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DESIGN ANALYSIS REPORT
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
PHASE 2 CELL

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COMMENT/RESPONSES

ASARCO East Helena Smelter

Corrective Action Management Unit (CAMU)

Phase 2 Cell Design Analysis Report and Supplemental Submittals

April 4, 2007 EPA Letter, Regarding Design Analysis Report

Conditions of Approval

Comment 1. ASARCO must establish adequate financial assurance via an EPA-approved mechanism prior to commencement of construction of the cell. A detailed cost estimate supporting the proposed financial assurance amount must be submitted with the revision of the proposed design and construction procedures and construction quality assurance plan.

Response: Asarco acknowledges this requirement and is arranging for the financial assurance that EPA requires as a condition of approval for the project.

Comment 2. ASARCO is prohibited from placing bulk or non-containerized liquid hazardous waste or free liquids contained in hazardous waste in the CAMU. ASARCO is also prohibited from placing any liquid which is not a hazardous waste in the CAMU, exclusive of liquid used for dust control measures under an approved EPA plan.

Response: No free liquids will be placed in the CAMU Phase 2 Cell. Section 203.07.8 of Appendix J has been revised to state that, "…no liquid wastes will be placed in the CAMU Phase 2 Cell."

Comment 3. The 2007 demolition work should facilitate installation of the Dross/Speiss Area slurry wall.

Response: Asarco acknowledges and confirms that construction of the CAMU Phase 2 Cell will facilitate installation of the Dross/Speiss Area slurry wall.

Comment 4. ASARCO is responsible for ensuring the selected construction personnel are familiar with and adhere to the EPA-approved design, which may differ from the bid documents.

Response: URS Corporation has been chosen as the construction contractor for the CAMU Phase 2 Cell and has proposed using Helena Sand and Gravel as a subcontractor for this work. Asarco has already forwarded a list of major changes to URS and once approved, Asarco will provide the contractor with a copy of the design report, including EPA comments. In addition, Asarco will brief the contractor on EPA's requirements during the preconstruction meeting.

Comment 5. ASARCO must submit a final construction report for the CAMU Phase II Cell within sixty (60) days of construction completion.

Response: Asarco acknowledges this requirement.

Comment 6. ASARCO must specify the post-closure care period for the CAMU is 30 years to be extended indefinitely based on the integrity of the CAMU cell components, as verified by long-term monitoring, inspection, and maintenance. ASARCO is required to follow the requirements of 40 CFR Subpart G.

Response: Asarco acknowledges that the post-closure care period for the CAMU is 30 years to be extended indefinitely based on the integrity of the CAMU cell components, as verified by long-term monitoring, inspection, and maintenance. Appendix E has been revise to provide a plan for meeting the requirements of 40 CFR Subpart G.

Comment 7. A condition of approval is that all QA/QC must be overseen by an independent third party geotechnical engineering firm, including construction of the final cap. ASARCO must submit a statement of training and qualifications of individuals designated by the selected firm to provide such oversight of installation of liners, geonet, geotextiles, construction of the leachate collection and leak detection systems and permanent cap, for EPA review and approval. The field QA/QC oversight personnel shall have the authority to require field testing at locations of their choice. They shall also have the authority to require re-work or removal and replacement for areas that do not meet the QA/QC specifications. If 10% or more of the field QA/QC test fail, EPA shall be notified immediately. The Construction Quality Assurance Plan (CQAP) shall be revised to reflect this requirement.

Response: Womack and Associates has been retained by Asarco to provide independent oversight of Quality Assurance and Quality Control. Although retained by Asarco, we understand that Womack and Associates role will be to oversee EPA interests. Womack and Associates is an independent geotechnical engineering firm located in Jackson Hole, Wyoming. Ray Womack, P.E. will provide senior review and oversight. His statement of training and qualifications is included in Appendix L.

Comment 8. Future evaluations of groundwater flow direction (potentiometric maps) would benefit from an additional well or piezometer installed in the area to the southwest of what is referred to as "the subsequent cell" located southwest of the current Phase I Cell and northwest of the proposed Phase II Cell. Since there is currently no well or piezometer located in that area, installing one would aid in defining groundwater flow direction in the CAMU area for both the Phase I and Phase II Cells. This is a requirement for the groundwater monitoring system for design for the Phase II Cell.

Response: An additional well has been installed and added in this location on Figure 1-2 of Appendix D of the design report.

Comment 9. ASARCO must place restrictions on the deeds for both CAMU cells by October 1, 2007.

Response: Asarco acknowledges the requirement to have restrictions on the deeds for both CAMU cells by October 1, 2008.

COMMENT/RESPONSES

ASARCO East Helena Smelter

Corrective Action Management Unit (CAMU)

Phase 2 Cell Design Analysis Report and Supplemental Submittals

I. Landfill Components

A. General Conditions

Comment 1. As reflected in EPA's conditional approval letter for construction of the CAMU Phase II cell, ASARCO must establish acceptable financial assurance prior to commencement of construction of the CAMU cell. This financial assurance shall include adequate funds for construction, capping, and operation and monitoring of the CAMU cells into perpetuity.

Response: Asarco acknowledges this requirement and is arranging for the financial assurance that EPA requires as a condition of approval for the project.

Comment 2. Since the CAMU will be the final storage and disposal location for hazardous waste, ASARCO must consider 40 CFR 264.18 Location standards. 40 CFR 264.18 specifies seismic considerations that require compliance demonstration pursuant to 40 CFR 270.14(b)(11). ASARCO must provide additional information to demonstrate compliance with this standard.

Response: Section 3.8 has been added to the design report and acknowledges that 40 CFR 264.18 requires that the CAMU Phase 2 Cell may not be located within 200 feet of a fault that has had displacement in Holocene time. As discussed in the CAMU Phase 1 Cell Design Report (Hydrometrics, 2000), the U.S. Geologic Survey lists no record of a fault within 200 feet of the site. Part 270, EPA Administered Permit Programs: The Hazardous Waste Permit Program, was not referenced because EPA approved Asarco's request for multiple cells as part of Asarco's 2000 CAMU proposal. The CAMU Phase 2 Cell is to be located in Lewis and Clark County, Montana, which is listed in Appendix VI of 40 CFR 264. Therefore, Figure 3-7 has been added to the design report to demonstrate, based on data from the U.S. Geologic Survey, that there is no known fault, having had displacement in Holocene time, within 3,000 feet of the facility.

In addition, ASARCO is required under 40 CFR 264.301(c)(1)(ii) that the liner be constructed of material that has sufficient strength and thickness to prevent failure due to pressure gradients. Language in the solid waste regulations more clearly explains seismic requirements. 40 CFR 258.14(a) requires all containment structures, including liners, leachate collection systems, and surface water control systems, be designed to resist the maximum horizontal acceleration in lithified earth material for the site.

Response: The U.S. Geologic Survey's seismic deaggregation website suggests that a 2500-year seismic event at the site proposed for the CAMU Phase 2 Cell will result in bedrock

acceleration greater than 0.1 g. Therefore, the proposed location is in a seismic impact zone, which requires Asarco to demonstrate to EPA that the CAMU Phase 2 Cell is designed to resist the maximum horizontal acceleration in lithified earth material for the site. As explained by EPA, "Although deformation is not likely to cause slope failure or liner breachment, damage to the leachate collection system or leak detection system can occur through the bending or rupturing of collection pipes and collection risers" (EPA, 1986). ***Therefore, the CAMU Phase 2 Cell design has been revised to include a seismic analysis focused on the seismic considerations for the design of riser pipes, gas extraction vents, and cap stability and Section 3.8 has been added to the design report to address seismic concerns. This additional analysis has shown the pipes and their foundations to be adequately designed for seismic loads and the cap cover to be stable in an earthquake. These analyses have been added to Appendix C of the design report.***

ASARCO must demonstrate to EPA that engineering measures have been incorporated into the cell's design to ensure that the integrity of the structural components of the landfill unit will not be disrupted. The design should include seismic stability studies for designing the failure along the critical liner interface and for the cap cover stability over the geomembrane.

Response: A seismic slope stability analysis of the cover was performed using a Newmark Rigid Sliding Block Analysis applied to the critical liner interface of the cap cover. Appendix C contains this analysis, demonstrating that the 5:1 cap cover slopes will be stable under seismic loading.

ASARCO has not provided slope stability analyses under static and dynamic (seismic) conditions in the design report. The analyses should include the worst-case conditions.

Response: The Newmark Rigid Sliding Block Analysis is a dynamic analysis developed by the U.S. Geological Survey and is commonly used to check stability of slope under seismic loadings. In addition, a static analysis of the cover was performed using a common slope stability model called STABL and it has been added to Appendix C of the design report as well.

Comment 3. 3.1, Site Selection cites "Montana DEQ siting guidance." ASARCO must include in the report the specific name of this guidance.

Response: The Montana DEQ siting guidance used is found in ARM 17.50.505. This reference has been added to section 3.1, which now states:

> *As required by either 40 CFR 264.18 or ARM 17.50.505, the proposed site, shown on Figure 3-1, has no:*
>
> - *Wetlands*
> - *Floodplains*
> - *Faults*
> - *Instability*

- *Underlying rock fractures or fissures*
- *Insufficient land area*
- *Insufficient public access*
- *Groundwater or surface water pollution potential*
- *Public water supplies*
- *Hydraulic connections to springs*
- *Airport that has jet aircraft within 10,000 feet or*
- *Other airports within 5,000 feet.*

In addition, the site is:

- *At least 200 feet from adjacent property lines.*
- *At least 500 feet from public drinking water sources, residences, schools, hospitals, and centers of community activity.*
- *Within a seismic impact zone. However, pursuant to 40 CFR 270.14(b)(11) it is over 3,000 feet from a fault that has had displacement in Holocene time.*
- *Without subsidence areas.*
- *Not in a sole-source aquifer recharge area.*
- *Without endangered species habitat.*
- *Not in designated state and federal wilderness, parks and preserves.*
- *Not zoned for activities other than industrial use or agriculture.*
- *Without historic or archaeological significance.*
- *Vertically separated from the underground aquifer and without springs.*
- *Distant from groundwater discharge to a water supply well or to surface water.*
- *In simple (homogeneous) hydrogeologic stratigraphy.*
- *In soils that are nearly impermeable or at least in a location which does not intercept or directly overlie an appreciable thickness of permeable soils.*

B. Leachate Collection and Leak Detection System

Comment 1. 2.3, Leachate Collection and Removal System cites 40 CFR 265.301(c)(2) and (c)(3) as design performance standards. This citation is incorrect and should be 40 CFR 264.301(c)(2) and (c)(3).

Response: Section 2.3 has been revised to cite 40 CFR §264.301 (c)(2) and (c)(3).

Comment 2. 2.3, Leachate Collection and Removal System: ASARCO states that the leachate collection and removal system shall be constructed with a bottom slope of one percent or more. ASARCO also states that the CAMU Phase 2 Cell is designed to comply with the Administrative Rules of Montana (ARM) 17.50.506. ARM 17.50.506(6)(b) states that a leachate collection and removal system must be designed and constructed to ensure that the minimum slope at the base of the overlying leachate collection layer is at least 2% and side slopes do not exceed 33% when a compacted soil liner or recompacted natural lithology is used as the barrier layer. ASARCO must clarify whether the design will comply with ARM 17.50.506(6)(b).

Response: Asarco acknowledges the need for a minimum slope of 2% for the leachate collection layer and for a maximum side slope of 33%. The CAMU Phase 2 Cell leachate collection and removal system meets these requirements and complies with ARM 17.50.506(6)(b). Section 2.3 has been revised to state: ***"This system shall be constructed with a bottom slope of two percent or more."***

Comment 3. 3.5.2, Leachate Systems: ASARCO states that the HELP 3 model indicated the designed leachate collection system capacity will be exceeded during a 25-year, 24-hour storm when the fill in the cell is less than 60 inches. The design work plan stated that during construction, the construction contractor will be required to have pumps ready in case of a significant rainfall event. The MDEQ received through their attorney an electronic copy of the Bid Solicitation and Construction Documents, 2007 Cleaning & Demolition Project and CAMU Phase 2 Cell Project. This document was not submitted to the MDEQ by ASARCO for review and comment. The bid document does not include the requirement that the contractor have on-site pumps to manage water in the event of a storm. ASARCO must clarify how water from a storm event prior to final closure of the CAMU will be managed.

Response: The Construction Contract Documents have been revised to require that ***"The contractor shall have readily available pumps capable of pumping 400 gallons per minute in the event of a significant rainfall event."*** *In addition, Section 203.07.8 of Appendix J requires that,* ***"The contractor shall provide a temporary 20-mil RPE Liner for the waste material placed in the CAMU Phase 2 Cell. Special care must be taken to ensure that the waste is covered prior to significant occurrences of precipitation. In addition, the Contractor shall ensure that the waste is placed in a manner that will ensure that the water which falls on the temporary liner will drain to a sump without coming in contact with the waste material and without significant ponding of the water on the temporary liner. The water reaching the sump shall immediately be discharged to the storm water retention pond shown on the Drawings. Therefore, the storm water retention pond shall be constructed prior to placing waste material into the CAMU Phase 2 Cell. Any storm water coming in contact with the waste material shall not be discharged but shall be removed by the Contractor to the Plant water treatment system."***

Comment 4. Page 3-23, storm water management for precipitation events: the text should be expanded to further discuss management of water pumped from the cell during construction and waste placement, providing specifics on the construction of a temporary structure for precipitation management, storage, and transport to the HDS system or offsite TSDF.

Response: Section 4 of the design report has been revised to explain that: ***"The contractor shall be required to have readily available pumps capable of pumping 400 gallons per minute in the event of a significant rainfall event and shall provide a temporary 20-mil RPE Liner for the waste material placed in the CAMU Phase 2 Cell. Special care must be taken to ensure that the waste is covered prior to significant occurrences of precipitation. In addition, the Contractor shall ensure that the waste is placed in a manner that will ensure that the water which falls on the temporary liner will drain to a sump without***

coming in contact with the waste material and without significant ponding of the water on the temporary liner. The water reaching the sump shall immediately be discharged to the storm water retention pond shown on the Drawings. Therefore, the storm water retention pond shall be constructed prior to placing waste material into the CAMU Phase 2 Cell. Any storm water coming in contact with the waste material shall not be removed by the Contractor but shall be allowed to soak into the waste or removed to the Plant water treatment system."

The Asarco East Helena Plant utilizes two million-gallon-capacity storage tanks to manage stormwater collected from the Plant. Asarco's practice is to limit maximum storage to one million-gallon-capacity tank. The remaining one-million-gallon-capacity tank will be reserved for storm water collected at the CAMU, should it be needed by the contractor.

Comment 5. 3.5.2.1, Primary Leachate Collection and Removal (PLCR) System and 3.5.2.2 Leak Detection, Collection, and Removal (LDCR) System: ASARCO's PLCR and LDCR design includes a geonet layer. For better leachate collection and drainage, additional liner protection, and seismic stability, we strongly encourage ASARCO to use a geo-composite drainage laminate. The geo-composite drainage laminate must be comprised of an 8 oz. non-woven geotextile below and above a geonet.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): Although the addition of a double-sided geo-composite might improve the stability of the liner system and possibly some additional liner protection, it would significantly decrease leachate collection and drainage. Composite geonets have a lower transmissivity than regular geonets and the potential for holding a significant amount of water, which will slow down the drainage rate. In our design, we are using a non-composite geonet for the leak detection drain and a single sided composite for the leachate collection drain. The largest portion of the cell covered by geonet, is the relatively flat bottom where the friction angle between the liner and the geonet is not critical to the cell performance. The geonet located on the steeper 3:1 side slopes are to be anchored with the liners and have slope lengths of less than 30 feet long. Therefore, in an application like this one where the slope lengths are short and the slopes relatively shallow, there is not a compelling need to sacrifice transmissivity for slope stability. Please clarify whether you are requiring the use of the double-sided geo-composite, recommending it despite the engineer's explanation given above, or just suggesting that we consider it in the design.

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): Direct shear test and seismic stability analysis were not provided in the design report. EPA has required this information. Asarco should provide the analysis demonstrating that the friction angle between the liner and the geonet is not critical. A geo-composite drainage laminate will likely improve the stability of the liner system. Geonet itself lacks filter fabric to avoid introduction of fines. Preventing the intrusion of fines into the geonet is critical to performance and drainage. Asarco must provide test to support assertions regarding drainage if a geo-composite is not used.

Response: Section 3.7.2.2 has been revised to address EPA's requirement, stating, ***" In fact, the system is identical to the PLCR in design with the geonet used as a composite between two 8 oz non-woven geotextiles"*** *and Section 624 of Appendix J has been revised to require the drainage layer to be comprised of a geocomposite, stating,* ***"The work covered by these Specifications consists of furnishing and installing high density polyethylene (HDPE) geonet heat bonded and sandwiched between two layers of 8 oz/yd^2 non-woven geotextile where shown on the Drawings or directed by the Engineer."***

Comment 6. Page 3-22, Section 3.5.2.1, please provide the construction specifications for the leachate system and leak detection system, including the materials of construction for the pumps, sumps, geonet, riser pipers, methods to join and connect these materials.

Response: The design of the leak detection and leachate collection system has been added as Sheet 29 of Appendix I and Section 624 and 708 of Appendix J.

Comment 7. Pages 3-25 and 3-26, for the PLCR and the LDCR, please provide the capacity calculations and design size.

Response: Appendix C of the report has been revised to include these calculations.

C. Compacted Clay Liner

Comment 1. Page 3-4, Section 3.2.1, EPA disagrees with ASARCO's statement that the effective permeability of $1*10^{-7}$ can be achieved using site borrow soils. Our evaluation of the geotechnical engineering characteristics of the soils indicates that they do not have the properties necessary to consistently meet the performance standard for the hydraulic conductivity. Asarco must revise the text. If a GCL is used in combination with 3 feet of clay liner, EPA will require that all borrow soils used for the clay liner meet a minimum hydraulic conductivity of $1.0 * 10^{-6}$.

Response: Both the plans (Appendix I) and specifications (Appendix J) have been revised to include the GCL used in combination with 3 feet of clay liner. However, please note that the intended purpose of the geotechnical investigation and design report were not to demonstrate to EPA that a permeability of 1x10-7 can be achieved using site borrow soils. Asarco believed this performance standard was a forgone conclusion to which EPA had already

consented. In a July 16, 2006 letter, Hydrometrics intended to request EPA's concurrence on this matter so that they would be free to take an abbreviated approach for the geotechnical investigation than was conducted for the CAMU Phase 1 Cell design. The CAMU Phase 1 Cell investigation had gone to great expense to build a test liner, install a large diameter double-ring-infiltrometer and over the course of several months of testing, demonstrate that the clayey-loam soil would provide the 10^{-7} centimeter-per-second permeability required to meets or exceeds EPA performance standards. Therefore, Hydrometrics suggested that for CAMU Phase 2 Cell, time and effort would be better spent on insuring that the site of the CAMU Phase 2 Cell meets or exceeds the conditions of the site for the CAMU Phase 1 Cell. The July 16, 2006 letter was intended to be a request for EPA approval to take this approach.

Comment 2. If a GCL is used with the clay liner, the design report must be updated to include additional information on the GCL design specifications. EPA will require that the geosynthetic clay liner be needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile. The needle-punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope.

Appendix G should be modified to include the specification requirements for the GCL and conformance testing. If a test result is in non-conformance, all material from the lot represented by the failing test should be considered out of specification and rejected.

Response: The project plans, which have been added as Appendix I of the report, have been revised to include a GCL above the 3-feet of compacted clay, and Sections 625.04 and 625.05 of the specifications, which have been added as Appendix J of the Design Report, have been revised to require a needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile. The needle-punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope.

Comment 3. Page 3-8, Table 3-1, Geotechnical Test Pit Sample Summary, Hydraulic Conductivity, please amend the text to indicate that the required hydraulic conductivity was not achieved even after an increase of effective stress to 22 psi and resulting consolidation.

Response: Section 3.2.2.4 has been revised to include a statement that ***"Although these results are relatively consistent with those obtained for the CAMU Phase 1 Cell and indicate that hydraulic conductivity is reduced by one to two orders of magnitude under a surcharge pressure, the EPA required hydraulic conductivity of 10-7 cm/sec was not***

achieved by any of the samples. Therefore, the addition of a GCL to the secondary liner will be required by EPA in order to meet this performance standard."

Comment 4. Page 3-12, second paragraph. EPA disagrees with ASARCO's assessment that the site soil is suitable for use in construction of the compacted clay liner. A major concern for the proposed CAMU Phase II Cell is related to the on-site soils that are to be separated out and used for the compacted clay liner. Evaluation of the geotechnical engineering characteristics of the soils indicates that they do not have the properties necessary to consistently meet the performance standard for the hydraulic conductivity. Soils data contained in the Geotechnical Investigation Report (Hydrometrics, Inc., October 2006) indicate that the soils are borderline with regard to attaining the performance standard. Table 2 of that report indicates that none of the soil samples from the Phase II Cell area submitted for hydraulic conductivity testing attained the performance standard after standard compaction. None of those soils had been tested at an effective stress of 22 psi, which will simulate consolidation and can lower the conductivity. However, for comparative purposes, Table 2 also contains the results for nine soils that were tested at the effective stress of 22 psi, for the Phase I Cell, five out of nine (56%) of those soils failed to attain the performance standard. Therefore, from a comparative standpoint, similar results would be expected from the soils proposed for use at the Phase II Cell. This is especially poignant given that they exhibit higher pre-stress conductivities than the Phase I Cell soils. Consequently, there is a high probability that most of the on-site soils will not attain the performance standard. This is a serious problem that must be adequately addressed.

There are four ways to address this issue. The first is to amend the soils with bentonite. This will require adding powdered bentonite to the soil and mixing in a pug mill at the optimum moisture for mixing, prior to placement and compaction. The second is to import clay liner material that will meet the performance standard from an off-site location. The third is to visually separate the on-site soils as proposed; however, QA/QC samples from the separated soils must be collected on a much more frequent basis than that proposed in Table 3-1 of the CQAP. Each stockpiled batch must be proven to meet the hydraulic conductivity performance standard. This will require each batch to be stockpiled separately until the results are obtained for that batch; batches that fail are to be discarded or amended. The fourth alternative is to install a geosynthetic clay liner on top of the compacted liner.

