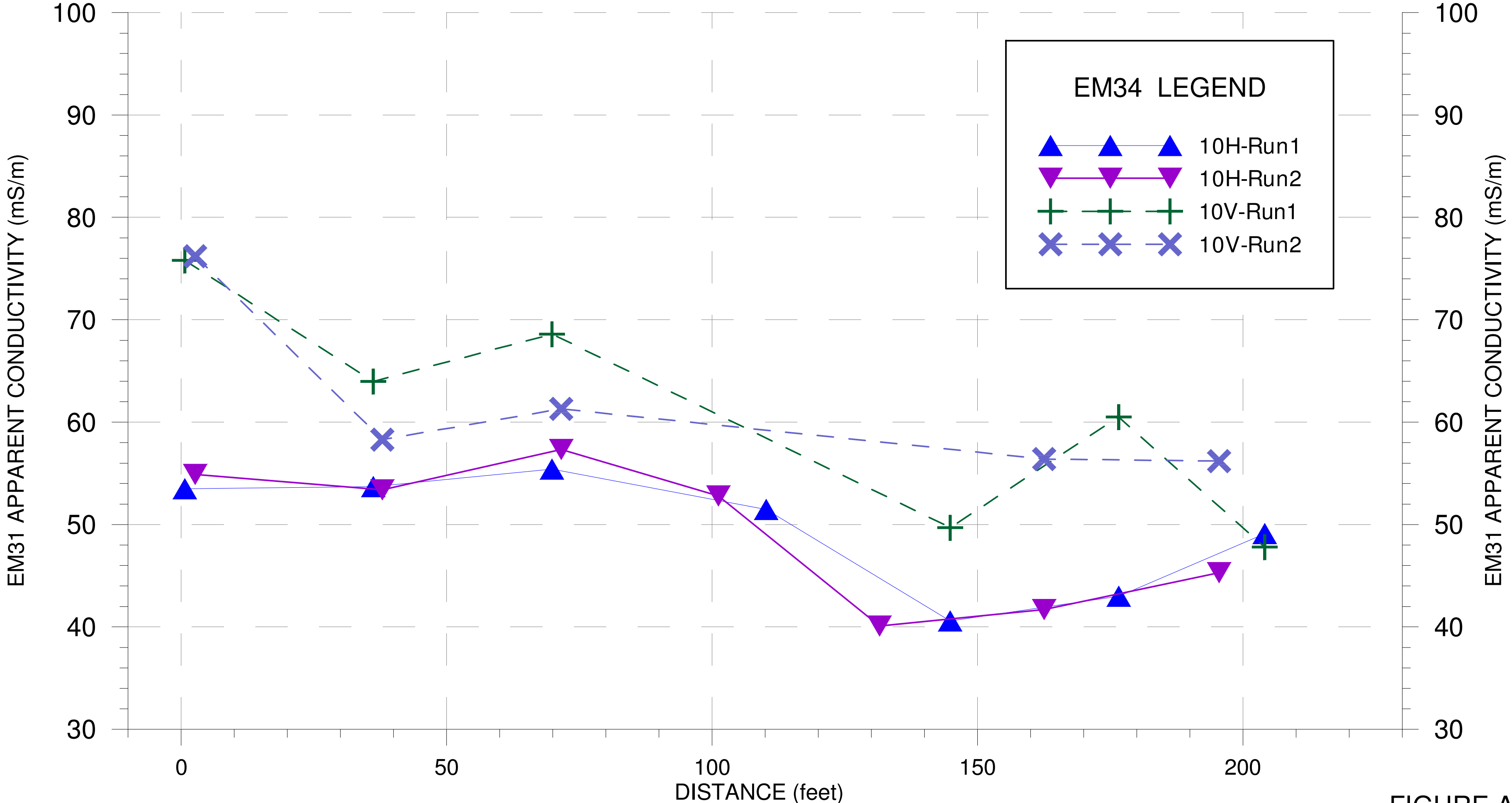


FIGURE A3

EM34 REPEAT DATA PLOT

Geophysical Investigation
L-Bar Property
Chewelah, Washington

Prepared by: Zonge TRUSTED GEOPHYSICS.

Prepared for: CH2MHILL

Geophysical Investigation

L-Bar Site

Chewelah, Washington

APPENDIX B

Technical Note:

Electromagnetic Induction

Geophysical Services

Environmental • Groundwater • Geotechnical

Electromagnetic Induction

Electromagnetic induction (EM) profiling is a surface geophysical technique used to measure terrain conductivity, a term which refers to the bulk electrical conductivity of subsurface materials. EM conductivity surveying is primarily a tool for rapid lateral mapping of variations in soil conductivity. It is used for ***mapping lateral transitions in soil type, contaminant plumes, sand and gravel deposits, clay aquitards, and shallow bedrock***.

FIGURE 1 - GEONICS EM31

FIGURE 2 - GEONICS EM34-3

APPLICATIONS

"Terrain Conductivity," the electrical conductivity of the earth, depends on several soil or geologic parameters including:

- groundwater conductivity,
- clay content,
- soil or formation porosity, and
- degree of water saturation.

EM techniques will respond to changes in any of these parameters. EM techniques are widely used for:

- mapping changes in soil type,
- mapping alluvial paleo-channels,
- delineating leachate plumes from landfills and other impoundments,
- mapping windows or discontinuities in aquitards,
- mapping zones of permafrost,
- mapping and/or detecting other geologic features, and
- detecting and mapping buried metallic objects and debris.

EM surveys can be helpful for siting boreholes, interpolating between boreholes, or directing further detailed site studies.

INSTRUMENTATION

The most common instruments for measurement of terrain conductivity are the Geonics EM31 (Figure 1) and the EM34-3 (Figure 2). Both instruments operate on the same principle, but they differ in their respective depths of exploration. In the EM31, the transmitting and receiving coils are mounted at the ends of a 3.7-meter rigid boom, so that the instrument can be operated by one person. The EM34-3 consists of a transmitting console, a receiving console, and two separate coils which are connected by a cable. The EM34-3 operates with three transmitter-receiver coil separations: 10, 20, or 40 meters. This instrument requires two operators.

(Continued next page)

Northwest Geophysical Associates, Inc.

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www.nga.com · info@nga.com

These EM instruments do not require any ground contact or surface disturbance; therefore, they are rapid, relatively inexpensive, and can be run with little or no exposure to buried toxic materials.

PRINCIPLE OF OPERATION

The basic principle of operation of the EM method is illustrated in Figure 3. A transmitter coil radiates an electromagnetic field which induces electrical currents (termed eddy currents, Je) in the earth below the coil.

These eddy currents in turn generate a secondary magnetic field (Bs). The receiver coil detects and measures this secondary field. The instrument output, calibrated to read in units of terrain conductivity (apparent conductivity), is obtained by comparing the strength of the quadrature phase component of the secondary field to the strength of the primary field. The apparent conductivity measurement represents a weighted average of subsurface conductivity from the ground surface to the effective depth of exploration of the instrument.