If the choice is to use the separated soils without amendment with bentonite, then the CQAP must be revised to reflect a significant increase in the frequency of QA/QC samples needed to ensure the performance standard is met. QA/QC batch size will be small (hundreds), not thousand of cubic yards. Each batch must have a hydraulic conductivity test performed on it, which must meet or exceed the performance standard prior to placement.

The CQAP should be revised to reflect which alternative will be employed at the site. It should also be revised to reflect the necessary changes in QA/QC to ensure the performance standards are met. In addition, it should include a discussion of

contingencies to be undertaken in the event that the performance standards are not met.

Response: As explained in response to comment 1, the plans and specifications have been modified to incorporate a GCL liner between the compacted clay soil and the bottom 60-mil HDPE membrane in the secondary liner as shown in Figure 1-1. However, please note that the intended purpose of the geotechnical investigation was not to demonstrate to EPA that a permeability of 1x10-7 cm/sec can be achieved using site borrow soils, because Asarco believed that achievement of this performance standard was a forgone conclusion to which EPA had already consented. Otherwise, Asarco's engineer, Hydrometrics, would have demonstrated to EPA at what compaction effort, if any, a 10^{-7} cm/sec permeability can consistently be obtained using site soils. "EPA requires that soil liners be built so that the hydraulic conductivity is equal to or less than 1 x 10^{-7}cm/sec. To meet this requirement, certain characteristics of soil materials should be met. First, the soil should have at least 20 percent fines (fine silt and clay sized particles)." "Second, plasticity index (PI) should be greater than 10 percent." "Hydraulic conductivities are consistently below 10^{-7} cm/sec of soils with PIs greater than 10 percent" and "Third, coarse fragments should be screened to no more than about 10 percent gravel-size particles." (EPA 1989) Therefore, the geotechnical and design reports focused on comparing these three factors to what was used to construct the compacted clay liner in the CAMU Phase 1 Cell.

Comment 5. Page 3-10, Section 3.4, Soil Materials: The initial clay liner of the CAMU Phase 1 cell was rejected because ASARCO was not able to meet the compact clay liner specifications requiring no cobbles and rock fragments having a maximum dimension of more than 2-inches. A screening plant was required to sort and screen the native material to achieve this standard. The Phase 2 Design Analysis Report does not discuss a screening plant for construction of the CAMU Phase 2 cell. ASARCO must explain how it intends to meet the Phase 2 specifications for the compact clay liner without screening.

*Response: Section 203.07.8 of Appendix J has been revised to require "**Cobbles and rock fragments having maximum dimensions of more than 1-inch shall be screened from clay soil used in these liners."** Asarco agreed to replace a portion of the CAMU Phase 1 Cell in order to cooperate fully with EPA. However, Asarco's engineer disagrees with a portion of EPA's comment and would be willing to share data and insight concerning this statement should EPA be interested. Asarco's engineer also disagrees that it is in the best interest of the project to screen plus 1-inch material, because in CAMU Phase 1 Cell, 95% plus of the material screened from the soil was clay not rock as suggested by EPA. However, in order to cooperate fully with EPA, the specifications have been changed as you require.*

Comment 6. Pages 3-10 and 3-12, 3.4 Soil Materials, please expand the document to include the construction specification performance standards for all materials, including local and project site sources for the random fill, engineering fill, and drainage gravel and cover soil.

Response: Construction Specifications have been added as Appendix J of the Design Report.

Comment 7. Page 3-12, last paragraph, no soil particles greater than 1 inch will be allowed to be used to construct the liner. Amend the text to reflect this.

*Response: Section 203.07.8 of the specifications has been revised to require: "**Cobbles and rock fragments having maximum dimensions of more than 1-inch shall be screened from clay soil used in these liners**." The text in the last paragraph on Page 3-12 was taken directly from EPA guidance (EPA/625/4-89/022 Requirements for Hazardous Waste Landfill Design, Construction, and Closure).*

Comment 8. Page 3-22, 3.5.1.2 Secondary Composite Liner, last paragraph, as stated in our comments above, EPA disagrees that ASARCO's geotechnical work has shown that the compaction of native soils will consistently achieve a compacted clay liner with the desired permeability. Asarco must revise the report's text.

*Response: The report text has been revised to explain that the secondary liner **"consists of a 60-mil, double-sided textured HDPE FML, identical to the primary FML in design, underlain by a geosynthetic clay liner and 3 feet of compacted clay. As discussed in Section 3.6.1, EPA has required that a GCL be included above the clay liner to insure a permeability of 10^{-7} centimeters-per-second as required by 40 CFR 264 subpart N**."*

D. Flexible Membranes

Comment 1. 3.5 Component Design: Section 5.0 of the CAMU Phase I design report specified a two feet protective layer adjacent to the bottom and sides of the cell. ASARCO must include a two feet protective layer over the primary liner in the CAMU Phase 2 design. The two feet protective layer must include 12 inches of ¼ to ½ inch size material on the bottom. This two feet protective layer may include 12 inches or more of ¼ to ½ inch size gravel layer used for leachate management. If soil is used as part of the protective layer, the soil may not impede the movement of leachate. The two feet protective layer must be free of oversized material and sharp objects.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): Does this imply that the bottom 12 inches of cushion material can consist of only ¼ to ½ inch size material or can this simply be material smaller than ½ inch? Please clarify what cushion material is required.

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): The 12-inch cushion layer adjacent to the primary leach collection system must be material consisting of material between ¼ to ½ inch in size. This specification is based on guidance and good practice to ensure the flow of leachate and protection of the liner systems.

*Response: Section 203.07.8 of Appendix J has been revised to require that **"The CAMU Phase 2 Cell shall have cushion course placed between the installed liner systems and the larger graded backfill placed in the center of the cell. The cushion material shall be 24" perpendicular to the liner systems along the bottom and sides of the cell. The bottom 12" of***

the cushion layer shall consist solely of material between ½" and ¼". The top 12" shall consist of material passing the ½" screen."

Comment 2. 3.5 Component Design: Frost protection of the liners is very important. Therefore, in the event that ASARCO is not able to load the cell to grade as planned by the end of the 2007 construction season, ASARCO must maintain a 2 feet layer of gravel or other approved material over the bottom and side walls of the cell.

Response: Section 203.07.8 of Appendix J has been revised to require that ***"The CAMU Phase 2 Cell shall have cushion course placed between the installed liner systems and the larger graded backfill"*** *and that* ***"This 24" layer shall be maintained over the side walls and bottom of the cell at all times."***

Comment 3. 3.5.1.1 Primary Flexible Membrane Liner (FML) and 3.5.1.2 Secondary Composite Liner: To ensure a stable interface with the clay and geonet, ASARCO must use a 60 mil double-sided textured HDPE. In addition, the HDPE must have no factory seams.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): Textured liners sacrifice membrane effective thickness for frictional stability. Therefore, this comment is similar to B5, in that EPA appears to be suggesting that the primary function of the liner be somewhat degraded in order to improve stability, even though the engineering and experience with the Phase I cell suggest stability is not a significant issue. Please clarify whether are not you are requiring a textured liner, recommending on despite the engineer's explanation given above, or simply suggesting we consider one in the design.

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): Asarco must use a 60 mil double-sided textured HDPE; **this is not a suggestion but a design requirement**. EPA does not agree that a textured liner sacrifices membrane effectiveness. Asarco may provide minimum average roll values (MARVs) for the nominal thickness and nominal asperity height with test from manufactures to document Asarco's assertion. EPA will evaluate any submitted manufacturer information. As requested in other comments, Asarco must submit lab testing and seismic stability analysis of all proposed liners, geonet, and geocomposites.

Response: Section 3.7.1.1 and 3.7.1.2 have been revised to explain that: ***"Although a 40-mil HDPE will satisfy the strength and survivability requirements for design, the 60-mil HDPE double-sided textured geomembrane used in the cell design provides an additional factor of safety during the critical period of increased stress that may occur when the CAMU is being filled"*** *and that the liner* ***"consists of a 60-mil, double-sided textured HDPE FML".***

Comment 4. Page 3-13, second paragraph, the text indicates that waste materials at the East Helena Plant could subject the cell liners to an extreme pH. Per 264.301(c)(2)(iii), the liner must be constructed of materials that are chemically resistant to the waste managed in the landfill and the leachate expected to be generated. Please provide the testing which ASARCO has performed, per SW-846 Method 9090 to demonstrate this

chemical resistance for the spectrum of wastes to be placed in the landfill or likely to be generated as leachate.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): We did not intend to suggest that we intend to place materials with extreme pH in the CAMU Phase 2 Cell. Asarco has taken steps to drain the Acid Treatment Plant, which is the likely source of extreme PH material, and the Contractor will be required to neutralize any small remaining residual acids left in pipe elbows or low spots. In addition, we have included HDPE liners in our design because we felt that it is the best product for materials with varying pH. Does EPA disagree with this approach, or can EPA suggest a better-suited liner material for this application?

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): EPA agrees that the materials of construction must be compatible with the anticipated waste streams. Please specify the volume of extreme pH material from elbows and low spots which ASARCO estimates will require neutralization. Free liquids are prohibited from disposal in the CAMU.

The third point which I wish to clarify pertains to ASARCO's requirement to ensure that the design of the CAMU cell complies with 40 CFR 264.301(c)(2)(iii), the determination that the liner is constructed of materials that are chemically resistant to the waste managed in the landfill and the leachate expected to be generated. EPA had requested submission of the testing performed per SW-846 Method 9090 to demonstrate the compatibility of the materials of construction with the anticipated waste streams, especially for extreme pH wastes. As you indicated in the conference call, ASARCO has not performed this testing which would require months to conduct. You have proposed, in lieu of this testing, to submit a list of the waste streams which will be placed in the CAMU along with the manufacturers' specifications for the materials of construction to demonstrate material compatibility. You have also committed to submit to EPA the estimated quantity of material which will require neutralization prior to disposal along with the neutralization procedures. As we discussed, ASARCO must also ensure that any neutralized waste stream meets the general prohibition of introduction of liquids into a landfill or CAMU cell, per 40 CFR 264.314 and 264.552(a)(3) requirements.

Response: The following is a partial list of waste streams that will be placed in the CAMU Phase 2 Cell. Neutral pH demolition debris comprised of material identified in the approved list of CAMU eligible wastes make up the balance of the remaining waste streams.

WASTE MATERIALS

Solid Waste Material	***Location***	***Approximate Volume***
Sulfates	*Acid Plant Pipes, Towers, and Tanks*	*10 – 20 Tons*
*Sulfuric Acid (Neutralized)**	*Acid Plant Pipes, Towers, and Tanks*	*5 – 50 Gallons*
Soda Ash (Neutralized)	*Bin 17 Under Highline Railroad*	*4 Cubic Yards*
Catalyst (Neutralized)	*Acid Plant Converter*	*120,000 Liters*
Talc (Neutralized)	*Talc Room at Blast Flue*	*500 Pounds*
Blast Furnace Dust (Neutralized)	*Blast Flue, Loadout, and Baghouse*	*30 Tons*
Wood Chips (Neutralized)	*Bin 18 Under Highline Railroad*	*2 Tons*
Lead Bullion (Neutralized)	*Ringling Building*	*50 Tons*
Matte	*Ringling Building*	*10 Tons*
Speiss	*Ringling Building*	*10 Tons*
Dross	*Ringling Building*	*20 Tons*

* Liquid that will be neutralized and solidified prior to placement in CAMU Phase 2 Cell.

WASTE APPROVED FOR DISPOSAL IN THE CAMU

Category	***Waste Material Examples***
Montana Decree Waste (Direct result of performing Montana Decree cleaning and demolition)	*- Brick, masonry, and kettles* *- Fiberglass, pipe, and ACM transite* *- Soils, slag, and asphalt* *- Concrete blocks, walls, and slabs* *- Furnace metal, dust and lead residue* *- Baghouse bags, belting, lighting* *- Plastic/ceramic saddles and catalyst* *- Rail ties, wood, blankets, insulation*
Contaminated Debris (Waste located throughout the facility and subject to future Montana Decree action)	*- Industrial-sized vacuum hose* *- Wood planking* *- Railroad ties and pallets* *- Concrete slabs/blocks/rubble* *- Plastic/PVC piping/rubber belting* *- Wood chips, soda ash, talc* *- Soda ash and lime* *- In Plant Road Sweepings* *- Slag (mixed with debris)* *- Temporary stack* *- Wood fire houses* *- Adobe clay pile*
Montana Decree 2005 Work Plan	*- Acid plant limerock* *- Zinc plant copper*
Soils from Corrective Action or Capping Activities	

As shown in the first table, the amount of sulfuric acid that may exist in elbows or low spots within the acid plant cannot be accurately estimated, but is estimated to be between 5 and 50 gallons. The project specifications require the contractor to neutralize this material by mixing it with crushed lime rock or other approved means. Additional research and testing related to HDPE liners has been added to Appendix C and based on this documentation, Asarco concludes that the HDPE liners will be compatible with the wastes placed in the CAMU.

Comment 5. Page 3-21, paragraphs one and two, please provide the testing conducted to ensure compatibility of the liner materials with all known and potential waste constituents.

Response: See response to 4 above.

Comment 6. Page 3-17 through 3-22, please amend the text and associated figures to address the above comments and requested to changes to the liner selection and construction.

Response: Section 3.7 and Figures 3-5 and 3-6 have been amended as requested.

Comment 7. Appendix C, Design Analysis Calculations, amends and resubmit the calculations to reflect the revisions in material type and quantities used for construction.

Response: The calculations in Appendix C and Table 3-4 have been revised as you requested.

E. Cushion Layer for Bottom Liner

Comment 1. Page 4-1, Section 4.0, Placement of Waste Soils, Sediments, and Demolition Debris in Cell: The CAMU design must include protection of the liner system. The geotextile and geonet may not be sufficient to protect the liners given the nature of the waste to be placed in the cell.

Asarco's design proposes use of 12 inches of crushed concrete or brick as a cushion layer to protect the liner systems against puncture. EPA will require that a minimum of two feet of material be used as a protective layer. This section indicates that concrete and brick will be crushed on-site to 3/8 inch minus. EPA would prefer the crushing of on-site slag or the use of clean gravel, rather than potentially contaminated or hazardous brick and concrete be used for a cushion layer.

Treatment of hazardous waste in this manner triggers the applicability of additional requirements which are not identified in the report. Large quantity generators may treat hazardous waste on site without a permit provided they are in compliance with the applicable provisions in 40 CFR 262.34 and provided that the treatment is not thermal treatment. We assume ASARCO intends to have equipment onsite that can size the concrete and brick. This activity would likely involve a crusher, conveyors, and staging piles of the waste. A crusher and other mixing and handling equipment would not likely be considered a tank or container because they are not designed to contain an accumulation of hazardous waste. EPA guidance states that if a unit would contain any waste, including a free-flowing liquid, it is a tank (Faxback 12899). Therefore, this operation would not qualify under the exclusion of 40 CFR 264.34 or be "permitted" as a temporary unit pursuant to 40 CFR 264.553.

Since EPA considers the concrete and brick remediation waste, 40 CFR 264.554 staging piles may be applicable. 40 CFR 264.554 states that storage includes mixing, sizing, blending or other similar physical operations to prepare waste for subsequent management or treatment. 67 FR 2997 specifies that more significant treatment operation involving something other than physical treatment—that is, where the chemical character of the waste is changed through chemical or biological treatment do

not fall into the staging pile regulations. Based on our assumptions on how the concrete and brick would be sized, the staging pile regulations would likely apply. If the staging pile regulations are not applicable, it is possible that the activity would need to comply with 40 CFR Subpart X Miscellaneous Units.

The concrete and brick (remediation waste) might also be managed under the CAMU regulations; however, the proposed activity would not be the same activity and design previously approved. The currently approved CAMUs are land disposal units not treatment units. Therefore, the unit would be subject to 40 CFR 264.552 and would likely require an opportunity for the public to review and comment on the plan. Managing this issue under 40 CFR 264.552 would require further evaluation to determine if the treated waste would be subject to treatment standards prior to disposal in the grandfathered CAMU.

EPA can administratively manage a staging pile, Subpart X unit, or new CAMU under the existing federal Consent Decree. The current CAMU was managed as an interim measure. Since a staging pile or Subpart X unit was not included in the Phase I CAMU, we would be obligated to seek public comment if they are used. ASARCO will have to submit additional information to ensure compliance with the applicable standards and to allow EPA to set conditions.

ASARCO must include in the CAMU Phase 2 design report additional information on concrete and brick sizing. If ASARCO intends to have equipment on-site that can produce material to this specification, a description of the type of crushing equipment to be used and the location where the equipment will operate must be specified. If ASARCO is going to treat concrete and brick that may be a hazardous waste, ASARCO must provide additional information regarding the process.

If the facility wishes to contend any treated waste is non-hazardous, a sampling plan to characterize the waste must be submitted. In addition, the implication of sizing any ACM containing material must be addressed by ASARCO.

Response: Section 203.07.8 of Appendix J has been revised to require that ***"The CAMU Phase 2 Cell shall have cushion course placed between the installed liner systems and the larger graded backfill placed in the center of the cell. The cushion material shall be 24" perpendicular to the liner systems along the bottom and sides of the cell. The bottom 12" of the cushion layer shall consist solely of material between ½" and ¼". The top 12" shall consist of material passing the ½" screen."***

F. Construction Quality Assurance/Quality Control Plan

Comment 1. Pages 1-1 and 1-2, "Although QC elements are included in this CQAP, this plan does not fully describe the QC requirements for Phase 2 cell construction. The project specifications describe the majority of QC measures and when taken together with this plan, form a complete set of Construction Quality Control (CQC) requirements. Please amend and resubmit this plan, including the plans project

specifications, which will make this a complete document describing all of the inspection and quality assurance and control requirements.

Response: The CQAP has been revised and resubmitted.

Comment 2. Table 2-1, Quality Assurance Roles by Functional Position, the table indicates that EPA will conduct the progress meetings; however, in Section 2.4.3, the text indicates that the Owner and regulatory agency "may also choose to attend." Please rectify this discrepancy. To clarify our position, EPA would like to be notified of progress meetings, provided an agenda and handouts, participate via phone or in person.

Response: The reference to the regulatory agency in Section 2.4.3 of the CQAP has been deleted. Table 2-1 has been changed to read that EPA will be notified of progress meetings, provided an agenda and handouts, and may participate via phone or in person.

Comment 3. Table 4-1, please see Comment 1, for soil content, liquid and plastic limits, and grain size distribution, please provide the specification or specified limit. For soil content and scarification depth, please provide the specification which serves as the rejection criteria. For number of passes, equipment type and weight, please specify the number of passes, the equipment type and weight.

Response: Table 4-1 of the CQAP has been modified in response to comment 1. Testing components have been segregated into QC or QA tests and, in some cases, acceptance or confirmation tests. The requested limits and rejection criteria have been added to the appropriate tables with one exception. The rolling pattern and equipment that best delivers compaction has been left to the contractor to determine. Once that pattern has been established and shown to give the required results, it will be used as a standard for the rest of the project.

Comment 4. To address EPA's concerns regarding the inability of the soils to consistently meet the hydraulic conductivity performance standard, if ASARCO chooses to separate the soils without amendment with bentonite, then the CQAP must be revised to reflect a significant increase in the frequency of QA/QC samples needed to ensure the performance standard is met. QA/QC batch size will be small (hundreds), not thousand of cubic yards. Each batch must have a hydraulic conductivity test performed on it, which must meet or exceed the performance standard prior to placement. The CQAP should be revised to reflect which alternative will be employed at the site. It should also be revised to reflect the necessary changes in QA/QC to ensure the performance standards are met. In addition, it should include a discussion of contingencies to be undertaken in the event that the performance standards are not met.

Response: A GCL has been added to the secondary liner design to address EPA's concerns regarding the inability of the soils to consistently meet the hydraulic conductivity

performance standard. Therefore, the QA/QC plan has been revised as EPA directed to require:

1. *The CCL will be compacted to meet the performance standard of 1 x 10-6 cm/sec for hydraulic conductivity (Section 4.0).*

2. *The QA/QC requirements in Tables 4-1, 4-2 and 4-3 have been modified as follows:*

   - *Moisture Density Curve – 1 per 2500 cy*
   - *Hydraulic Conductivity - @ 1 test per 3,500 cy*
   - *In-place Density (electrical or nuclear), 5 per acre per lift, no more that 3% outliers, with no dry densities less than 5 pounds per cubic foot below required value.*
   - *In-place Water Content (electrical or nuclear), 5 per acre per lift, no more that 3% outliers, with no water content less than 2% or more than 3% of allowable value.*
   - *In-situ Sand Cone, one per every 10 electrical or nuclear density test*
   - *Oven Water Content, one per every 10 electrical or nuclear test*

3. *Confirmation Test for Hydraulic Conductivity.*

   - *One per five acres (or one for the site).*

Comment 5. If ASARCO decides to install a geosynthetic clay liner on top of the compacted liner, QA/QC criteria for the GCL and reject criteria must be submitted. We refer you to pages 184 through 189 of Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182, September 1993, for establishment of acceptance and conformance testing, placement, joining, repairs, backfilling and covering.

Response: Requirements from EPA/600/R-93/182 have been added to Section 7.0 of the CQAP for the GCL liner.

Comment 6. As stated in the cover letter, a condition of approval is that all QA/QC must be overseen by an independent third party geotechnical engineering firm, including construction of the final cap. ASARCO must submit a statement of training and qualifications of individuals designated by the selected firm to provide such oversight of installation of liners, geonet, geotextiles, construction of the leachate collection and leak detection systems and permanent cap, for EPA review and approval. The field QA/QC oversight personnel shall have the authority to require field testing at locations of their choice. They shall also have the authority to require re-work or removal and replacement for areas that do not meet the QA/QC specifications. If 10% or more of the field QA/QC test fail, EPA shall be notified immediately. The CQAP shall be revised to reflect this requirement.

Response: Womack and Associates has been retained by Asarco to provide independent oversight of Quality Assurance and Quality Control. Although retained by Asarco, we

understand that Womack and Associates role will be to oversee EPA interests. Womack and Associates is an independent geotechnical engineering firm located in Jackson Hole, Wyoming. Ray Womack, P.E. will provide senior review and oversight. A statement of training and qualifications are attached as Appendix L.

Quality Assurance for the project will be provided by Hydrometrics, Inc. Mike Oelrich will be the project manager for this effort. Mr. Oelrich has a Master of Science degree from the geotechnical program at Colorado State University's School of Civil Engineering. His study in that program included the following courses relevant to the CAMU design and construction.