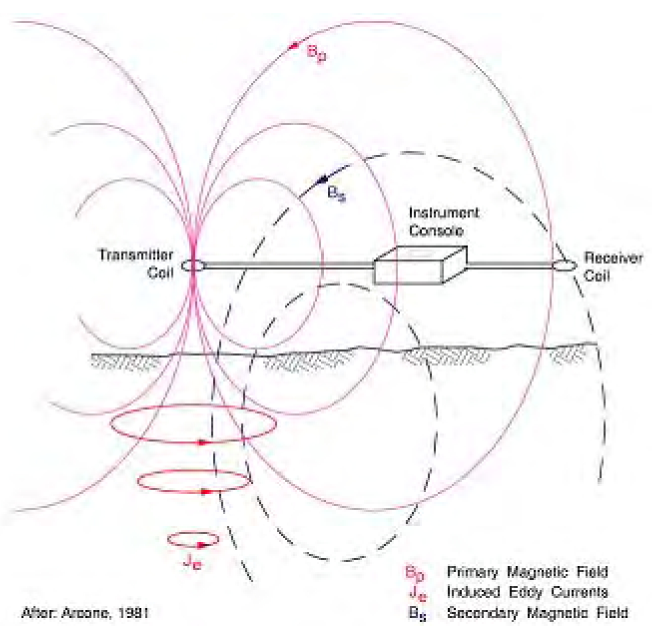


FIGURE 3 - EM PRINCIPLES OF OPERATION

The depth of exploration depends on the separation between the transmitter coil and the receiver coil, as well as on the coil orientation (coil axis/dipole horizontal or vertical). The eight configurations of coil separation and orientation which are possible for the EM31 and EM34-3 are summarized in the table below, together with their "nominal" depths of exploration. In practice, depths of exploration tend to be less than the "nominal" or ideal depths. Nevertheless, the table presents a general overview of the relative depths of exploration of the various coil configurations.

Instrument	Coil Separation	Orientation	Nominal Depth
EM31	3.7 meters	HD	2.5 m (8 ft)
		VD	5.2 m (17 ft)
EM34-3	10 meters	HD	6.8 m (22 ft)
		VD	14.3 m (47 ft)
EM34-3	20 meters	HD	13.5 m (44 ft)
		VD	28.6 m (94 ft)
EM34-3	40 meters	HD	27 m (89 ft)
		VD	57 m (188 ft)

TABLE 1 - NOMINAL DEPTH OF EXPLORATION FOR GEONICS EM INSTRUMENTS

Table Notes
1. HD - Coil Axis/Dipole Horizontal
   VD - Coil Axis/Dipole Vertical
2. "Depth of Exploration" - Depth above which 67% of the signal originates in a uniform earth