Courses	***Application On Project***
Advanced Mechanics of Materials	*HDPE Liner Design*
Advanced Soil Mechanics	*Embankment and Compacted Clay Liner Design*
Soil Dynamics	*Seismic Design*
Foundation Engineering	*Settlement Analysis*
Earth and Earth Retaining Structures	*Embankment and Liner Design*
Groundwater Hydrology	*Leachate Collection and Detection Drain Design*
Solutions to Groundwater Problems	*Leachate Collection and Detection Drain Design*
Engineering Geology	*Seismic Design and Site Selection*
Physical Hydrology	*Surface Drainage Design*
Subsurface Investigation	*Site Investigation*
Flow in Porous Media	*Leachate Collection and Detection Drain Design*
Physio-Chemical Aspects of Soil	*Compacted Clay Liner Design*

In addition, Mr. Oelrich has taken the following courses and seminars that are relevant to the CAMU oversight and design.

Course or Seminar	***Sponsor***
Seismic Analysis – methods and Reference Seminar	*Montana DNRC*
Reinforced Concrete Design	*Auburn University*
Geosynthetic Clay Liners for Waste Containment Systems	*Colorado State University*
Geotextiles in Transportation Applications	*Auburn University*
Filter and Drain Design	*U.S. Bureau of Reclamation*
Environmental Law	*Montana Tech*
Slope Stability Analysis	*GEI Consultants*
Geotextiles and Geomembranes, Properties and Design	*J.P. Giroud*
Seismic Design & Analysis	*University of Missouri Rolla*
Reliability Based Design	*Purdue University*
Frozen Soils	*University of Alaska*

Mr. Oelrich has a significant body of experience with installation and oversight of both compacted clay and HDPE liners, including oversight at two previous RCRA Class C landfills:

- *Tacoma Upland Remediation Design, Commencement Bay Nearshore/Tideflats Superfund Site Operable Unit 02, Asarco Tacoma Smelter, Washington. Independent Quality Assurance Manager – Lead oversight of construction quality on a 200,000 cubic yard hazardous waste landfill. Work included identification of quality assurance protocols, development of Standard Operating Procedures, collection, tracking, and reporting of quality assurance measurements.*

- *Asarco East Helena Corrective Action Management Unit (CAMU), East Helena, Montana. Project Manager for planning, investigation, design and quality assurance of a 100,000 cubic-yard RCRA Hazardous Waste Landfill on the East Helena Lead Smelter plant. Services included preparation of the CAMU proposal, site investigation, material analysis, and design for an RCRA Class C solid waste landfill. Site investigation included drilling exploratory holes and excavating test pits. Design analysis included soil testing, HELP modeling, and engineering for the design of a double liner and leachate collection system. Design included preparation of construction documents, bid proposals, drawings, and specifications. Quality assurance included oversight of the work of field inspector and engineer.*

Comment 7. Where native soils are used, all material greater than 1 inch must be removed prior to placement. This will require a vibrating screen on-site. The CQAP should be revised to reflect this requirement.

Response: Section 4.0 of the CQAP and Section 203.07.8 of Appendix J have been revised to require that all material for the CCL must have been screened to 1-inch minus.

Comment 8. No lifts shall be greater than six inches. Lifts smaller than six inches may be necessary to achieve the performance standards for density. The CQAP should be revised to reflect this requirement.

Response: Section 4.0 of the CQAP has been revised as requested.

Comment 9. The CQAP does not contain any post-construction samples of the liner for conformational hydraulic testing. The CQAP must include post-construction conformational testing for final hydraulic conductivity performance. The CQAP should be revised to include this requirement.

Response: Section 4.0 of the CQAP has been revised to include requirements for confirmation testing of the CCL/GCL composite.

Comment 10. The CQAP must be expanded to discuss repair of holes from sampling and testing. A number of tests will require that a penetration be made into a lift of compacted soil. All penetrations must be repaired. Backfill may consist of the soil liner material itself, granular or palletized bentonite, or a mixture of bentonite and soil liner material. Please specify the material and procedure to be used to fill test holes. Hole repair is critical. Approximately 20% of all the repairs should be inspected by a

different person than the one who did the repair and written records of the backfill procedures be documented.

Response: Section 4.0 of the CQAP has been revised to include repair of holes and check of repairs by the independent quality assurance inspector.

Comment 11. The submitted CQAP must be amended to identify the field seaming to be used, including the material, methods, preheat, seaming rate, use of tents or enclosures and other details of the procedure. The type, nature, number, condition, and details of trial seams, as well as the results of such tests, should be detailed. The type, nature, number and details of destructive samples and disposition of sections of the sample should be described. Any unusual condition with respect to personnel, equipment, sampling and/or testing should be described, documented, reported to EPA verbally within twenty-four hours, and followed within three-days by a written notification to EPA.

Response: Section 5.0 of the CQAP as been revised to require these areas to be recorded.

Comment 12. Page 5-1, first paragraph, please discuss what measures will be taken should the Contractor and Engineering Inspector discover, ridges, ruts, and other non-uniformities in the surface, beyond spray painting and rejecting the area.

Response: Section 5.0 of the CQAP has been revised to require these areas to be reworked.

Comment 13. The recommended maximum percentage of failing compaction tests for the following parameters is:

Parameter	Maximum Allowable Percentage of Outliers
Water Content	**3% and Outliers Not Concentrated in One Lift or One Area, And No Water Content Less than 2% or More than 3% of the Allowable Value**
Dry Density	**3% and Outliers Not Concentrated in One Lift or One Area, and No Dry Density Less than 0.8 kN/cubic meters below the Required Value**
Number of Passes	**5% and Outliers Not Concentrated in One Lift or One Area**

Please amend the text to reflect these requirements

Response: Section 4.0 of the CQAP has been modified to include these requirements.

Comment 14. Table 4-1, Testing of Clay Liner after compaction, please amend the table to indicate that the test rejection criteria for the in-situ water content, in-situ density, and water content will have no more than 3% outliers and the outliers may not be concentrated in one area or lift. For the in-situ water content, use the ASTM 3017

method and allow no water content less than 2% below the line of optimums. For the in-situ density, use ASTM 2922 and allow no dry densities less than 5 pounds per cubic foot below required value. Please amend the table to reflect that the in-situ density will be checked using ASTM D 1556, on a 1 per every 10 tests basis. Please amend the table to indicate that the water content will be checked using ASTM D 2216 on a frequency of 1 per every 10 in-situ water content tests; with no more than 3% outliers and no water content less than 2% or more than 3% of the allowable value.

Response: These requirements have been added to Section 4.0 of the CQAP.

Comment 15. Table 4-1, Testing of Soil Prior to Compaction, please add the Moisture Content Parameter, using Test Method ASTM D3017, on a one per 1000 cubic yard basis.

Response: This test has been added to Section 4.0 of the CQAP.

Comment 16. Table 4-1, Testing of Soil Prior to Compaction, for scarification, please amend the table to indicate that the effectiveness will be tested with a tape measure on a frequency of 10/acre, with a rejection criteria of a scarification depth less than specification limits at 2 or more tests per acre. Please discuss how the scarification will be done. To enhance the bonding of lifts, to maximize the hydraulic tortuosity along lift interfaces, and to minimize the overall hydraulic conductivity, please make sure the surface of a previously compacted lift is rough before placing the new lift of soil (the previously compacted lift is often scarified with a disc prior to placement of a new lift), which promotes bonding and increased hydraulic tortuosity along the lift interface and use a fully-penetrating footed roller (the feet pack the base of the new lift into the surface of the previously compacted lift) where the roller foot length is approximately equal to the lift thickness.

Response: Section 203.07.8 has been revised to include methods for scarification, and Section 4.0 of the CQAP has been revised to include testing criteria for scarification.

Comment 17. Table 4-1, Testing of Soil Prior to Compaction, Construction Stakes. Per EPA/600/R-93/182, "The recommended survey procedure for control of lift thickness involves laser sources and receivers. A laser beam source is set at a known elevation, and reception devices held by hand on rods or mounted to grading equipment are used to monitor lift thickness….For those areas where lasers cannot be used, it is recommended that either flexible plastic grade stakes or metallic grade stakes (numbered and inventoried as part of QA/QC process) be used. It is preferable if the stakes are mounded on a base so that the stakes do not have to be driven into the underlying lift. Repair of grade stake holes should be required; the repairs should be periodically inspected and the repairs documented." Asarco must specify an acceptable method to be used.

Response: EPA/600/R-93/182 lists several methods of checking lift thickness, including survey methods. At the very beginning of the referred to section, it states, "The thickness of a

loose lift may be determined in several ways. One technique is for an inspector standing near the working face of soil being placed to observe the thickness of the lift. This is probably the most reliable technique for controlling loose lift thickness for CQA inspectors. If there is a question about loose lift thickness, one should dig a pit through the loose lift of soil and into the underlying layer." We propose this procedure, and have included this in Section 4.0 of the CQAP.

Comment 18. Sampling Patterns, please amend the CQAP to discuss how the sample locations will be selected for the compacted liner. A common method is to establish a grid pattern.

Response: As suggested, Section 4.0 of the CQAP has been revised to include a sampling grid pattern requirement.

Comment 19. In the amended CQAP, please include copies of all blank field forms to be used for quality assurance test for Items listed in Tables 3-1 through 6-1. If such forms do not exist, please develop them for the amended plan. EPA requests that these daily forms be faxed to us three times per week during construction of the CAMU cell: for work conducted Friday through Sunday, fax the forms on Monday; for work conducted Monday and Tuesday, fax to us on Wednesday; for work conducted on Wednesday and Thursday, fax the daily QA/QC sheets to us on Friday. When an item meets the test rejection criteria, notify EPA within 24 hours verbally, followed by a written notification within 3 days. Amend the CQAP to include these provisions.

Response: The requested field forms, provision for faxing the sheets to EPA, and for notifying EPA of test rejections have been added to the CQAP.

Comment 20. The Construction Quality Assurance Plan must be expanded to include construction criteria and QA/QC requirements for the leak detection and leachate collection system, inclusive of pumps, piping, drainage layers.

Response: Sections 6.0 and 8.0 of the CQAP have been added to include piping and drainage.

Comment 21. The Construction Quality Assurance Plan does not address the final cap. Please expand the plan to include the construction of both the temporary and permanent cap for all proposed cap components.

Response: Section 3.0 of the CQAP has been revised to include the final cap.

Comment 22. Appendix G, Construction Quality Assurance Plan: All geomembranes including the primary and secondary liners must be tested to ensure conformity of the material used with the design (40 CFR 264.19(c)(iii)). Tables 5-1 and 6-1 list the parameters, test methods, test frequency and rejection criteria. The tables should include the parameter values and units that the conformance tests are evaluating. If a

test result is in nonconformance, all material from the lot represented by the failing test should be considered out of specification and rejected.

Response: Section 5.0 of the CQAP has been revised to include testing of all materials used with design and material specifications.

II. Waste Materials

Comment 1. Page 1-1, 1.0 Introduction: The report states that the CAMU Phase 2 Cell will contain plant site soil and demolition debris generated through the implementation of the Montana Consent Decree and the RCRA Consent Decree. EPA understands that the Montana Consent Decree CDV-2004-212 has expired and was not extended. Table 3-3 lists demolition debris waste materials. Please revise the text to indicate that the Montana Consent Decree has expired. ASARCO should explain under what enforcement mechanism or work plan the waste for disposal in the CAMU is being generated for each line item in this table.

Response: Section 1.0 has been revised to note that the Montana Consent Decree has expired, and additional information regarding the waste materials has been provided in response to comment 6.

Comment 2. Page 3-13, Waste Material: It is our understanding that ASARCO will be disposing of asbestos in the CAMU Phase 2 Cell. Asbestos regulations require specific management practices. ASARCO must clarify whether asbestos containing material will be disposed in a separate cell within the CAMU Phase 2 Cell. ASARCO must comply with the MDEQ's Montana Asbestos Work Practices and Procedures Manual. ASARCO must include in the work plan a description of how asbestos will be managed; simply citing the applicable regulations is inadequate.

Response: Asbestos-containing material will be placed in the CAMU Phase 2 Cell and will be contained to one or two areas that can be surveyed so that they can be identified on the as-built drawings. However, the demolition contractor is not required to place it "in a separate cell within the CAMU Phase 2 Cell. Asarco acknowledges that we must comply with MDEQ's Montana Asbestos Work Practices and Procedures Manual. The manual allows either the building owner or demolition contractor to submit the asbestos removal NESHAPS permits application, and Asarco has chosen to have the demolition contractor submit it. Therefore, this design report is not intended to be the SOP PD for the asbestos removal.

Comment 3. Pages 3-14 and 3-15, Table 3-3, please provide a copy of the source document from which the major demolition debris waste material categories and quantities were extracted as an Appendix to the revised Design Analysis Report and include it as a listed reference in Section 8.0.

Response: The source document has been added to the report as Appendix K and has been listed as a reference on Table 3-3.

Comment 4. Pages 3-14 and 3-15, Table 3-3, the demolition debris waste must fall into one of the pre-approved categories, as defined in the July 2006 progress report, or ASARCO must describe and request approval for additional categories of wastes to be placed in the CAMU. The table includes 2000 cubic yards from "Excavation for Plant Cap." The meaning of this category is unclear, since a final site remedy has not been approved by EPA. The approval of the CAMU Phase 2 Cell Plan does not constitute approval of a plant cap.

The table includes a category "Remediation of Property for Chemet." ASARCO must explain this category that is slated to generate 5000 cubic yards of waste. The table also includes a category "Sanitary Treatment", which must be explained.

Response: A section of the property may have surface soil removed rather than capped. The 5,000 cubic yards is an estimate of the quantity of this soil that may refer to the Asarco On-Site Sanitary Treatment Building. In the approved CAMU eligible waste, there is an item labeled "excess contaminated soils" which include soils near American Chemet.

Comment 5. Page 3-23, first full paragraph, the text indicates that the HDS water treatment system may be removed. It is EPA's understanding that ASARCO will continue to need to treat purge water and storm water, as part of its site management and long-term monitoring. Projection of removal of this system seems premature since the corrective measures study has not yet been completed and onsite water treatment may be a necessary component of the remedial measures selected.

Response: Asarco acknowledges EPA's concern for removal of the HDS water treatment plant.

Comment 6. EPA request the evaluation performed by ASARCO to determine the acceptability of the waste for placement in the CAMU. ASARCO must submit an estimation of the weight of each general waste category and all analytical data for each waste stream.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): We are unclear as to EPA's expectations regarding the analytical data for each CAMU waste stream. We have reviewed the waste material categories, the manufacture's specification for these material types, evaluated the liner performance against these waste types, and have included HDPE liners in our design because it is the best product for these materials. Does EPA agree with this approach?

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): Table 3-3 of the design report includes an estimated volume (cubic yards). EPA is asking for an estimation of the weight of each general waste category and any analytical data for each waste stream, such as TCLP data.

Response: Please see the response to EPA comment I.D.4. Asarco will bulk weigh the materials prior to placement in the CAMU Phase 2 Cell.

Comment 7. In addition to wood debris, please list other organic or potential gas generating materials. Please discuss the potential organic constituents that may be released from these materials, mobilized into the leachate, and should be added to the groundwater constituent monitoring list.

Response: Some of the old timbers are coated in creosote. Section 3.9 has been added to discuss these timbers and liner compatibility issues.

Comment 8. 3.5 Waste Material: ASARCO should identify the waste material intended for disposal in the CAMU that ASARCO suspects may be of extreme pH that will require neutralization. The current report indicates that neutralization or blending of waste materials with an extreme pH is being planned. The specifics as to quantities anticipated needing blending and/or neutralization, the type of neutralization, the location of this process including units in which it will be conducted, etc., must be provided for approval.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): We did not intend to suggest that we intend to place materials with extreme pH in the CAMU Phase 2 Cell. Asarco has taken steps to drain the Acid Treatment Plant, which is the likely source of extreme PH material, and the Contractor will be required to neutralize any small remaining residual acids left in pipe elbows or low spots. In addition, we have included HDPE liners in our design because we felt that it is the best product for materials with varying pH. Does EPA disagree with this approach, or can EPA suggest a better-suited liner material for this application?

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): EPA agrees that the materials of construction must be compatible with the anticipated waste streams. Please specify the volume of extreme pH material from elbows and low spots which ASARCO estimates will require neutralization. Free liquids are prohibited from disposal in the CAMU.

Response: The amount of sulfuric acid that is still in elbows or low spots within the acid plant cannot be accurately estimated, but is believed to be between 5 and 50 gallons. The project specifications require the contractor to neutralize this material by mixing it with crushed lime rock or other approved means.

Comment 9. The current design report indicates that ASARCO evaluated and investigated the chemical compatibility and gas generating potential of the demolition debris. We request submission of this evaluation, as well as the results of any chemical or physical characterization performed on the CAMU-eligible waste categories.

Response: Please see our response to item 6 above.

III. Landfill Operations

Comment 1. 4.0, Placement of Waste Soils, Sediments and Demolition Debris in Cell. The design report must specify the size of the waste lifts and the placement of the waste.

*Response: Section 203.07.8 of the specifications, which have been added as Appendix J of the design report, state that "**Waste Materials. The Contractor shall compact waste soils with a minimum of eight (8) passes (4 cycles) of a sheepsfoot or padfoot roller. Place the waste soils in a maximum lift thickness of 2 feet."***

Comment 2. Page 4-1, Section 4.0, Placement of Waste Soils, Sediments and Demolition Debris in Cell: The text indicates a dust control program will be required. The dust control plan must be submitted prior to commencing construction of the CAMU.

Response: Asarco acknowledges this requirement and has included dust control in Appendix H, Waste Hauling Plan.

Comment 3. ASARCO must develop and submit for Agency review and approval a work plan for the operating life of the cell, which includes establishment of an operating record. This must include the mechanics of waste transport, including the following: conditions to halt waste placement and transport such as wind velocity and direction and precipitation events; communications; sorting, sizing, and sampling; spill response; weight; identification of wastes requiring special management (asbestos, super sacs of flue dust, acidic wastes, wood, etc.); pretreatment; oversize material; security; dust control; odor control; decontamination of equipment used to transport, place, compact, size and sort waste materials.

Response: The requirements for establishing an operating record as specified under 40 CFR 264.73 are outlined in Appendix E, Operation, Maintenance and Post-Closure Plan. Details concerning waste transport including the conditions to halt waste placement and transport, communications, spill response, identification of wastes requiring special management, dirt control, and decontamination of equipment are described in Appendix H. Specifications requiring that materials be sized appropriately are included in Section 203.07.8 of Appendix J.

Comment 4. Material transfer and waste placement. Specifics regarding waste staging, segregation, and pre-placement sizing need to be provided in the revised plan.

Response: Other than asbestos containing materials, Asarco does not propose to sort or segregate the waste. Section 302.07.8 of Appendix J limits waste size to vertical distance of two feet during placement. See response to EPA comment II.2.

Comment 5. Please expand the text to describe the decontamination procedures to be used during cell construction and waste placement, especially to prevent spread of contamination beyond the cell boundaries. Include methods to be used, location of decontamination structures, management of wastes produced.

Response: A Waste Hauling Plan has been added as Appendix H that addresses these items.

IV. Sampling Plan: Monitoring, Verification, Criteria, Statistics

Comment 1. ASARCO must include in the post-closure plan (such as Appendix D or E), a leak detection monitoring equivalent to 40 CFR 264.303(c).

Response: A leak detection monitoring equivalent to 40 CFR 264.303(c) is included in Section 3.3 of Appendix E, the Operation, Maintenance, and Post-Closure Plan. This section states:

"The monitoring and maintenance of the CAMU leachate collection and leak detection systems will be conducted in compliance with 40 CFR 264.303. The pump used to remove liquids from the sumps will remove all but the last two feet of liquids from each sump. Therefore, the Pump Operating Level is defined as two feet of liquids in the sumps, which minimizes the head in the sumps and avoids backup into the drainage layer. The owner/operator will record pre- and post-pumping water levels and the amount of liquids removed from the leachate collection and leak detection system sumps once a week during the active life and closure period. After the final cover is installed, pre- and post-pumping water levels will be recorded and liquids will be removed from the leachate collection and leak detection system sumps monthly. The amount of liquids removed will be recorded on the CAMU inspection form (Attachment A). If the liquid level in the sump stays below the pump operating level for two consecutive months, the amount of liquids in the sumps will be recorded quarterly. If the liquid level in the sump stays below the pump operating level for two consecutive quarters, the amount of liquids in the sumps will be recorded semi-annually. If at any time during the post-closure care period the pump operating level is exceeded at units on quarterly or semi-annual recording schedules, the owner/operator must return to monthly water level recording and liquids removal from each sump until the liquid level again stays below the pump operating level for two consecutive months."

Comment 2. Page 2-4, Section 2.8, Monitoring, Inspection and Construction Quality Control, Please amend the text to include 264 Subpart F requirements for establishment of a groundwater monitoring program for releases.

Response: Section 2.8 has been revised to state that, ***"The CAMU Phase 2 Cell systems must be inspected during operation and the leak detection system inspected after closure. Inspection of the CAMU Phase 2 Cell during operations will be in accordance with 40 CFR § 264.303, and 264 Subpart F requirements will be used for establishment of a groundwater monitoring program for releases after closure."***

Comment 3. 3.5.5, Groundwater Monitoring System—Appendix D Sampling and Monitoring Plan

a. **5.0 Sample Handling and Analysis: The parameter list proposed in Table 5-2 is inadequate. The parameter list must include all constituents that may be a source from the waste. The list must be expanded to include: arsenic, aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, tin, vanadium, and zinc. The detection limits must be low enough to allow comparison to DEQ-7 standards.**

Response: The table has been revised.

b. **6.2, Data Reporting: ASARCO must include with each semiannual data submittal, a table of the unique sample numbers and the corresponding sample location.**

Response: Section 4.3 of Appendix D has been revised to require unique sample numbers.

c. **6.2, Data Reporting: ASARCO must include with each annual groundwater monitoring report a potentiometric contour map.**

Response: Section 4.3 of Appendix D has been revised to require these maps.

d. **6.2, Data Reporting: ASARCO must include a concentration contour map of any detected analytes with each semiannual report.**

Response: Section 4.3 of Appendix D has been revised to require these maps.

e. **6.3, Monitoring Program Review: The Plan does not adequately address steps for compliance monitoring or corrective action if a statistically significant increase in groundwater is noted. In addition, the Plan does not include procedures for prompt notification of EPA. ASARCO must revise the Plan to address these deficiencies. We suggest ASARCO refer to 40 CFR 264 Subpart F including 40 CFR 264.98 through 264.100.**

Response: New sections (Section 4.4, Section 5.0 and Section 6.0) have been added to the plan to address these requirements.

Comment 4. Page 3-9, Section 3.3.2, Groundwater, Future evaluations of groundwater flow direction (potentiometric maps) would benefit from an additional well or piezometer installed in the area to the southwest of what is referred to as "the subsequent cell" located southwest of the current Phase I Cell and northwest of the proposed Phase II Cell. Since there is currently no well or piezometer located in that area, installing one would aid in defining groundwater flow direction in the CAMU area for both the Phase I and Phase II Cells. This is a requirement for the groundwater monitoring system for design for the Phase II Cell.

Response: An additional well has been installed where requested by Randy Breedon (e-mail from L. Jacobson April 25, 2007) and is shown on Figure 1-2 in Appendix D (Sampling and Monitoring Plan).

Comment 5. Page 3-27, 3.5.5, Groundwater Monitoring System, please expand the text to indicate that a detection monitoring program will be established in compliance with 264 Subpart F requirements. The SMP for the long-term monitoring of releases from the CAMU must be amended to include the following:

- **Establishment of trigger levels for each selected contaminant of concern**
- **Verification sampling protocol**
- **Notification requirements**
- **Resampling frequency and**
- **Corrective measure responses and actions for a verified release from the CAMU cell.**

Please refer to the materials previously provided as guidance.

Response: This section has been revised to state that, ***"The sampling and monitoring plan, contained in Appendix D of this report, establishes a detection monitoring program in compliance with 264 Subpart F requirements"*** *and the SMP has been revised to address the items listed.*

Comment 6. Appendix A, Figure 1, please ensure the accuracy of these cross-sections and well-transects. Please indicate on this figure the location of the additional CAMU well requested by EPA.

Response: The cross-sections and well-transects have been corrected on Figure 1 in Appendix B.

Comment 7. As reflected in our February 21, 2007, comment letter on the Technical Inspection Report, CAMU Phase I Cell, Revised January 2007, we have concluded that ASARCO accurately conducted the Mann-Kendall non-parametric trend testing on the data with the few caveats noted in our comment letter. EPA has reviewed ASARCO's responses to our comments which dealt with the use of the one-way or two-way test and the identification of how non-detects (censored data) were addressed and found them to be acceptable. The approach described in your responses should be included in the development of the long-term verification monitoring program and statistical evaluation of the monitoring data.

Response: The statistical procedures proposed in the SMP (Appendix D) include the Mann-Kendall test as conducted in the Technical Inspection Report.

Comment 8. Appendix D, Sampling and Monitoring Plan (SMP), February 2007, we offer the following comments related to the statistical evaluation procedures proposed in the SMP:

a. **The SMP identifies a number of different analytical methods for dissolved trace metals in Table 5-2. One of the problems noted in our earlier review was the lack of information regarding non-detection levels (measured and as reported). If analytical methods were changed in the course of the reported data time frames, the methods used and detection limits should also be reported. It is quite possible that analytical method sensitivities can affect the statistical evaluations. It would be better to have a consistent set of data with constant detection limits and based on the same analytical technique. From Table 5-2, it**

appears the ICP-MS is being used for metals, potentially a much more sensitive technique.

Response: Statistical evaluations will include consideration of possible influences from different methods and reporting limits. Although these will be kept consistent from this point forward, previously collected data must be used as is, or discarded if evidence suggests that variable methods and detection limits have too great an effect on the power of statistical testing to detect groundwater protection standard exceedances.

b. **The data reported in our earlier review contained some curious reporting significance levels. Specifically for arsenic, data were reported to one, then two, and occasionally three significant decimal places. With such small changes in level involved, statistical testing outcomes could be affected. ASARCO needs to adhere to a consistent approach in the future for the number of reported significant decimal places and should propose a procedure to address this for existing data.**

Response: Future data will be reported consistently in terms of significant figures. Existing data may be reevaluated from original laboratory reports to ensure that database import routines have not modified the originally reported number of significant figures.

c. **The results using Mann-Kendall trend testing suggested a least one significant increase in sulfate in Well MW-6, and possible arsenic increases in wells MW-2, 3 and 4. The question for now is what happens next. Will the Mann-Kendall test be applied at each new data event acquisition and repeated? This may be satisfactory if there is no evidence of a trend, but what is the approach for wells and analytes with increases? Obviously, one can continue to evaluate whether the increases continue or cycle back to somewhat lower levels. At some point, it seems necessary to start the data evaluation over from scratch; otherwise complex historical patterns could negatively affect future testing. ASARCO should respond to this point.**

Response: Mann-Kendall trend testing is one statistical method for determining groundwater protection standard exceedance. If increases are noted and verified, trend testing may be conducted starting from a different "base point" (such as after implementation of corrective action) to identify more recent trends. Statistical methods and rationales will be presented in the reports to EPA required by the SMP.

d. **The SMP has suggested switching to control charts. However, the same problem with historical data having a definite trend would cause similar problems with control charts. There is a way to remove the trend from the data and work with residuals; however, all future data must be treated the same way (since a continuing trend is presumed). At some point, if the trend differs (e.g., a decrease), then the control chart might show a negative trend (significant but not**

important). Please discuss how these issues would be addressed if control charts are used.

Response: The report indicated control charts might be an option in the future, after a significant set of data (8 – 10 years) has been collected and shown no strong trends. If a decision is made to use control charts, it will be made in consultation with EPA and will be based on the observed distribution and variability of the data.

e. **ASARCO is simultaneously collecting sulfate and other major ions. We suggest evaluation of the cation/anion and TDS balances on the data for well MW-6 to see if a more geochemical explanation might be found for the sulfate increase. Generally, more than one ion will be involved with such a change and may turn out to be natural water quality variation.**

Response: Geochemical characterization will be conducted as part of ongoing monitoring. Although not expressly considered in the SMP, ion-balance and major ion chemistry are routinely reviewed during data evaluations for Asarco groundwater samples.

V. Maintenance

Comment 1. Reutilization of the temporary cap. It appears, from the text, that reutilization of the RPE temporary cap is anticipated. Please explain how and where it will be stored, how it will physically be removed and replaced, what measures are to be taken to preserve its integrity and prevent contamination. Please discuss the pros and cons of leaving it in place rather than remove it each season.

*Response: Section 5.0 of the report has been revised to explain that**, " If it is to be reused, the liner may be divided into small enough panels to remove from the CAMU and then reanchored with sandbags on adjacent land that is out of the way of construction. The liner will need to be inspected prior to reuse in order to insure that it is accepted for re-use. If it is determined that it is not, it will need to be shredded so that it will not hold water, prior to placing it in the CAMU cell, or placed over the top of the waste material prior to capping the cell. The Operation, Maintenance and Post-Closure Plan (O&M Plan) addresses temporary closure activities of the CAMU and is located in Appendix E."***

Comment 2. Please describe additional security measures that may be required while the cell is open, being filled, and the temporary cap is in place. What measures are being taken to ensure the temporary cap will withstand high wind events, precipitation, control fugitive emissions, and prevent animal excursions and physical contact with the waste.

*Response: Section 104.10 of the specifications, which have been added as Appendix J of the report requires the CAMU construction contractor to: "**Install new gates and fencing as necessary to provide site security both during and after work hours. Contractor is responsible for securing the work site."** In addition, Section 104.11 requires that, **"The***

CAMU Phase 2 Cell facility . . . will be fenced with a 6-foot high welded wire farm fence with a single strand barbed wire top section until completion of the final cap when a 6-foot high chain link fence with a 3-strand barbed wire top section will be used. Gates (24 feet wide) will be provided at the access roads. Project signs will be installed on each of the four sides of the CAMU Phase 2 Cell perimeter fence. Temporary orange poly fence (safety fence) will be installed around the Asarco East Helena Smelter facility perimeter in places where demolition leads to gaps in the facility fence. Temporary fence should be used for the shortest duration possible and should be replaced with permanent facility fencing quickly to increase site security." *The project drawings, which have been included in the report as Appendix I, include details for anchorage of the temporary cap, which are similar to what has been used at the facility except that the edges will be anchored in a trench rather than with batton strips. The 6-foot high welded wire farm fence is designed to keep deer and other animals off the temporary cap.*

Comment 3. Page 5-1, 5.0 Temporary Closure and Monitoring, please amend the text to include the following items for the temporary cap: type of cushion layer, installation method, prevention of precipitation, site security, freezing effects, wind, and animal intrusion.

*Response: Section 5 has been revised to read, "**The construction of the CAMU Phase 2 Cell is scheduled to begin in 2008. Once the cell is excavated and the liner, leak detection, and leachate collection systems are constructed the cell will be filled with waste materials from both 2006 and 2007 demolition work. Placement of waste materials generated from 2006 demolition work will free up containment building storage space that may be used to store waste materials generated from demolition work after temporary closure of the CAMU cell before the end of the 2008 construction season. By the end of the 2008 construction season, a temporary cap constructed from 20 mil Reinforced Polyethylene (RPE 25) with stitched z-fold seams will be placed over the waste, using sandbags to hold it in place. Prior to placement of the liner, the surface of the waste will be graded to drain, rolled smooth, and covered with a 10-ounce cushion fabric. Sandbags placed in a 5-foot grid will be installed to anchor the middle portion of the cap and edges will be anchored in trenches. The cell has been designed to contain 40,000 cubic yards of material in the excavated portion of the cell. This will allow the contractor to grade the waste material level with the existing ground surrounding the CAMU Phase 2 Cell, which will help to promote runoff from the temporary cover. The temporary RPE 25 cap may also be used at the conclusion of subsequent construction seasons if it is stored carefully in between uses. However, the cushion fabric will need to be replaced. Freezing and wind and other weather related damage may limit the useful life of the temporary cap, in which case, a new cap will need to be provided.***

VI. Final Cap

Comment 1. 3.5 Component Design: The design report must be updated to include additional information on the proposed cap including the GCL. The geosynthetic clay liner should be needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin

staple fiber non-woven geotextile. The needle punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope. No horizontal seams should be allowed on the slopes.

Response: Section 3.5.1.3 has been revised to read, ***"This component of the CAMU Phase 2 Cell cap closes the CAMU Phase 2 Cell and prevents infiltration of precipitation. It consists of a 40-mil double-sided textured HDPE FML, underlain by a geosynthetic clay liner (GCL). The geosynthetic clay liner will be needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile. The needle punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope. No horizontal seams should be allowed on the slopes. An HDPE geomembrane was chosen for this FML to ensure that the permeability of the cap liner is no less than the cell liner system, as required by 40 CFR 264 subpart N. In addition to acting as a component of the composite liner, the GCL covering the waste material provides a smooth surface for installation of the cap FML and provides an additional factor of safety in preventing percolation through the cap."***

Appendix G should be modified to include the specification requirements for the GCL and conformance testing. If a test result is in non-conformance, all material from the lot represented by the failing test should be considered out of specification and rejected.

Response: These requirements have been added to Section 7.0 of the QA/QC Plan in Appendix G.

Comment 2. 3.5.1.3 Cap Composite Liner: To improve stability, ASARCO must use a 40 mil double-sided textured HDPE for the cap liner. A geocomposite should be used between the liner and the 12 inch drainage layer, especially on the cap slopes, to prevent sloughing.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): If a geocomposite is used, we would like to eliminate the 12 inch drainage layer and replace it with 12 inches of cover soil. Does EPA have any concerns with this plan for incorporating their comment?

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): EPA recommends using a geocomposite especially on the cap slopes to prevent sloughing. Asarco must include stability information demonstrating that this is not necessary. We believe the drainage layer should be a 12-inch layer of gravel or other suitable material. EPA does not approve the use of 12 inches of soil at this time; EPA will evaluate the cap design upon receiving further information in the design report; but, the drainage material's particle size must not impede the movement of liquid.

Response: The design report, plans, and specifications have been modified to include a double-sided textured liner (see response to comment 1) and a geocomposite drain under the granular drain. However, Asarco's engineer noted that the CAMU Phase 1 Cell design did not use a textured liner or a geonet under the drain material and has shown no signs of sloughing in the 5 years that it has been in place.

Comment 3. Page 3-13, 3.5 Waste Material, last paragraph, the text indicates that a gas extraction system is included in the design; however, on page 3-17, Section 3.5 Component Design [please renumber in your revision], there is no gas collection and removal system included or described. ASARCO must include additional information including design specifications, drawings, and QA/QC requirements. A 6 inch gas migration layer is proposed on Figure 3-5. We recommend that the top of the waste be covered with at least 12 inches of material to ensure protection of the cap. The waste layer should be smoothed prior to the gas migration layer being applied to ensure that all protuberances are adequately covered.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): The current design requires the surface of the waste to be level and smooth, prior to placement of the 6-inch gas migration layer, a geosynthetic clay liner (GCL), a 40 mil HDPE liner a drainage layer (to be replaced by a composite geonet) and finally cover soil. Because the GCL is itself a sandwich of clay and geotextile that will provide excellent protection for the overlying HDPE liner, it is unclear why EPA recommends an additional 6-inches of gas migration material in addition to the GCL in order to provide sufficient protection of the HDPE liner. Please clarify.

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): Please note that at this time, EPA does not approve replacing the drainage layer with a composite geonet. We recommended that the top of the waste be covered with 12 inches rather than 6 inches to ensure that any settling of waste would not result in a puncture of the GCL and HDPE liner. Solid waste landfills in Montana normally have 12 inches on top of the waste between daily cover and the gas migration layer. Daily cover has not been included in the design of the CAMU. Therefore, ensuring the cap's integrity by an additional 6 inches seems prudent.

Response: The design report and project plans have been revised to include 12-inches of gas migration layer, and the design plans and specifications have been added to the report in Appendices I and J.

Comment 4. Page 3-22, 3.5.1.3, Cap Composite Liner, the text states that the GCL cap slopes will be reinforced. The GCL specifications, which are requested to be included in the resubmission of the design plan, should address the transition from the gentle top slopes to the side slopes. Sharp changes in slope, or uneven or variable-radius curved transitions, may lead to unacceptable wrinkles or poor contact with the subgrade at these locations. Please ensure the specifications provide instructions for constructing the subgrade slope transitions that are uniformly curved and smooth.

Response: Section 625.05.2 in Appendix J have been revised to ensure the subgrade slope transitions are uniformly curved and smooth.

Comment 5. For the GCL liner, please provide the design analyses, including the results of the interface friction testing according to ASTM Method D5321 with both dry and hydrated GCL of the specific type proposed for use in the CAMU, to support the conclusion that the slopes will be stable. Provide relevant literature or case study citations, if available.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): Given that the cell cap has 5:1 slopes, the design engineer does not feel interface friction testing is necessary. Do EPA's engineers disagree? If so, is there any degree of slope at which EPA's engineer's would feel confident that this testing is no longer required?

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): Asarco must include the requested interface friction testing on the proposed design.

Response: Once samples of the specific type of GCL is received from the CAMU contractor, we will perform the testing and provide EPA with a design analysis including friction testing with both dry and hydrated GCL by letter.

Comment 6. Page 3-27, Cover System, the cover system proposed for this cell consists of 6-inches of seeded topsoil overlying 24-inches of subsoil. The cover for CAMU Cell 1 consisted of 8-inches of seeded topsoil overlying 16-inches of subsoil. Please explain why the design has been altered. Please also expand the text to discuss the vegetation mix selected to reseed the cap.

Response: The CAMU Phase 2 Cell was designed with the same requirements as the as-built CAMU Phase 1 Cell. The original CAMU Phase 1 Cell design consisted of 8-inches of topsoil overlying 16-inches of subsoil, 12-inches of drain gravel and 24-inches of compacted clay. However, during construction of the CAMU Phase 1 Cell the quantity of clay liner material was less than anticipated, and the cap design was changed to include a GCL instead of the 24-inches of compacted clay. In order to better protect the GCL, the subsoil layer was increased from 16-inches to 24-inches. Subsequently, the topsoil layer was reduced from 8-inches to 6-inches to keep the overall dimensions of the cell the same as was originally designed. Observations of the good vegetative growth on the CAMU Phase 1 Cell show 6-inches of topsoil is an acceptable depth. The vegetation mix selected is the same one used for the CAMU Phase 1 Cell and is contained in Section 627.00 of Appendix J.

VII. Post-Closure Care

Comment 1. The O & M Plan must be amended to establish specific criteria and response time lines for repair for each inspection element. It must also include notification provisions of required repairs to the regulatory agencies.

Response: The Operation, Maintenance, and Post-Closure Plan has been amended to establish specific criteria and response time lines for repair for inspection elements and includes notification provisions of required repairs to regulatory agencies. These amendments are included throughout the text in Section 3.0 – Site Monitoring and Inspection. Section 3.5 – Corrective Action for Identified Problems includes the following text:

"If any problems are encountered during routine inspections, they will be documented on the Inspection/Repair form and the owner/operator will be notified within 24 hours. The owner/operator is responsible for making sure all repairs are scheduled and/or completed within 14-calendar days of the inspection. Details of completed repairs will be noted on the Inspection/Repair form. The owner/operator is also responsible for reporting any significant issues to the EPA representative verbally within 7-calendar days and in writing within 14-calendar days."

Comment 2. Page 2-4, Section 2.9, Please amend the text to include compliance with 264 Subpart H requirements for post-closure care.

Response: Section 2.9 has been revised to include compliance with subpart H and these requirements have been added to the revised O&M and Post Closure Plan.

Comment 3. Page 2-4, Section 2.9, please amend the text to include compliance with 264 Subpart G, closure and post-closure requirements which include the survey plat, notice to the deed, and post-closure notices.

Response: Section 2.9 has been revised to include compliance with subpart G and these requirements have been added to the revised O&M and Post Closure Plan.

Comment 4. O&M Plan, Appendix E, revise in response to comments.

Response: The Operation, Maintenance, and Post-Closure Plan has been updated to include compliance with 264 Subpart H requirements for post-closure care and to include compliance with 264 Subpart G, closure and post-closure requirements which include the survey plat, notice to the deed, and post-closure notices. These are mainly included in Sections 2 and 5.

Comment 5. Operation and Maintenance Plan, ASARCO must establish permanently surveyed benchmarks for both CAMU cells.

Response: The Operation, Maintenance, and Post-Closure Plan includes the establishment of a permanently surveyed benchmark for both CAMU cells. Section 2.1 of the text states:

"The owner/operator will follow surveying and recordkeeping regulations in accordance with 40 CFR 264.309. The owner/operator will establish a permanent surveyed benchmark, which will be placed on the top of the CAMU Phase 2 Cell after the final cap is complete.

The owner/operator will also establish a permanent surveyed benchmark, on the top of the CAMU Phase 1 Cell."

Comment 6. 5.0 Temporary Closure and Monitoring—Appendix E Operation and Maintenance Plan: This appendix includes an operation and maintenance plan for the temporary cap and post-closure care monitoring of the CAMU. Section 3.3 Site Inspection states that a technical inspection will be performed no less than very five years. The section discusses informal inspections to be conducted no less than once per month. Formal inspections once every five years are insufficient. Asarco must inspect the CAMU Phase 2 Cell twice a year. The inspections should evaluate settling and subsidence, erosion, membrane liner damage, and the cap's vegetation. ASARCO must document the inspections and any corrective action taken. The reports should be submitted to EPA in an annual report. Significant issues should be reported verbally to EPA within 7-calendar days and in writing within 14 calendar days. The plan should be updated to include these additional inspection and reporting requirements.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): We cannot find any guidance on inspection frequency. Please provide rationale for increasing the frequency of inspections.

Reply: **(EPA April 17, 2007 letter, regarding Response to Asarco's Questions):** The CAMU regulations do not specify post-closure inspection frequency. Inspection frequency for hazardous waste units with waste left in place is governed by an approved post-closure plan. The regulations do not specify an inspection frequency for post-closure care. Regulated units in Montana with waste left in place such as landfarms, surface impoundments, and CAMU Phase 2, are required to be inspected quarterly to semi-annually. Inspections must be performed semi-annually by a technically trained person. Some sites are also required to be inspected annually by a P.E.

Solid waste landfills in Montana must be inspected at least annually by a licensed P.E. The resulting P.E. annual report must support financial assurance cost estimates and adjustments, if necessary. Monitoring reports must provide adequate data to assess performance of control systems and need for corrective actions. Financial assurance must be annually reviewed and increased for at least inflation, but also any annual increases in maintenance.

Asarco will be required to inspect the CAMU semi-annually including one inspection per year by a P.E. This frequency may be decrease after vegetation has been adequately established and routine monitoring demonstrates the performance of the cap and liners.

Response: The Operation, Maintenance, and Post-Closure Plan Section 3.0 - Site Monitoring and Inspection has been updated and includes the requirements semi-annual inspections by a professional engineer. Inspections will evaluate settling and subsidence, erosion, membrane liner damage, stormwater control system, and the cap's vegetative state and will be documented and compiled into an annual report that will be submitted to the EPA. Significant issues will be reported verbally to EPA within 7-calendar days and in writing within 14 calendar days.

Comment 7. ASARCO must evaluate and establish a rapid and large leakage rate (RLL) and an action leakage rate (ALR) for the existing CAMU cell and the CAMU Phase II cell and include these in a Response Action Plan developed for each cell. These requirements are further outlined 40 CFR 264.302.

Response: The text in Section 3.3 of the Operation, Maintenance, and Post-Closure Plan has been updated to state the following:

"Experience with the CAMU Phase 1 Cell indicates that it is difficult to establish an Action Leakage Rate within the first five years of the post-closure period. In this timeframe, it is difficult to distinguish the volume of leachate from leakage from the volume of water that entered the drainage system during construction that was not able to be removed. According to EPA guidance (Survey of Technologies for Monitoring Containment Liners and Covers, 2004) leachate levels generally fall to a negligible level in 10 years or less. Therefore, an Action Removal Rate for the CAMU Phase 2 Cell will be established as soon as sufficient data is collected and within the first 10 years of the post-closure period. Action Leakage Rate and leachate collection volumes will be presented as an average daily flow rate (40 CFR 264.302) in the annual inspection report. Once the Action Leakage Rate is established, the Response Action Plan, outlined in Section 3.5.1, will be followed if the Action Leakage Rate is exceeded.

Until an action leakage rate is established, the owner/operator will insure that the depth of leachate does not exceed 12-inches over the primary and secondary liners, by keeping the depth of the leachate to less than 5-feet in the 4-foot deep sumps of the leachate collection and leak detection systems. If the water level in either vertical standpipe exceeds 5-feet, the sump will be pumped immediately."