FILE: EM_Info04.pub, REVISION: 14-SEPT-2011

Attachment C

Site Photographs taken during the June 2012 Geophysical Survey

Photo 1
Looking West along South Toe of MRP

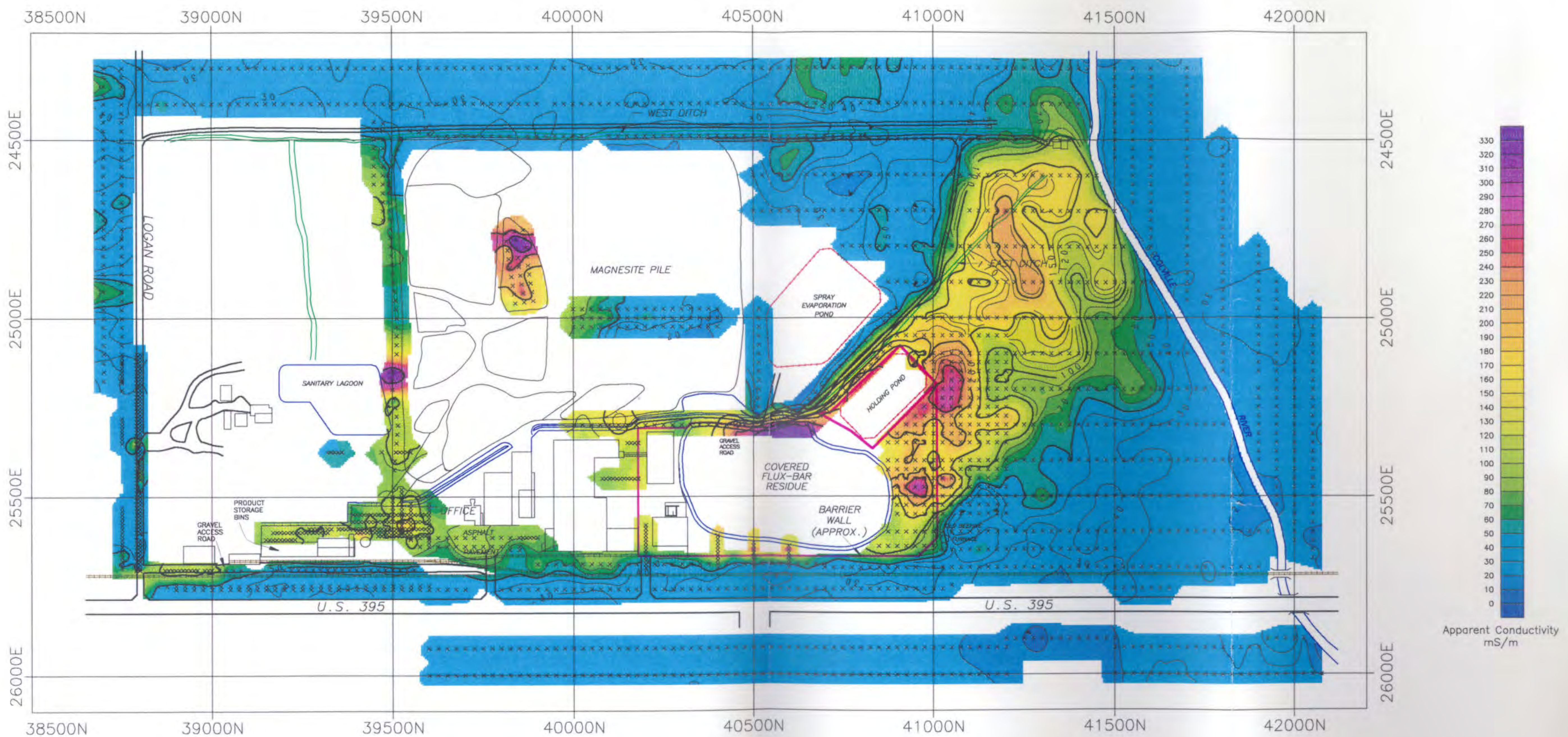
Photo 2
Looking NW from SE Toe of MRP

Photo 3
Looking NW from atop the SE corner of MRP

Photo 4
Looking SW toward Lagoon from atop SE corner of MRP

Attachment D

Survey Results from the Electromagnetic Terrain Conductivity Investigation Report from Northwest Geophysical Associates, Inc. (NGA 1995)



LEGEND

× × × EM-31 DATA POINTS

CONTOUR INTERVAL
10 mS/m

NOTES:

1) BASE MAP FROM CH2M HILL WITH MODIFICATIONS (SEE TEXT)
2) BARRIER WALL LOCATION IS APPROXIMATE, ESPECIALLY ON SOUTH AND WEST SIDES OF FLUX-BAR RESIDUE PILE.
3) DATA LOCATIONS FOR LINES 24490E, 39500N, AND 25300E ARE APPROXIMATE (SEE TEXT).

0 200 400
1 inch = 300 feet

FIGURE 4

EM-31 APPARENT CONDUCTIVITY
HORIZONTAL DIPOLE

L-Bar Site
Chewelah, Washington

Prepared by:
Northwest Geophysical Associates, Inc.
P.O. Box 1063, Corvallis, Oregon 97339
Prepared for:
CH2M HILL

NGA PROJECT #: 335,349 FILE: CDBX12H DATE: 5-JUL-95 REVISION: G-4-DEC-95

LEGEND

× × × × EM-31 DATA POINTS (JUNE SURVEY)

× × × × × EM-31 DATA POINTS (NOVEMBER SURVEY)

× × × × × EM-31 DATA POINTS INFLUENCED BY METALLIC CONDUCTORS; DATA NOT USED IN FINAL COMPILATION

NOTES:

1) BASE MAP FROM CH2M HILL WITH MODIFICATIONS (SEE TEXT)
2) BARRIER WALL LOCATION IS APPROXIMATE, ESPECIALLY ON SOUTH AND WEST SIDES OF FLUX-BAR RESIDUE PILE.
3) DATA LOCATIONS FOR LINES 24490E, 39500N, AND 25300E ARE APPROXIMATE (SEE TEXT).

0 200 400

1 inch = 300 feet

FIGURE 6

EM-31 IN-PHASE RESPONSE

HORIZONTAL DIPOLE

L-Bar Site
Chewelah, Washington

Prepared by:
Northwest Geophysical Associates, Inc.
P.O. Box 1063, Corvallis, Oregon 97339
Prepared for:
CH2M HILL

NGA PROJECT #: 335 FILE: IPHBOX12 DATE: 5-JUL-95 REVISION: G-20-DEC-95