VIII. General Provisions for Design Revision

Comment 1. ASARCO should provide a more detailed construction schedule similar to Figure 4-1 Construction Schedule in the Phase I Design.

Response: Asarco does not have a more detailed schedule, other than the milestones that the contractor is being required to meet, which are July 15, 2007 for the Stage I Cleaning and Demolition, October 15, 2007 for the Stage 2 Cleaning and Demolition, October 15, 2008 for the CAMU Construction, which includes waste placement and temporary capping, and December 1, 2008 for all other items. These dates were based on an April 1, 2007 start date, which has changed as the CAMU Design Report is being finalized.

Comment 2. 3.5, Component Design: This section states that the landfill has been designed and constructed pursuant to EPA and Department guidance. However, 8.0 References does not reference any Department guidance. Please specify the Department guidance that ASARCO is using. Please revise 8.0 References, to reflect all materials and guidance relied upon during development of this design plan.

Response: We have added the Department guidance, referenced in the comments within this document to Section 8. At the time Section 8 was initially written, Asarco and Hydrometrics, Inc. believed that the Department's response to Hydrometrics' June 16, 2006 letter that stated our intention of designing the CAMU Phase 2 CAMU Cell "much the same as the previous one" gave us permission to use the same design standards as the CAMU Phase 1 Cell. Therefore as in CAMU Phase 1 Cell, department guidance was not referenced. Design of a CAMU Phase 2 Cell to differing state and federal standards to both Hazardous and Municipal waste guidance and standards to comply with good design practices presents unique challenges.

Comment 3. Page 7-1, 7.0 Standard Plans and Specifications, please amend this section to reflect the revisions required elsewhere throughout the document and responsive to state and EPA comments.

Response: Plans and specifications have been revised to reflect the revisions required elsewhere throughout this document. Primarily these changes include:

- *Change the smooth 60 mil HDPE FML to* ***Double-Sided (DS) Textured 60 mil HDPE FML.***
- *Add* ***reinforced GCL*** *between the compacted clay liner (CCL) and the bottom.*
- *Increase the cushion material layer thickness to* ***24"****.*
- *Crushed brick or concrete* ***will not*** *be allowed as cushion material. Crushed slag, imported gravel, or select fill from the CAMU Phase 2 Cell excavation* ***will be*** *allowed as cushion material.*
- Change the size specification for cushion material from minus 3/8" to **minus ½". However, the first 12" of the cushion layer must consist solely of material less than ½" but larger than ¼"**.
- Contractor must have local readily available pumps capable of pumping **400 gpm** on standby in the event of a significant rainfall.

- Change maximum dimension of particle to be used in the compacted clay liner from 2-inches to **1-inch**.
- Change the 250 mil geonet to **8 oz Double-Sided Geocomposite** as shown on attached Sheet 3.

Comment 4. A Final Construction Report for the CAMU Phase 2 cell must be developed and submitted within sixty (60) days of the completion of cell construction.

Question (Asarco April 12, 2007 e-mail titled CAMU Comments, Asarco Questions): Does this mean the final construction report is required once the final cap is in place or at the end of the 2008 or 2009 construction season? Please clarify.

Reply (EPA April 17, 2007 letter, regarding Response to Asarco's Questions): The final construction report is due within 60-calendar days of completion of the final cap, scheduled for 2009.

Response: Asarco acknowledges this requirement.

IX. Responses to May 28, 2007 Initial Comments On Design Analysis Report Asarco East Helena Plant Corrective Action Management Unit (CAMU) Phase 2 Cell Revised May 2007

Comment 1. Conditions of Approval, Comments 1, 5, and 9, ASARCO responded by acknowledging EPA's conditions for approval. It is our understanding that the company intends to comply with each of these stated requirements.

Response: Asarco agrees to comply with the requirements of Comments 1, 5, and 9.

Comment 2. Page x, Asarco Response to EPA's Comment # I.A.2: Please amend Section 8.0 References to include the reference "EPA 1986" cited here.

Response: The reference U.S. EPA, 1986. "Design Construction, and Evaluation of Clay Liners for Waste Management Facilities." Report No. EPA/530/SW-86/007F has been added to Section 8.0 of the Design Report. The cited phrase from the reference is found on Page 6-13 of the EPA document.

Comment 3. Page xiv, EPA's Comment #I.C.1, Appendix G Table 4-1 Stockpile Acceptance Testing, Appendix G, 4.0 Compact Clay Liner, page 4-4, and Appendix J, Table 4-1, Stockpile Acceptance Testing: The text and tables specify that the hydraulic conductivity must not exceed 10^{-6}. Asarco must modify the text and tables to specify 1.0 x 10^{-6}. We wish to clarify that it remains the project goal that the compact clay liner achieves a hydraulic conductivity of 1.0 x 10^{-7}; however, given the results of the geotechnical work, EPA established a performance standard of a hydraulic conductivity of no greater than 1.0 x 10^{-6}. Please make note of this here and throughout the remainder of the design where 10^{-6} is used rather than 1 x 10^{-6}. Please do not interpret this as any value between 1.0 x 10^{-6} to 9.9 x 10^{-6} as being permissible.

Response: All references to 10^{-6} have been changed to read 1.0 x 10^{-6} with the understanding that a hydraulic conductivity of 1.0 x 10^{-7} is the project goal as shown in replacement Table 4-1 of Appendix G, Page 4-4 of Appendix G, and Table 4-1 of Appendix J.

Comment 4. Page xiv, Response to Comment 6, please expand the text to include additional construction specifications and descriptions for the pumps, sumps, riser pipes, and methods for construction of these items.

Response: Section 3.7.2.1 of the Design Report has been expanded to include descriptions of the piping, sumps, and riser pipes as found on replacement page 3-26. No pumps are included in the design of the leachate collection or detection systems, because significant leachate generation from the waste is not anticipated. Therefore, a portable submersible pump will be used to remove leachate from the sumps if any is noted during inspections.

Comment 5. Page xxi, Waste Materials, please amend this table to correctly identify which of these wastes will require neutralization.

Response: The table has been corrected and is shown below.

WASTE MATERIALS

Solid Waste Material	***Location***	***Approximate Volume***
Sulfates	*Acid Plant Pipes, Towers, and Tanks*	*10 – 20 Tons*
*Sulfuric Acid (Neutralized)**	*Acid Plant Pipes, Towers, and Tanks*	*5 – 50 Gallons*
Soda Ash	*Bin 17 Under Highline Railroad*	*4 Cubic Yards*
Catalyst	*Acid Plant Converter*	*120,000 Liters*
Talc	*Talc Room at Blast Flue*	*500 Pounds*
Blast Furnace Dust	*Blast Flue, Loadout, and Baghouse*	*30 Tons*
Wood Chips	*Bin 18 Under Highline Railroad*	*2 Tons*
Lead Bullion	*Ringling Building*	*50 Tons*
Matte	*Ringling Building*	*10 Tons*
Speiss	*Ringling Building*	*10 Tons*
Dross	*Ringling Building*	*20 Tons*

* Liquid that will be neutralized and solidified prior to placement in CAMU Phase 2 Cell.

Comment 6. Page xxii, Waste Approved for Disposal in the CAMU, We understand that you have proposed to include soil sampling and temporary capping as part of the demolition work. Due to the nature of this activity, it more appropriately falls under the scope and auspices of the EPA RCRA corrective action work. Removal of excess soils would also fall under EPA's corrective action authority. Please amend the table to reflect this.

Response: The table has been corrected to show removal of excess soils will be excavated under EPA Corrective Action Authority. The changes are found on the table below.

WASTE APPROVED FOR DISPOSAL IN THE CAMU

Category	***Waste Material Examples***
Montana Decree Waste (Direct result of performing Montana Decree cleaning and demolition)	*- Brick, masonry, and kettles* *- Fiberglass, pipe, and ACM transite* *- Soils, slag, and asphalt* *- Concrete blocks, walls, and slabs* *- Furnace metal, dust and lead residue* *- Baghouse bags, belting, lighting* *- Plastic/ceramic saddles and catalyst* *- Rail ties, wood, blankets, insulation*
Contaminated Debris (Waste located throughout the facility and subject to future Montana Decree action)	*- Industrial-sized vacuum hose* *- Wood planking* *- Railroad ties and pallets* *- Concrete slabs/blocks/rubble* *- Plastic/PVC piping/rubber belting* *- Wood chips, soda ash, talc* *- Soda ash and lime* *- In Plant Road Sweepings* *- Slag (mixed with debris)* *- Temporary stack* *- Wood fire houses* *- Adobe clay pile*
Montana Decree 2005 Work Plan	*- Acid plant limerock* *- Zinc plant copper*
Soils from Corrective Action or Capping Activities	

Comment 7. Page xxiv, Asarco's Response to EPA's comment E.1: Asarco should explain what material it intends to use for the cushion layer.

Response: Imported local gravel meeting the gradation requirements specified by EPA and Section 203.07.8 A.2 of Appendix J will be used in construction of the cushion layer.

Comment 8. Page xxx, Asarco's Response to Comment E.17, Use of Construction Stakes. Here the text indicates that rather than stakes or a laser beam, an inspector will observe the lift thickness; however, in Appendix J, Project Specifications, 203.07.01 and Table 4-2, indicate that construction stakes will be used. Please amend the text to indicate that an inspector rather than stakes will be used during construction.

Response: Table 4-2 in Appendix J Section 203.07.01 has been changed to clarify that construction stakes (grade stakes) for grade control will be inventoried as part of the contractor's QC. The specifications in Table 4-2 have been clarified to reflect this as found on replacement page 3 of Section 203.07.01 of Appendix J. Table 4-2 is not meant to imply that stakes will be used for lift thickness QC.

Comment 9. Page xxxi, Comment 20, please expand the text to provide further details on the pumps, piping and drainage layers for the leak detection and leachate collection system.

Response: The text has been expanded to provide further QA/QC details for the Leachate Collection and Detection system as described in replacement page 8-1 of Appendix G. Additional details of the drainage layers are found in Sections 3.0 (Pages 3-1 through 3-5), and 6.0 (Pages 6-1 through 6-2) of Appendix G and are not included as replacement pages. Additional text has been added to the design report to provide additional details of the Leachate Collection and Detection Systems as outlined in our response to Comment 4.

Comment 10. Page xxxii, Comment 2, EPA acknowledges that this is not intended to be the SOP PD for the asbestos removal but recognizes that the EPA-approved CAMU Phase 2 Cell will be used for final disposal of the removed asbestos-containing material. Please provide additional specifics on the removal, segregation, containerization, labeling, and transport of the asbestos material, as well as how this disposal will be noted on any future deed restriction.

Response: The text has been expanded to provide further specifics on the removal, segregation, containerization, labeling, and transport of the asbestos material, as well as how this disposal will be noted on any future deed restrictions as shown on replacement page 3-2, 3-3 and Attachment A of Appendix E.

Comment 11. Page xxxiii, Comment 6, please provide the requested analytical data, such as any available TCLP data. During a discussion on May 11, 2007, ASARCO indicated its willingness to perform sampling of stored materials and newly demolished materials on a load basis. Please submit this proposal, including the number of samples and analytical parameters in response to these additional comments.

Response: Asarco has no analytical data for the demolition debris waste. A sampling and analysis plan for the waste has been added as Attachment C to the Operating Plan in Appendix E.

Comment 12. Page xxxv, Comment 3, please revise your "Waste Hauling Plan" to incorporate all components from the O&M Plan, Appendix H, and Appendix J, into one Operating Plan that addresses the requirements of EPA's comment.

Response: The Waste Hauling Plan (Appendix H) has been combined with the Operating Plan (Appendix E), which describes operation, maintenance, waste hauling, dust control, inspection criteria, closure, and post-closure. Appendix E includes all of the following mechanics of waste transport requested:

1. *Conditions to halt waste placement and transport such as wind direction and precipitation events – Section 3.6;*
2. *Communications – Section 1.3;*
3. *Sorting and Sizing – Section 3.1;*
4. *Sampling – Section 3.2;*
5. *Spill Response – Section 3.8;*
6. *Weight – Section 3.2;*
7. *Identification of Wastes Requiring Special Management – Section 3.5;*
8. *Pretreatment – Section 3.5;*
9. *Oversize Material – Section 3.1;*
10. *Security – Section 1.5;*
11. *Dust Control – Throughout Section 3.0;*
12. *Odor Control – There is no need for odor control, therefore this item is not discussed in Appendix E; and*
13. *Decontamination of Equipment used to Transport, Place, and Compact Materials – Section 3.7. Sizing and sorting of materials will be done at the demolition site and will be decontaminated on-site; therefore, this equipment is not discussed in Appendix E.*

Comment 13. Page xxxv, Comment 4, please clarify what is meant by your response in regard to limitation of waste size to a vertical distance of two feet. Will there be any waste sizing? If so, please amend the appropriate portions of the text to describe this in detail.

Response: Some large pieces of concrete or metal debris may need to be resized in order to make the vertical dimension of the debris 2 feet or smaller, however, there is no size restriction to the horizontal or width dimension of the waste except that it needs to be small enough to fit in a haul truck. Larger pieces will result in less void space and reduce the potential for settlement. This debris will be placed in the cell so the 2 foot or smaller dimension is the vertical dimension. The text "All material requiring size reduction will be resized at the structure demolition site using excavators with concrete breakers or shears." has been added to the text as shown on replacement page 4-1.

Comment 14. Page xlvi, Comment 6, regarding inspection requirements for the two CAMU cells, please allow us to reiterate the relevant portions from EPA's April 25, 2007 letter:

> **"…ASARCO must adhere to the current monthly CAMU inspection requirements until an approved post closure plan is approved for both closed CAMU cells. If ASARCO wishes to alter its currently approved monitoring program for CAMU Cell 1, please submit a formal request to the EPA project manager. Further, as stated in an April 18, 2007, email, the intent of the original CAMU Phase 2 Cell comment, Section VII. Post Closure Care, Comment 5, was to require more frequent formal inspections by a professional engineer rather than a five-year evaluation frequency as proposed by ASARCO."**

Response: Asarco will comply with the inspection requirements provided in the EPA April 25, 2007 letter for the two CAMU cells.

Comment 15. Page xlviii, Asarco's Response to EPA's Comment VIII.1: Following approval of the design of the CAMU Phase 2 Cell, please provide a detailed construction schedule similar to Figure 4-1 Construction Schedule in the Phase 1 Design.

Response: A Construction Schedule, similar to the one provided in the Phase I Design, has been provided in replacement Appendix F. This schedule will be updated once the project begins.

Comment 16. Page xlviii, Asarco's Response to EPA's Comment VIII.2. Please note that this response erroneously references a Montana Department of Environmental Quality (MDEQ) response to Hydrometrics' letter dated June 16, 2006. The MDEQ's files do not include a response to Hydrometrics or Asarco. We believe the response is referencing a July 11, 2006 letter from EPA that approved the geotechnical work.

Response: Although MDEQ did not respond directly to Hydrometrics' letter dated June 16, 2006, which was sent to the MDEQ, EPA response stated that MDEQ had received the letter, reviewed it, and approved of the proposed plan for geotechnical and site investigation. We apologize if our assumption that this letter represented a response from DEQ was in error.

Comment 17. Section 3.6 and Section 3.7: The gas migration layer and cushion layer on top of the waste is inconsistent between Figure 3.5 and Figure 3-6. This should be corrected.

Response: Figure 3-6 has been revised to show the cushion layer as the 12", as required by Comment 3 on page xliii and not 24". This change is shown on replacement Figure 3-6.

Comment 18. Section 3.7 Component Design: The gas migration layer is not discussed in the component design section. A brief description should be included. In addition, Asarco should clarify how many vent pipes are proposed for the gas vent system.

Response: A discussion of the gas migration layer along with the number of vent pipes has been added to Section 3.7.3 as shown on replacement page 3-27.

Comment 19. Section 3.7.1.3 Cap Composite Liner: The requirements for the geosynthetic clay liner listed in this section are also applicable to the GCL that is on top of the compact clay liner. This point is not clear in the Design Report and should be clarified in Section 3.7.1.2.

Response: The following text has been added to Section 3.7.1.2 as shown on replacement page 3-22: "The geosynthetic clay liner will be needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile. The needle-punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope. No horizontal seams should be allowed on the slopes."

Comment 20. Section 3.7.1.3 Cap Composite Liner: This section states the cap liner will consist of a 40-mil double-sided textured HDPE FML on top of a geosynthetic clay liner (GCL). However, various figures and specification sheets do not match the text and appear to have the GCL on top of the FML. The following figures and sheets must be modified: Figure 3-6; Sheet Number 28; and Sheet Number 30.

Response: Figure 3-6 and Sheets 28 and 30 have been revised to clearly show the 40-mil double-sided textured HDPE FML on top of the GCL.

Comment 21. Section 5.0, Temporary Cap: please explain how the 10 ounce cushion fabric from the temporary cap, which will not be reusable, will be sized before disposal in the cell.

Response: The cushion fabric will be shredded or cut into pieces no larger than 36 square feet before placement in the cell. The contractor will be required to place the pieces flat and distribute the pieces of fabric evenly throughout the cell as described on replacement page 5-1.

Comment 22. Appendix G 4.0 Compact Clay Liner, page 4-4: The text discusses conformance testing of the compact clay liner following completion. As reflected in Comment 3, the text should be revised to specify that the hydraulic conductivity must not exceed 1.0 x 10^{-6} not simply 10^{-6}. In addition, the text must include provisions for discussion with EPA and approval of the liner by EPA if any of the conformance tests do not meet the standard. EPA and Asarco will need to agree on a path forward such as rejecting the liner or mitigation to decrease the conductivity.

Response: Page 4-4 of Appendix G has been revised to state that if any of the specimens have a hydraulic conductivity in excess of $1x10^{-6}$cm/sec, Asarco will consult with EPA on what actions will be taken to mitigate the overall conductivity of the CCL.

Comment 23. Appendix H Section 2.0 Dust Control: The dust control plan appears to adequately address dust control during transportation unless there are high wind or precipitation events. Please specify whether work stoppage criteria apply to on-site and off-site transport. If transport is halted, please amend the text to indicate that trucks containing wastes will be tarped until conditions improve.

Please state where the wind speed numbers are obtained. We assume the Helena airport. We also suggest installation of wind socks strategically placed as an indicator of high wind conditions requiring work stoppage.

Wastes already in place in the CAMU may be a fugitive emission source. The dust control plan must include control measures for waste already disposed of in the CAMU. Fugitive emission may not simply be "nuisance dust" but may be hazardous waste containing emissions. Therefore, fugitive emissions must be diligently controlled. We recommend inspections of the cell at least twice daily to assess the potential for windblown dispersion and establishment of procedures to address visible releases from the cell. Please amend the Operating Plan (refer to Comment 12 above) to include provisions for this.

Response: The Waste Hauling Plan has been included in Appendix E – Operating Plan. Section 3.6 of Appendix E has been updated to specify that work stoppage criteria applies to both on-site and off-site transport and that in the event that transport is halted, no additional trucks will be loaded and any trucks containing wastes will be covered until conditions improve.

Section 3.6 of Appendix E states – "Sustained wind speeds will be monitored by management personnel through the use of a calibrated on-site wind sock; as well as, through data provided by the National Oceanic and Atmospheric Administration (NOAA) at www.noaa.gov for wind speeds at the Helena Airport."

Section 3.3 of Appendix E addresses the need for control measures for fugitive dust emissions created by waste already placed in the CAMU and includes inspections of the CAMU cell and surrounding areas twice daily. Daily inspections are addressed in Section 6.1 of Appendix E.

Comment 24. Appendix H, Waste Hauling, 2.3 and 4.0: Please expand this plan to describe how and where wastes within the transport vehicles is removed. If the haul truck tires contact the hazardous wastes within the cell, decontamination must occur before they enter the haul roads. Please Expand Section 4.0 to describe how and where equipment used within the cell will be decontaminated.

Response: Wastes will simply be dumped from haul trucks into the CAMU Phase 2 Cell where they will be placed and compacted by designated equipment. As stated in Section 3.7 of Appendix E, "Haul trucks leaving the CAMU Phase 2 Cell will be traveling on paved haul roads and will not be decontaminated until they enter the ASARCO smelter facility, where they will be decontaminated. Any large debris will be knocked off of haul trucks as they

leave the CAMU Phase 2 Cell. The section of haul road between the CAMU Phase 2 Cell and the ASARCO smelter facility will be constantly monitored and swept on a regular basis. This section of haul road will be inspected twice daily." "Equipment used in the CAMU cell for spreading and compacting waste will be decontaminated at the ASARCO smelter facility. This equipment will be placed on trailers and driven via the haul road back to the ASARCO smelter facility, where it will be decontaminated." By requiring the contractor to pave the haul roads and continually sweep them, Asarco's intent is to control contamination without the muddier alternatives of wheel washing.

Comment 25. Appendix H, Waste Hauling: Please expand this plan to include the daily inspections requested in Comment 23 above, as well as weekly inspections of fences, gates, condition of haul roads, storm water pond, presence of precipitation run-off or ponded liquids, decontamination pads, etc. Please develop forms to document these inspections.

Response: The Operating Plan – Appendix E includes Section 6.0 – Site Monitoring and Inspection, which has been expanded to include daily and weekly inspections as requested. Inspection forms for Daily and Weekly Inspections have been added to Appendix E – Attachment B to accompany the Monthly and Semi-Annual Inspection Form.

Comment 26. Appendix I Sheet 26 and Sheet 27: The cushion material size specifications are inconsistent. Sheet 27 should be corrected to match Sheet 26

Response: Sheet 27 has been corrected to match Sheet 26 as shown on replacement Sheets 27 and 26.

Comment 27. Appendix I Sheet 30: Please explain "construction geotextile" on Sheet 30.

Response: No construction geotextile is to be used and has been removed from Sheet 30 as shown on the revised Sheet 30.

Comment 28. Appendix J: Table 4-1 Stockpile Acceptance Testing should be revised to specify the hydraulic conductivity must not exceed 1.0 x 10^{-6}, as reflected in Comment 3 above.

Response: Table 4-1 has been revised to show hydraulic conductivity must not exceed $1.0x10^{-6}$ as shown on revised Table 4-1 of Appendix J.

Comment 29. Appendix J; 203.07.8, A. 3. Waste Material, please describe how and where the size reduction of the demolition debris, both newly generated and stored wastes, will occur, and amend the text to include this discussion.

Response: The text has been amended to include "All material requiring size reduction will be resized at the structure demolition site and all stored material requiring size reduction will be resized at the location the material is stored" as shown on replacement page 7 of Appendix J.

Comment 30. Appendix J, Section 203.07.07 D. 2 and 2, the text lists 8 inches of excavated soil for use as topsoil and 16 inches of soil for use as subsoil; however, on page xliv, in response to Comment 6, ASARCO indicates that a cover of 6 inches of seeded topsoil will be placed over 24 inches of subsoil. Please amend Appendix J to reflect this proposed cap design.

Response: This section of the specification refers to stripping of the soil prior to excavation of the cell. The contractor will be required to strip the top 8 inches of material for use in the 6- inch topsoil cap requirement and then strip the next 16 inches of subsoil for use in the 24-inch subsoil cap requirement. The deficiency of subsoil will be made up with excess material from the remainder of the cell excavation.

Comment 31. Appendix J: Please note that Section 203.07.7 D.3. on page 6 erroneously discusses the compacted clay cover. A clay cover is not proposed for the Phase 2 CAMU. Please amend the text.

Response: The clay cover reference has been removed as shown on replacement Page 6, Section 203.07.7 D.3 of Appendix J.

Comment 32. Appendix J, 203.07.8 C.1, page 9, please explain whether the specifications have erroneously required a compaction to 90 percent Proctor maximum dry density rather than 95 percent, as listed in Table 4-2, QC Testing for CCL Placement.

*Response: The 90 percent Proctor maximum dry density requirement in Section 203.07.8 C.1 on Page 9 of Appendix J is in reference to the **subgrade** below the Compacted Clay Liner. To help clarify this statement, the following text has been added to Section 203.07.8 C.1 on Page 9 of Appendix J: "prior to placement of the compacted clay liner" as shown on replacement Page 9 of Appendix J.*

Comment 33. Appendix J, 203.07.8 C.1. b.1, the project specifications state that "No more than 20 percent of the material represented by the samples shall be at dry density less than 95 percent of Proctor maximum dry density." Please correct this to reflect that not more than 3%, rather than 20%, outliers are allowed.

Response: The reference has been changed to 3% as shown on replacement page 10 of Appendix J.

Comment 34. Appendix J, 623.02, A.: Table 4. Geomembrane Specifications may contain an error of the gauge for the CAMU CAP. The value listed is 20 mils. The designed cap liner should be 40 mil. Also Table 4 Geomembrane Specifications and Table 5-1 Manufacture's QA Test for FML include discrepancies between them; for example, tear strength values differ between Table 4 and Table 5-1. Please reconcile these tables.

Response: Table 4 has been changed to reflect the 40 mil liner for the CAMU Cap and the design values have been reconciled against Table 5-1 as shown on Revised Page 2 of Section 623.02 of Appendix J.

Comment 35. Appendix J: Page 3, Section 625.05.7 Cover Placement discusses placing soil over the GCL. For the CAMU Phase 2 Cell's bottom and cap, soil should not be placed directly on the GCL. Asarco must amend these specifications to ensure their consistency with the proposed design.

Response: The reference to placing soil over the GCL has been removed from Page 3 of Section 625.05.7 of Appendix J.

Comment 36. Appendix J; 203.07.8 C. 7. Waste Materials, please specify whether crushed slag, imported gravel or select fill will be used.

Response: Section 203.07.8 C.7 Page 7 of Appendix J has been modified to state that imported gravel will be used as cushion material.

X. Responses to June 2, 2007, Additional Comments on the Revised Design Analysis Report for the ASARCO East Helena Smelter CAMU Cell 2

Comment 1. Section 3.4, Soil Materials. This section states: "Results from the geotechnical investigation indicate the site soil is suitable for use in construction of the compacted clay liner for the CAMU Phase 2 cell." As stated in Section 3.2, however, Geotechnical Investigation, this is only true with the addition of a geosynthetic clay liner (GCL) as required by the U.S. EPA. Please amend the text to reflect this.

Response: The text in Section 3.4 has been changed to read:" As explained in Section 3.2, results from the geotechnical investigation indicate that site soil may not be suitable for use in construction of the compacted clay liner for the CAMU Phase 2 Cell therefore a geosynthetic clay liner (GCL) will be placed above the compacted clay liner to meet the hydraulic conductivity performance requirements" as shown on replacement page 3-12 of the Design Report.

Comment 2. Appendix C, Design Analysis: The design/analysis of the FML, Geonet, anchor trench, selection of the cover soil cap slope, concrete sump footing, cell settlement, and leachate system capacity appear to be accurate and in accordance with the accepted design standards. However, a similar design/analysis for the GCL is missing. Please submit this in your responses.

Response: An analysis of the GCL has been included in Appendix C.

Comment 3. Appendix F, Construction Schedule: The proposed duration of the identified CAMU construction activities appears reasonable; however, the chart will require updating to reflect revised work start dates.

Response: An updated construction schedule has been added to Appendix F as shown on replacement Appendix F.

Comment 4. Appendix I, Project Drawings: Only Sheets 24 through 32 are attached to the design report. Please clarify whether there are other sheets which deal with the construction of the CAMU and submit them with your responses.

Response: Sheets 1 through 23 are for the Asarco Smelter Cleaning and Demolition portion of the project and do not deal with construction of the CAMU.

Comment 5. Appendix I, Project Drawings, Sheet 28: The required 24-inch thick cushion layer on top of the bottom liner, while shown on both Sections A and B, is not identified. See Figure 3.5 of the design report for similar sections with proper identification.

Response: Sheet 28 has been revised to identify the 24-inch thick cushion layer as shown on revised Sheet 28.

Comment 6. Appendix J, Project Specification Division 200—Earthwork, Page 10: In discussion of compaction of the cushion layer, drainage layer, drain layer, gas migration layer, and subsoil, the specification calls for light rolling of the layer. It would be appropriate to identify an acceptable class of rolling equipment (perhaps by maximum weight) to accomplish the required compaction, while minimizing the potential for damage to the underlying liner components.

Response: Nonvibratory compaction equipment with a static weight of 1.5 tons or less has been specified for light rolling of the cushion layer, drainage layer, drain layer, gas migration layer and subsoil has been added to Page 10 as shown on revised Page 11 of Appendix J.

Comment 7. Appendix J, Project Specification Division Section 625—GCL, Page 3, Paragraph 1 of Section 625.04 should be modified to include the following text: "The needle punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond."

Response: The text "The needle punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond" has been added to Page 3 as shown on replacement Page 3, Paragraph 1 of Section 625.04 in Appendix J.

Comment 8. Appendix J, Project Specification Division Section 625—GCL, Page 4. Has the specified sheer and peel strengths been determined to be adequate to resist

damage during and after installation for the proposed design? See Comment 2. Please include this information in your responses.

Response: An analysis of the GCL has been included in Appendix C.

Comment 9. EPA's consultant concluded that the magnitude of displacements predicted by Hydrometrics' analysis and their analysis suggest adequate earthquake performance of the landfill cover. Please see the attached seismic analysis for further detail.

Response: Comment noted, and the seismic analysis performed by EPA's consultant has been added to Appendix C.

DESIGN ANALYSIS REPORT
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) PHASE 2 CELL

1.0 INTRODUCTION

This document and its associated appendices constitute the design analysis submittal for the proposed Corrective Action Management Unit (CAMU) Phase 2 Cell near the Asarco East Helena Plant ("the plant"). The plant is described in detail in other documents, particularly the Comprehensive Remedial Investigation/Feasibility Study (RI/FS, Hydrometrics, 1990), the Current Conditions Release Assessment (CCRA, Hydrometrics, 1998), and the RCRA Facility Investigation (ACI, 2003). The CAMU Phase 2 Cell for the East Helena Plant will contain plant site soil and demolition debris generated through the implementation of the Montana Consent Decree (CDV-2004-212), which expired December 31, 2006, and the RCRA Consent Decree (CV98-3-H-CCL). Asarco and the Montana Department of Environmental Quality have been negotiating a new Montana Administrative Order that will govern future cleaning and demolition projects at the East Helena site.

Although not required by CAMU regulations, the proposed CAMU Phase 2 Cell is designed to comply with the Resource Conservation and Recovery Act (RCRA), Subtitle C regulations and the Administrative Rules of Montana (ARM 17.50.506).

Tasks necessary to construct the CAMU Phase 2 Cell include:

1. Identification of Performance Standards
2. Site Selection
3. Geotechnical Investigation
4. Material Testing
5. Project Design

6. Project Construction
7. Waste Placement and
8. Closure and Monitoring.

Each of these tasks is discussed in this Design Submittal.

2.0 PERFORMANCE STANDARDS

The following performance standards for hazardous waste landfills, defined in 40 CFR 264 and ARM 17.50.506 were used for design of this project.

2.1 BOTTOM LINER SYSTEM

(40 CFR § 264.301 (c)(1) and ARM 17.50.506)

a. The liner system shall include two or more liners with a leachate collection removal system above and between them.
b. The upper component of the bottom liner system shall consist of a flexible membrane with a minimum thickness of 35 mil, and will be designed and constructed to prevent migration of hazardous constituents into the bottom liner system.
c. The lower component of the bottom liner system shall consist of a composite liner which shall include a minimum of three (3) feet of compacted soil with a maximum hydraulic conductivity of 1×10^{-7} cm/sec overlain by a flexible membrane liner with a minimum thickness of 35 mil, designed and constructed to minimize the migration of hazardous constituents if a breach in the upper component were to occur.
d. The liner system shall be designed and constructed to comply with 40 CFR §§ 264.301 (a)(1)(i), (ii), and (iii) to ensure that it is engineered to withstand the chemical and physical stresses it will be subjected to while containing the source area soils and demolition debris. The liner system shall be located, designed, constructed, and operated to be completely above the seasonal high water table.

2.2 COVER SYSTEM

(40 CFR §§ 264.111, 264.310 AND 264.19)

The cover system shall:

a. Minimize the need for further maintenance;
b. Control, minimize or eliminate, to the extent necessary to protect human health and the environment, escape of source area soils and demolition debris, hazardous

constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere;

c. Provide long-term minimization of migration of liquids through the closed CAMU;
d. Function with minimum maintenance;
e. Promote drainage and minimize erosion or abrasion of the cover;
f. Accommodate settling and subsidence so that the cover's integrity is maintained; and
g. Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

2.3 LEACHATE COLLECTION AND REMOVAL SYSTEM

(40 CFR §§ 264.301 (c)(2), (c)(3)), and ARM 17.50.506(6)(b).

a. The leachate collection and removal system immediately above the top liner must be designed, constructed, operated, and maintained to collect and remove leachate from the CAMU Phase 2 Cell. It shall be designed and operated to ensure that leachate depth over the liner is minimized to the extent practicable, and does not exceed one (1) foot.
b. This system shall be designed and constructed to comply with 40 CFR §§ 264.301 (c)(3)(iii) and (iv) to ensure that it is engineered to withstand the chemical and physical stresses to which it will be subjected and to minimize clogging.
c. This system shall be constructed with a bottom slope of two percent or more.
d. This system shall be constructed of either a granular drainage material with a hydraulic conductivity of $1x10^{-2}$ cm/sec or more and with a minimum thickness of 12 inches, or of a synthetic geocomposite material with a transmissivity of $3x10^{-5}m^2$/sec or more.
e. The leachate collection and removal system shall have a sump to collect the leachate from the drainage layer and a removal system of sufficient size to prevent liquids from backing up into the drainage layer.

2.4 LEAK DETECTION, COLLECTION, AND REMOVAL SYSTEM

(40 CFR §§ 264.301 (c)(3) AND (c)(4), 264.302, AND 264.304)

a. The leak detection, collection and removal system between the liners shall be constructed with a bottom slope of two percent or more of granular drainage materials with a hydraulic conductivity of 1 x 10^{-2} cm/sec and a thickness of 12 inches or more, or with synthetic or geocomposite drainage materials with a transmissivity of 3 x 10^{-5} m^2/sec or more and it shall be constructed with sumps and liquid removal methods that shall be operated to minimize the head on the bottom liner system in accordance with 40 CFR §§ 264.301 (c)(3)(v) and 264.301 (c)(4). An action leakage rate and response action plan will be established for the CAMU in accordance with 40 CFR §§ 264.302 and 264.304 to address design flow rates in the leak detection system which will result in a head greater than one foot on the bottom liner system.

b. The leak detection, collection and removal system between the liners shall be designed and constructed to comply with 40 CFR §§ 264.301 (c)(3)(iii) and (iv) to ensure that it is engineered to withstand the chemical and physical stresses to which it will be subjected and to minimize clogging.

2.5 SURFACE RUNON CONTROL SYSTEM

(40 CFR §§ 264.301 (g) AND (i))

The run-on control system shall be capable of preventing flow onto the active portion of the CAMU Phase 2 Cell during peak discharge from a 24-hour, 25-year storm. Collection and holding facilities that are associated with this system must be emptied, or otherwise managed expeditiously after storms, to maintain design capacity of the system.

2.6 SURFACE RUNOFF CONTROL SYSTEM

(40 CFR §§ 264.301 (h) AND (i))

The run-off management system shall collect and control at least the water volume resulting from a 24-hour, 25-year storm. Collection and holding facilities which are associated with this system must be emptied expeditiously, or otherwise managed after storms to maintain design capacity of the system.

2.7 CONTROL OF PARTICULATE MATTER

(40 CFR § 264.301 (j))

The CAMU shall be operated to control wind dispersal of waste soils, sediments, and demolition debris placed in it, consistent with the requirements of 40 CFR § 264.301(j).

2.8 MONITORING, INSPECTION & CONSTRUCTION QUALITY CONTROL

(40 CFR §§ 264.19 AND 264.303)

A Construction Quality Control (CQA) program shall be established for the CAMU to ensure that the constructed unit meets or exceeds all design criteria and specifications in accordance with 40 CFR §§ 264.19 and 264.303. A copy of the Construction Quality Assurance Plan is in Appendix G. The CAMU Phase 2 Cell systems must be inspected during operation and the leak detection system inspected after closure. Inspection of the CAMU Phase 2 Cell during operations will be in accordance with 40 CFR §264.303, and 264 Subpart F requirements will be used for establishment of a groundwater monitoring program for releases after closure.

2.9 CLOSURE CERTIFICATION AND POST CLOSURE CARE OF THE CAMU

(40 CFR §§ 264.310, 264.115 THROUGH .120)

The closure certification, monitoring, inspection, operation, maintenance, and record keeping requirements of 40 CFR §§ 264.310, 264.115-120, 264 Subpart H, and 264 Subpart G must be adhered to after closure of the CAMU. The post-closure period of the CAMU shall be indefinite.

2.10 OTHER DESIGN CRITERIA

Other design criteria are listed by reference in Section 3.0 CAMU Design.

3.0 CAMU DESIGN

This design analysis addresses the CAMU Phase 2 Cell that will be constructed in 2008 to contain demolition debris and waste soils from current remedial cleanup activities. The location of the CAMU Phase 2 Cell is shown on Figure 3-1.

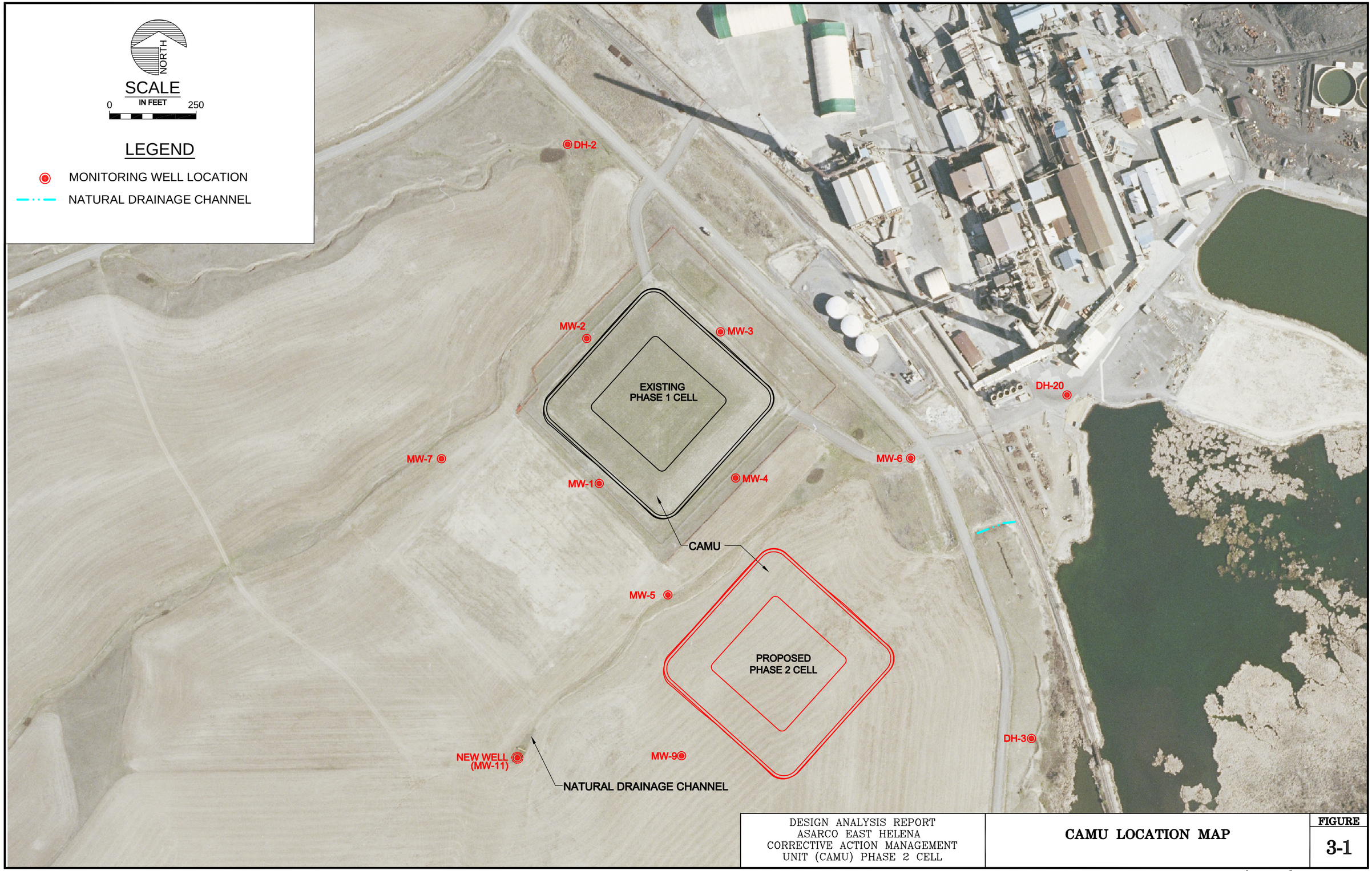
Most of the elements of CAMU Phase 2 Cell design were addressed in the CAMU Phase 1 Cell Design Report (Hydrometrics, 2000) approved by EPA in July 2000. Additional information addressed in this Design Analysis Report includes:

- Location of the CAMU Phase 2 Cell.
- Borehole and Test pit excavation and soil testing for CAMU Phase 2 Cell compacted clay liner construction (Section 3.2).
- Construction of three additional wells to better define site stratigraphy and groundwater flow conditions (Section 3.3).
- Changes to design of the Leachate Collection and Leak Detection Removal Designs.

3.1 SITE SELECTION

An examination of site soils adjacent to the CAMU Phase 1 Cell was completed in September 2006, and indicates that the area immediately south/southeast of the CAMU Phase 1 Cell is well suited as the site for the CAMU Phase 2 Cell. Further discussion of the CAMU Phase 2 Cell site location is found in the CAMU Phase 2 Cell Geotechnical Investigation (Hydrometrics, 2006). As required by either 40 CFR 264.18 or ARM 17.50.505, the proposed site, shown on Figure 3-1, has **no**:

- Wetlands
- Floodplains
- Faults
- Instability
- Underlying rock fractures or fissures



DESIGN ANALYSIS REPORT ASARCO EAST HELENA CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) PHASE 2 CELL	CAMU LOCATION MAP	FIGURE 3-1

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Hydrometrics, Inc.
Consulting Scientists and Engineers

- Insufficient land area
- Insufficient public access
- Groundwater or surface water pollution potential
- Public water supplies
- Hydraulic connections to springs
- Airport that has jet aircraft within 10,000 feet or
- Other airports within 5,000 feet.

In addition, the site is:

- At least 200 feet from adjacent property lines.
- At least 500 feet from public drinking water sources, residences, schools, hospitals, and centers of community activity.
- Within a seismic impact zone. However, pursuant to 40 CFR 270.14(b)(11) it is over 3,000 feet from a fault that has had displacement in Holocene time.
- Without subsidence areas.
- Not in a sole-source aquifer recharge area.
- Without endangered species habitat.
- Not in designated state and federal wilderness, parks and preserves.
- Not zoned for activities other than industrial use or agriculture.
- Without historic or archaeological significance.
- Vertically separated from the underground aquifer and without springs.
- Distant from groundwater discharge to a water supply well or to surface water.
- In simple (homogeneous) hydrogeologic stratigraphy.
- In soils that are nearly impermeable or at least in a location which does not intercept or directly overlie an appreciable thickness of permeable soils.

When combined with proper CAMU Phase 2 Cell design and construction, this site will prevent the migration of wastes into the surrounding water and soil.

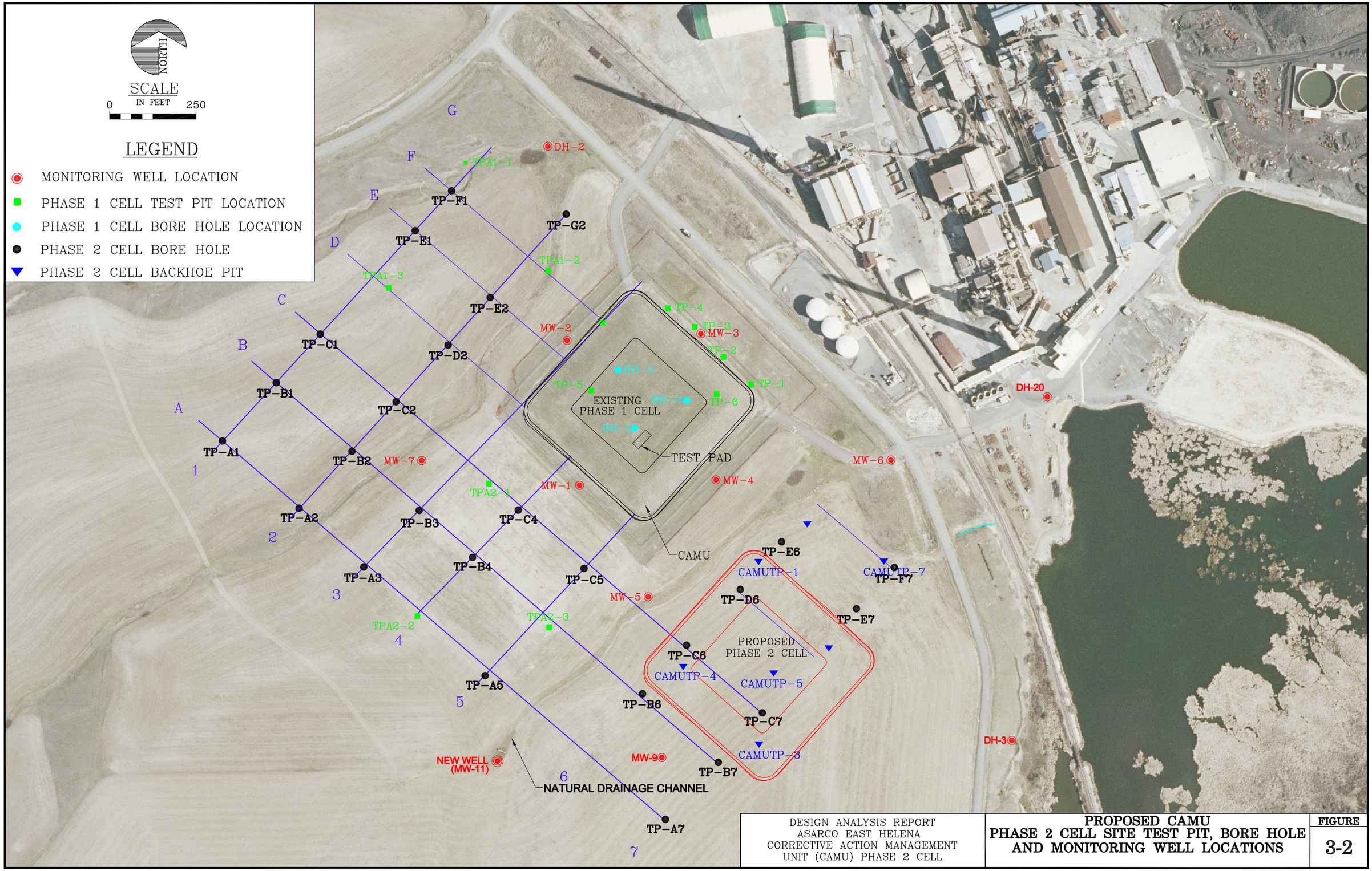
3.2 GEOTECHNICAL INVESTIGATION

Geotechnical evaluations were conducted during August and September 2006 to collect information for site evaluation and design. Twenty-eight (28) boreholes (TP-A1 through TP-G2) and seven (7) test pits (TP-1 through TP-7), shown on Figure 3-2, were drilled or excavated in the area of the CAMU Phase 2 Cell to collect geotechnical information. In addition, three groundwater monitoring wells (MW-8 through MW-10) were installed in the areas surrounding the CAMU Phase 2 Cell to provide additional stratigraphic information and to provide baseline and post construction groundwater quality and hydrology information. Details of the geotechnical investigation, including borehole and test pit logs, are documented in the CAMU Phase 2 Cell Geotechnical Investigation (Hydrometrics, 2006).

3.2.1 Review of Existing Data

Evaluation of the areal geology and hydrogeology has been addressed previously in the Remedial Investigation Report for the adjacent Asarco East Helena Lead Smelter (Hydrometrics, 1990) and the CAMU Phase 1 Cell Design Report (Hydrometrics, 2000). As described in this report, a test pad was constructed and a 6-foot sealed double-ring infiltrometer (SDRI) was installed in May 2000 in order to accurately measure the infiltration rate of a compacted clay liner (CCL) constructed from local borrow soil. The test pad was constructed using the field equipment and procedures that are similar to what will likely be used for CAMU Phase 2 Cell construction. As shown in Figure 3-3, the SDRI test results showed that an effective permeability less than 10^{-7} centimeters-per-second can be achieved using site borrow soils.

When combined with the list of desirable site characteristics, compiled in Section 3.1 of this report, these infiltrometer results confirm that site soils and geology will minimize the migration of any hazardous materials from the CAMU Phase 2 Cell and are conducive to construction of a reliable CAMU Phase 2 Cell.



DESIGN ANALYSIS REPORT ASARCO EAST HELENA CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) PHASE 2 CELL	PROPOSED CAMU PHASE 2 CELL SITE TEST PIT, BORE HOLE AND MONITORING WELL LOCATIONS	FIGURE 3-2

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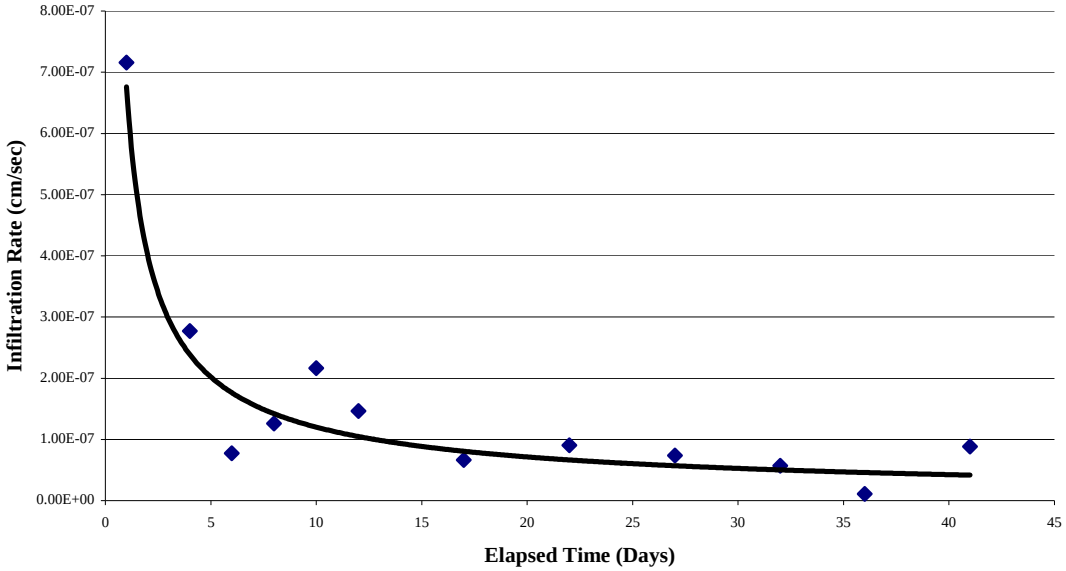
Hydrometrics, Inc.

FIGURE 3-3. SEALED DOUBLE RING INFILTROMETER TEST RESULTS FROM MAY 2000



3.2.2 Results of Geotechnical Investigation

Results from the 2006 geotechnical investigation were documented in the CAMU Phase 2 Cell Geotechnical Investigation (Hydrometrics, 2006) and are summarized in the sections that follow. As explained in this report, the soil conditions encountered during this investigation resulted in a shift of the proposed CAMU Phase 2 Cell location to the area adjacent to and east of the existing CAMU Phase 1 Cell.

3.2.2.1 <u>Depth of Sandy Loam Soil Layer</u>

At the proposed site of the CAMU Phase 2 Cell, the depth of the clayey loam varied from 15 to 20 feet. At that depth, the loam soil transitions over a 2 to 5 foot interval to a poorly graded gravel, cobble, and boulder soil layer. Depths of loam are very similar to those encountered during the site investigation for the CAMU Phase 1 Cell.

The intent of siting the CAMU Phase 2 Cell in this particular soil unit is to use the loam soil as an impermeable foundation and as a construction material for the cell's compacted clay liner. The depth and quality of the clayey loam soil layer impacts the feasibility of

constructing the clay liner from site soil and controls the allowable depth of excavation for the CAMU cell.

3.2.2.2 Maximum Proctor Density

The insitu density of the site loams ranges from 85 to 96 pounds-per-cubic-foot (pcf). Maximum compacted densities were measured to be approximately 100 to 112 pcf. Therefore, compaction of site soil can be expected to increase the average insitu density of the soil by almost 20 percent. These densities are similar to those measured during the CAMU Phase 1 Cell investigation and suggest that compaction of the site soils will result in a significant increase in density and a corresponding decrease in permeability.

3.2.2.3 Soil Classification

Soil gradation and plasticity were measured from bulk test pit samples and were used to classify site soils and to determine their suitability for construction of the compacted clay liner. All samples from the CAMU Phase 2 Cell site were classified as fine-grained soils, and except for one test pit that classified as low plasticity silt (ML), samples from test pits were classified as low plasticity clay (CL). As discussed in the CAMU Phase 2 Cell Geotechnical Investigation (Hydrometrics, 2006), site soils were generally found to be finer and more plastic than those tested in the CAMU Phase 1 Cell investigation and are suitable for use in construction of the compacted clay liner.

The soil classification is used to verify the appropriateness of many of the soil properties used for design. A CL-ML soil is expected to have a unit weight in the range of 90 pcf when loose to 120 pcf when compacted. It is expected to have an angle of internal friction (ϕ) of 20° to 30° depending on the amount of sand and the density of the material. Saturated cohesion for this material is likely to range from 190 to 460 psf depending upon how much of the fine material is silt and how much is clay. This information is valuable for slope stability and settlement calculations, as well as many other design decisions.

3.2.2.4 Hydraulic Conductivity

To determine the effect of surcharge on permeability, falling head parameter tests were conducted on three test pit samples. Appendix A contains the laboratory results that are summarized in Table 3-1. With a 22 pounds-per-square-inch (psi) surcharge, hydraulic conductivity for the site clayey soils ranged from 3 to 9.7 x 10^7cm/sec. Although these results are relatively consistent with those obtained for the CAMU Phase 1 Cell and indicate that hydraulic conductivity is reduced by one to two orders of magnitude under a surcharge pressure, the EPA required hydraulic conductivity of 10-7 cm/sec was not achieved by any of the samples. Therefore, the addition of a GCL to the secondary liner will be required by EPA in order to meet this performance standard.

TABLE 3-1. GEOTECHNICAL TEST PIT SAMPLE SUMMARY

CAMU Phase 2 Cell Sample No.	Soil Classification	% Fines	PI	Compaction Test Data (ASTM D 698)	Hydraulic[1] Conductivity (cm/sec)	Hydraulic[2] Conductivity (cm/sec)
TP-2	CL	57.9	8	Max. DD = 108 pcf OM = 17%	k= 1.8 x 10^{-6}	k= 9.3 x 10^{-7}
TP-3	CL	70.9	18	Max. DD = 100.5 pcf OM = 19.2%	k= 1.2 x 10^{-5}	k= 3.0 x 10^{-7}
TP-7	CL	61.9	8	Max. DD = 105 pcf OM = 18.5%	k= 2.0 x 10^{-6}	k= 9.7 x 10^{-7}

[1]Hydraulic conductivity measured after initial saturation with no effective stress (Hydrometrics, 2006).

[2]Hydraulic conductivity measured after increase of effective stress to 22 psi and resulting consolidation (Hydrometrics, 2006).

3.3 SURFACE AND GROUNDWATER INVESTIGATIONS

The list of desirable site criteria compiled in Section 3.1 suggests that site surface water and groundwater should be isolated to the extent possible from the CAMU Phase 2 Cell. Monitoring wells 8, 9, and 10 indicate the water table is present between 29 and 57 feet bgs and will be separated from the bottom of the CAMU Phase 2 Cell by 20 feet of low permeability sandy loam soil as described in Section 3.2.

3.3.1 Surface Water

Prickly Pear Creek flows along the east edge of Asarco's property boundary, but is over 2,000 feet from the CAMU Phase 2 Cell site. The floodplain boundary for Prickly Pear

Creek coincides with the edge of Upper Lake, which is over 500 feet from the site. As shown in Figure 3-1, a small drainage gully to the northwest of the site collects runoff and empties into a storm water ditch that bounds the northeast side of the site. This ditch directs storm water to Upper Lake.

The CAMU Phase 2 Cell site lies within a drainage area of 23.7 acres with an average slope of about 4 percent and a longest flow path of 1437 feet. A 25-year, 24-hour precipitation event at the site is expected to produce 2.3 inches of rain and a peak flow of 4 cubic-feet-per-second (cfs) that needs to be diverted around the site.

The cap of the CAMU Phase 2 Cell occupies approximately 5.1 acres with an average slope of about 13 percent and a longest flow path of 425 feet. A 25-year, 24-hour precipitation of 2.3 inches is expected to produce a peak runoff flow of 4 cfs and a total runoff volume of 1.08 acre-feet that will need to be controlled by Best Management Practices (BMP) until the cap cover vegetation is established. Peak flows and runoff volumes were calculated using software (EFH 2) from the Natural Resource Conservation Service's Engineering Field Handbook. Appendix A contains documentation of the site surface water investigation and calculations of flows.

3.3.2 Groundwater

The groundwater regime and hydrogeology of the CAMU area have been interpreted from stratigraphic and water level data from groundwater monitoring wells and from hydrogeologic data collected during the plant site remedial investigation and subsequent long-term monitoring. In addition to the seven groundwater monitoring wells that were constructed adjacent to the CAMU Phase 1 Cell site, three additional groundwater monitoring wells were constructed outside the footprint of the CAMU Phase 2 Cell and centered approximately on the southeast (MW-8), southwest (MW-9), and northeast (MW-10) sides. Well depths were 70 feet. All CAMU monitoring wells were located horizontally and vertically for subsequent interpretation of the groundwater potentiometric surface and groundwater flow direction. Table 3-2 shows well completion data for the CAMU Phase 2 Cell monitoring wells. Figure 3-2 shows the location of these wells with respect to the

TABLE 3-2. SUMMARY OF CAMU MONITORING WELL CONSTRUCTION

Well Number	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10
Screened Interval Lithology	ash/tuff	ash/tuff	ash/tuff	ash/tuff	ash/tuff	ash/tuff	ash/tuff	ash/tuff	ash/tuff	ash/tuff
Ground Surface Elevation (ft)[1]	3947.78	3940.57	3935.84	3941.08	3949.62	3931.92	3957.69	3952.37	3958.92	3940.26
Measuring Point Elevation (ft)[1]	3949.43	3942.36	3937.38	3943.52	3952.52	3934.54	3959.99	3954.97	3961.72	3942.59
Total Depth Drilled (ft bgs)[2]	68	66	50	72	71	40	60	70	70	70
Screened Interval (ft bgs)[2]	58-68	56-66	38.5-48	54-64	55-65	30-40	44-57	45-65	50-70	42-62
Date Installed	06/26/1997	06/27/1997	06/30/1997	05/08/2000	05/11/2000	05/13/2000	05/16/2000	09/26/2006	09/26/2006	09/27/2006

[1] Mean Sea Level
[2] bgs - Below Ground Surface

proposed CAMU Phase 2 Cell perimeter. Appendix B provides lithologic and construction logs for the wells.

In general, the stratigraphy encountered at the monitoring wells sites in the vicinity of the CAMU consists of silty clay (CL) interbedded with clayey silt (ML) from ground surface to 25 feet below ground surface (bgs). A 10 to 20 foot thick horizon of sandy gravel is present between 25 and 35 feet bgs. An ash/tuff unit underlies the sandy gravel unit in all CAMU monitoring wells. The ash/tuff unit in the CAMU monitoring wells was encountered to depths up to 72 feet bgs. None of the monitoring wells penetrate through the ash/tuff unit. Exhibit 1 in Appendix B contains geologic cross sections of the site created from the monitoring well logs.

Groundwater levels were measured in December 2006 to construct a groundwater potentiometric map for the CAMU area. A monitoring well network, consisting of over 40 monitoring wells at the Asarco plant site, was also evaluated to help define the groundwater potentiometric surface near the CAMU area.

Water levels ranged from approximately 36 feet bgs at well MW-10 to 55 feet bgs at MW-9. Previous investigations at the plant site (Hydrometrics, 1990) and in the Helena Valley (USGS, 1992) show that regional groundwater movement in the East Helena area is northward. In Appendix B are two potentiometric maps from 2004 and 2006 showing groundwater flow directions within the CAMU area.

3.4 SOIL MATERIALS

Earth fill, in sufficient quantities required for this project, exists within the East Helena area. Earth fill includes random fill, engineered fill, drainage gravel, and cover soil. All earth fill will be obtained from the project site except for drainage gravel, which is readily available from local sand and gravel suppliers. Test results for gradation and permeability of material from the local sources will be required as part of construction specification performance standards.

The compacted clay liners are key components of the CAMU liner and cover systems and require careful material control. Material for construction of the liners is available from excavated materials on-site. As explained in Section 3.2, results from the geotechnical investigation indicate that site soil may not be suitable for use in construction of the compacted clay liner for the CAMU Phase 2 Cell therefore a geosynthetic clay liner (GCL) will be placed above the compacted clay liner to meet the hydraulic conductivity performance requirements. During site preparation and excavation, the sandier (low clay content) site soil will be segregated from the more clayey soil, which will be tested to confirm suitable gradation and plasticity before being used for construction of the CCL.

Testing will be conducted during construction to verify that soils excavated for use in construction of the compacted clay liner are suitable. EPA guidance (EPA, 1989) explains that to produce a protective CCL, the soil used for construction of the soil liner should have certain characteristics. First, it should have at least 20 percent fines. Second, it should have a plasticity index greater than 10. Third, it should be composed of no more than 10 percent gravel-size particles, and fourth, it should contain no soil particles larger than 1 or 2 inches in diameter. As discussed in the CAMU Phase 2 Cell Geotechnical Investigation (Hydrometrics, 2006), it should be possible to meet these standards with site soil if used selectively. First, site soil has between 58 and 71 percent fines. The average fraction of fines for the four samples tested is 65 percent, which is well above the standard of 20 percent. Second, the Plasticity Index (PI) for site soil ranges between 8 and 18 percent, with an average of 12 percent, which is greater than the standard of 10 percent contained in EPA guidance. Third, site soils range from less than 1 to 8 percent gravel. The average gravel fraction is much less than the standard of 10 percent required to be indicative of soil suitable for construction of a compacted clay liner. Finally, material specifications for the compacted clay liner have been written to prevent soil particles greater than 1 or 2 inches from being used to construct the liner, as suggested by EPA design guidance.

3.5 WASTE MATERIAL

Waste material that is to be placed in the CAMU will consist of demolition debris and waste soils from within the plant area and generated from RCRA corrective action projects. The major demolition debris waste material source areas and quantities are listed in Table 3-3.

TABLE 3-3. MAJOR DEMOLITION DEBRIS WASTE MATERIAL QUANTITIES

		Cubic Yds
2006		
On Site Stored Demolition Material		14,000
	2006 Total	**14,000**
2007		
Blast baghouse area (exc. Stack)		4,120
Acid plant contact section (exc. Stack)		2,100
Monier Flue		1,650
Blast furnace flue		6,250
Stacks (Oak Park Chimney)		6,890
Garage, Gas meter house & North end of Highline trestle		100
Dross plant baghouse		130
Sample mill & old crushing mill		2,100
Ore yard & Thawhouse		980
Spray dryer building		250
Main Office		545
New & old breaking floors, Sinter stocking building & Charge floor		1,370
Carpenter shop and Pump house & Blast heat exchanger		130
Blast furnace building		140
Blast office, lunchroom & loco crane shed		160
Direct Smelt building		400
Machine shop & Blacksmith shop		180
Cement & Dust silos		50
Power house		100
South end of High line trestle		25
Paint shop & Motor storage shed		250
High lead shop, Refractory, and Meeting room		423
Powerhouse		100
	2007 Total	**28,443**

TABLE 3-3. MAJOR DEMOLITION DEBRIS WASTE MATERIAL QUANTITIES (continued)

	Cubic Yds
2008	
Shop lunchroom, Zinc Plant pumphouse & Truck scale	75
Storage Trailer, Contractor change & lunchroom	545
Records Storage, Warehouse annex, & belly yard rail	540
Slag handling pad, Warehouse oil & Oxygen/acetyl storage	635
Ore Storage Building (grade level)	12,000
Warehouse, Environmental office	500
Acid tanks, Coverall Bldgs, Truck scale & High grade	500
Rail road ties & timbers (slag dump & belly yard)	1,000
Slag dump cleanup	2,000
Excavation for Plant Cap	2,000
Remediation of property for Chemet	5,000
Lake Shore Shed	10
Asarco On-Site Sanitary Treatment	10
Zinc Plant Loco Shop	10
2008 Total	**24,825**
2009	
Bathhouse, Medical office, & Thornock tank	1,000
HDS water treatment, Car wash. Neutralization building & acid sump	1,000
Northwestern Energy substation	50
Rodeo tank & storm water sumps	50
2009 Total	**2,100**
TOTAL	**69,368**

See Appendix K for source document.

Some demolition debris may contain asbestos that will be managed in accordance with all applicable National Emission Standards for Hazardous Air Pollutants (NESHAP), OSHA, MSHA, and DOT regulations. All asbestos containing materials will be properly containerized or thoroughly wetted and labeled before being transported to the CAMU Phase 2 Cell. All asbestos containing material will be placed in the SW corner of the cell as designated on the design drawings, and covered with a minimum of 6-inches of non-asbestos containing material within 24-hours of placement in the cell. Records will be kept identifying when and where asbestos containing materials were placed in the CAMU Phase 2 Cell. Care will be taken when placing additional waste material above the asbestos containing materials as to not disturb containerized materials or expose them to the air.

In order to ensure that the CAMU Phase 2 Cell design is compatible with the waste material that is to be placed in it, the chemical compatibility and gas generating potential of demolition debris was investigated and examined.

HDPE geomembranes have adequate chemical resistance to endure and retain their integrity well beyond other factors that will cause a liner to fail. Although not anticipated, if the leachates contain unusually high concentrations of oxidizing acids, chlorinated solvents, or detergents that remain constantly on the liner for considerable times, environmental stress cracking may occur. Waste materials at the East Helena Plant that could subject the cell liners to an extreme pH will be identified to the demolition contractor, who will be required to either neutralize these materials or to blend them with neutral material and place them in the upper portion of the cell.

The primary source of gas generation within most landfills is typically the decomposition of organic materials (primarily household waste such as paper and lawn waste) and the subsequent release of methane gas. Average municipal (sanitary) landfill refuse contains 55 percent woody materials (paper, grass, leaves, etc.) by weight and 28 percent organic carbon (EPA, 1979). In comparison, the smelter waste materials consist largely of smelter demolition debris and granular fill materials that contain only small quantities of organic materials. However, there is a small quantity of wood, such as treated timbers and railroad

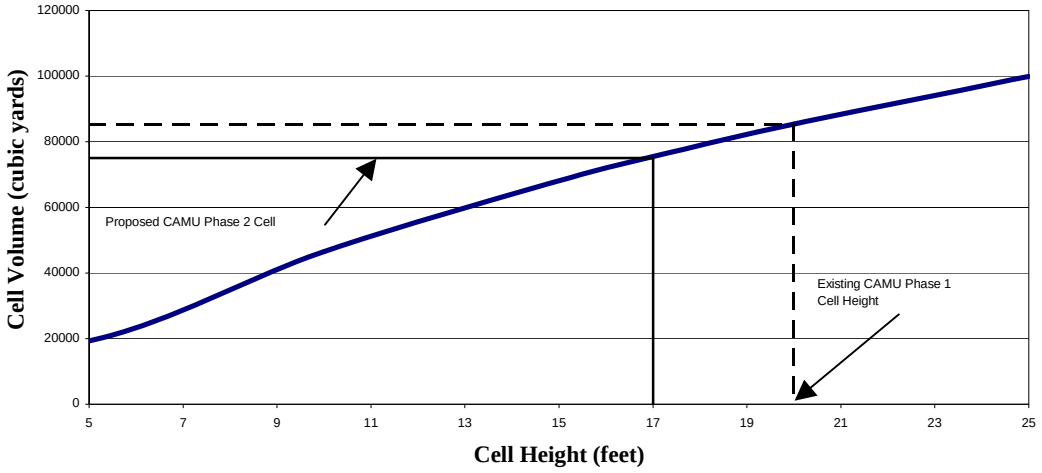
ties, that will be placed in the cell. Consequently, gas from these materials is expected to be generated and a gas extraction system was included in the design.

3.6 SIZE AND CONFIGURATION

Preliminary estimates for the construction indicate that approximately 70,000 cubic yards of demolition debris and waste material will be removed from the plant site and placed in the CAMU Phase 2 Cell. The sources and estimated quantities of waste material for the CAMU Phase 2 Cell are shown in Table 3-3.

The preliminary configuration of the CAMU Phase 2 Cell area includes 3:1 side slopes on the inside of the cell and 5:1 side slopes on the cap. A stability analysis of these slopes is contained in Appendix C. This configuration provides a potential storage volume in the cell of approximately 70,000 cubic yards, which is adequate capacity for placement of the wastes listed in Table 3-3, however, additional capacity can be obtained by raising the height of the cell while maintaining the identical footprint. Figure 3-4 shows the effect on cell volume of varying the cell height.

FIGURE 3-4. CAMU PHASE 2 CELL HEIGHT VS. VOLUME



The footprint for the CAMU Phase 2 Cell covers approximately five acres. Table 3-4 lists the configuration parameters. The site plan is shown on Figure 3-1.

The cross sections for the cell are shown on Figure 3-5. The proposed bottom of the cell excavation is approximately 8 feet below ground surface and the CAMU cap is approximately 17 feet above the ground surface.

3.7 COMPONENT DESIGN

The CAMU cell is designed and constructed to meet the Performance Standards stated in 40 CFR 264 subpart N – Landfills and ARM 17.50.506. General specifications are described below. In accordance with EPA and Montana DEQ guidance, the CAMU Phase 2 Cell has been designed and constructed with multiple barriers encapsulating the waste.

3.7.1 Liner Systems

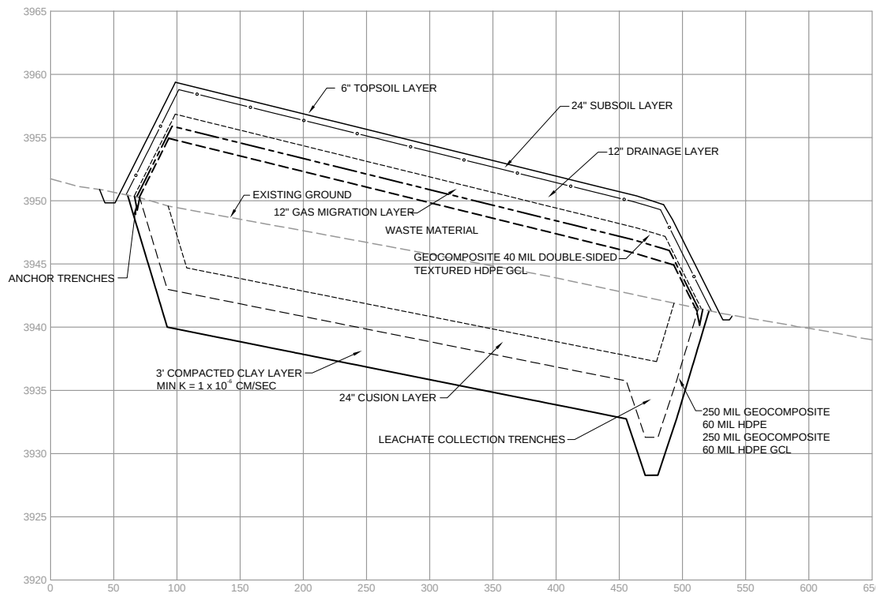
The typical CAMU Phase 2 Cell section, including the primary, secondary and cap liner systems; is shown on Figure 3-6. The primary liner underlies the waste material, but is separated from the waste by a geocomposite. The secondary liner system underlies the primary liner and is separated from it by another geocomposite layer. Unlike the primary liner, the secondary liner system is a composite consisting of a 3-foot thick layer of compacted clayey soil overlain by a geosynthetic clay liner and a flexible membrane. The cap liner system overlies the waste material and contains a composite liner consisting of a geosynthetic clay overlain by a flexible membrane. The cell liner systems utilize a 60-mil double-sided textured HDPE geomembrane for their flexible membrane component, while the cap liner uses a 40-mil double-sided textured HDPE geomembrane.

3.7.1.1 <u>Primary Flexible Membrane Liner (FML)</u>

The primary FML consists of a high density polyethylene (HDPE) geomembrane that is designed to contain any leachate that is produced from the waste material and to withstand the stresses applied to it from the weight of the waste material and cap, from construction of the cell, and from the settlement of underlying soils.

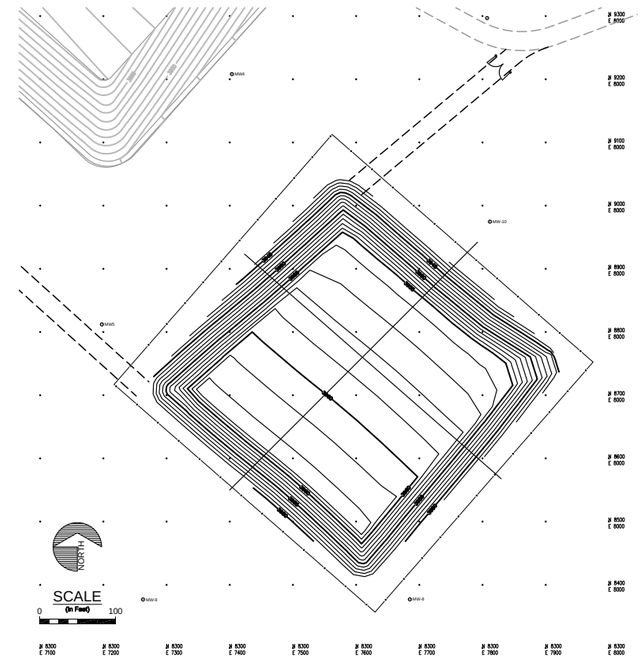
TABLE 3-4. CAMU PHYSICAL CONFIGURATION PARAMETERS

COMPONENT	QUANTITY
Landfill Footprint Width	455 Feet
Landfill Footprint Length	455 Feet
Area of Landfill Footprint	202,500 Square-Feet
Net Landfill Waste Capacity	70,000 Cubic-Yards
CELL COMPONENT	
Depth of Landfill Excavation	8 Feet
Slope of Landfill Bottom Sides	3:1
Area of Landfill Excavation Bottom	160,801 Square-Feet
Area of Landfill Excavation Slopes	48,383 Square-Feet
Total Area of Landfill Excavated Surface	209,184 Square-Feet
Volume of Excavation	61,304 Cubic-Yards
Volume of 3’ Clay Liner	23,243 Cubic-Yards
Volume of GCL	325 Cubic-Yards
Volume of Geogrids	325 Cubic-Yards
Volume of FML Liners	52 Cubic-Yards
Volume of Cushion Material	15,456 Cubic-Yards
Net Excavated Waste Capacity	16,066 Cubic-Yards
COVER COMPONENT	
Slope of Landfill Cap Sides	5:1
Height of Landfill Fill	17 Feet
Area of Top of Landfill Cap	81,225 Square-Feet
Areas of Landfill Cap Sides	128,291 Square-Feet
Total Area of Landfill Cap	209,516 Square-Feet
Volume of Landfill Cap	90,745 Cubic-Yards
Volume of Gas Migration Material	7,760 Cubic-Yards
Volume of GCL Liner	129 Cubic-Yards
Volume of FML Liner	39 Cubic-Yards
Volume of Geogrid	163 Cubic-Yards
Volume of 1’ Gravel Drain	7,760 Cubic-Yards
Volume of 2.5’ Cover Soil	19,400 Cubic-Yards
Net Cap Waste Capacity	55,495 Cubic-Yards



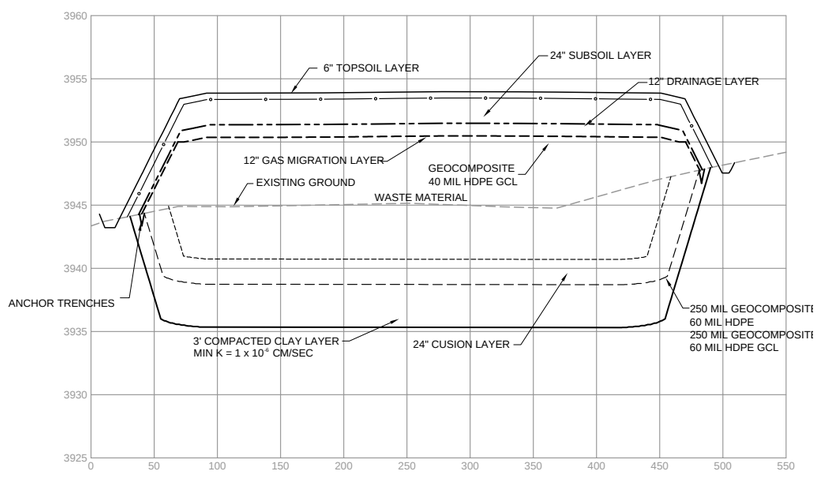
CROSS SECTION 8600(N),7300(E) - 9050(N),7750(E)

SCALE: (H) 1"=60' (V) 1"=6'



CAMU PLAN VIEW

SCALE: 1"=100'



CROSS SECTION 9000(N),7500(E) - 8650(N),7900(E)

SCALE: 1"=60' SCALE: (H) 1"=60' (V) 1"=6'

DESIGN ANALYSIS REPORT ASARCO EAST HELENA CORRECTIVE ACTIONS MANAGEMENT UNIT (CAMU)	**TYPICAL CAMU PHASE 2 CELL CROSS-SECTIONS**	**FIGURE** **3-5**

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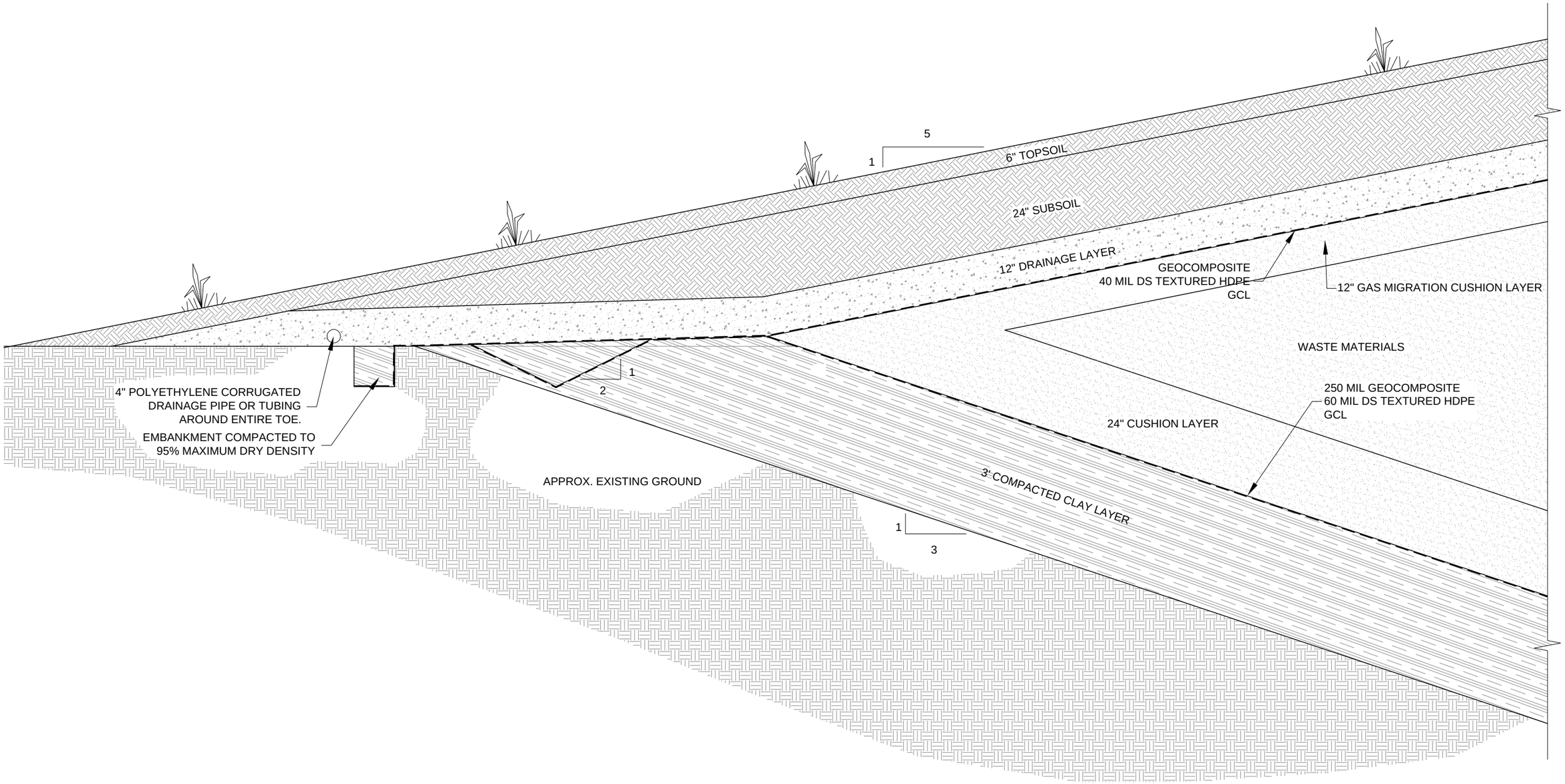
Hydrometrics, Inc.
Consulting Scientists and Engineers



LANDFILL SECTION

NOT TO SCALE

DESIGN ANALYSIS REPORT ASARCO EAST HELENA PHASE 2 CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)	**TYPICAL LANDFILL SECTION**	**FIGURE** **3-6**

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Hydrometrics, Inc.
Consulting Scientists and Engineers

The stress analysis completed for the design of this liner is included in Appendix C. This analysis includes determination of the stress placed on the membrane by its own weight prior to filling, during filling due to lifts of waste being placed against the cell side slopes, and following filling due to settlement of the cell foundation from the weight of the cell overburden. Other considerations in the design of the liner include the chemical compatibility of the liner and the waste material, the survivability required for the liner, and construction considerations.

As discussed in Section 3.4.2, wastes to be placed in the CAMU Phase 2 Cell are primarily demolition debris and waste soils containing elevated arsenic and metals concentrations. These wastes are compatible with the selected liner materials.

Landfill liners are required to have characteristics that help ensure a high degree of survivability for the liner. However, due to the nature of the construction debris being placed in the CAMU Phase 2 Cell the geomembranes were design to meet very high survivability specifications. The following minimum characteristics for very high survivability geomembranes (Koerner, 1998) were included in the material specifications for the geomembrane:

Thickness	40 mils
Tensile Strength (ASTM D882)	74 lb/in.
Tear Strength (ASTM D1004 Die C)	20 lb.
Puncture Strength (ASTM D4833)	45 lb.
Impact Strength (ASTM D3998 modified)	15 ft-lb.

Finally, construction considerations were taken into account in the liner design. Although a 40-mil HDPE will satisfy the strength and survivability requirements for design, the 60-mil HDPE double-sided textured geomembrane used in the cell design provides an additional factor of safety during the critical period of increased stress that may occur when the CAMU is being filled.

3.7.1.2 Secondary Composite Liner

The secondary composite liner ensures that any leakage through the primary FML is collected by the leak detection, collection, and removal (LDCR) system and prevents migration of groundwater into the CAMU Phase 2 Cell. It consists of a 60-mil, double-sided textured HDPE FML, identical to the primary FML in design, underlain by a geosynthetic clay liner and 3 feet of compacted clay.

As discussed in Section 3.4.1, EPA has required that a GCL be included above the clay liner to ensure a permeability of 10^{-7} centimeters-per-second as required by 40 CFR 264 subpart N. The geosynthetic clay liner will be needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile. The needle-punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope. No horizontal seams should be allowed on the slopes.

3.7.1.3 Cap Composite Liner

This component of the CAMU Phase 2 Cell cap closes the CAMU Phase 2 Cell and prevents infiltration of precipitation. It consists of a 40-mil double-sided textured HDPE FML, underlain by a geosynthetic clay liner (GCL). The geosynthetic clay liner will be needle punch reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile. The needle-punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond. All seams must be overlapped a minimum of 12 inches and sealed with powdered bentonite sealing compound. Seams must be oriented parallel to the line of maximum slope. No horizontal seams should be allowed on the slopes.

An HDPE geomembrane was chosen for this FML to ensure that the permeability of the cap liner is no less than the cell liner system, as required by 40 CFR 264 subpart N. In addition to acting as a component of the composite liner, the GCL covering the waste material provides a smooth surface for installation of the cap FML and provides an additional factor of safety in preventing percolation through the cap.

3.7.2 Leachate Systems

The primary leachate collection and removal (PLCR) system and the leak detection, collection and removal (LDCR) system will be constructed of geocomposite materials with a minimum

transmissivity of 3 x $10^{-5}m^2$/sec. The leachate collected in the leachate system will be removed through individual standpipes placed in each leachate system layer. Unlike in the CAMU Phase 1 Cell, these pipes will consist of individual vertical 24-inch HDPE access pipes, which allow collection, pumping, and withdrawal of leachate without penetrating the cell liners. This revised design should allow the two leachate systems to be emptied more easily.

In the design analysis of the CAMU Phase 2 Cell, Hydrologic Evaluation of Landfill Performance Modeling (HELP 3) was performed to evaluate the leachate generation potential of the CAMU Phase 2 Cell. Output from this model was used to check sizing of leachate system piping and flow capacities of drainage composite materials.

The HELP 3 model indicated that no leachate was expected to be generated following the filling of the cell. Tables 3-5 and 3-6 summarize the results of this modeling. However, if leachate is produced or if storm water enters the cell during construction, it will be collected and transported to the adjacent Asarco Lead Smelter for treatment in the existing High Density Sludge (HDS™) water treatment system in accordance with the existing MPDES Permit or transported to a licensed Treatment, Storage, and Disposal Facility (TSDF) should the HDS™ water treatment system be removed.

HELP 3 was also performed to evaluate leachate generation and runoff during the filling of the cell. Output from this model indicates the designed leachate collection system capacity will be exceeded during a 25-year, 24-hour storm when the fill in the cell is less than 60 inches. Therefore, during construction, the construction contractor will be required to have pumps ready in case of a significant rainfall event.

3.7.2.1 <u>Primary Leachate Collection and Removal (PLCR) System</u>

This CAMU Phase 2 Cell component is designed to collect any leachate associated with the waste material. Waste material deposited in the CAMU cell will be underlain by a geocomposite which has two layers of 8 oz. non woven geotextile which will act as a filter barrier between the waste and the geonet drain layer. This geocomposite drain layer will have a minimum transmissivity of 0.145 gallons/ minute/foot ($3x10^{-5}$ m^2/sec) at 4,000 pounds

TABLE 3-5. AVERAGE ANNUAL PRECIPITATION AND LEACHATE VOLUMES FOR 80 YEARS

	Inches	Cubic Feet	Percent
Precipitation	11.36	210226.7	100.00
Runoff	0.097	1,796	0.855
Evapotranspiration	11.237	208033	98.957
Lateral Drainage Collected From SWCR	0.00203	37.6	0.01790
Percolation/Leakage Through Cap Composite Liner	0.00000	0.00000	0.00000
Lateral Drainage Collected From PLCR	0.00000	0.00000	0.00000
Percolation/Leakage Through Primary FML	0.00000	0.00000	0.00000
Lateral Drainage Collected From LDCR	0.00000	0.00000	0.00000
Percolation/Leakage Through Secondary Composite Liner	0.00000	0.00000	0.00000

SWCR - Surface Water Collection and Removal
PLCR - Primary Leachate Collection and Removal
LDCR - Leak Detection Collection and Removal

TABLE 3-6. PEAK DAILY PRECIPITATION AND LEACHATE VOLUMES FOR 80 YEARS

	Inches	Cubic Feet
Precipitation	1.62	29991
Runoff	0.400	7399
Drainage Collected From Layer SWCR	0.013	246
Percolation/Leakage Through Cap Composite Liner	0.00000	0.00000
Drainage Collected From PLCR	0.00000	0.00000
Percolation/Leakage Through Primary FML	0.00000	0.00000
Drainage Collected From LDCR	0.00000	0.00000
Percolation/Leakage Through Secondary Composite Liner	0.000000	0.00000

per square foot of confining pressure, as required by the performance standards discussed in Section 2.3. The performance of the PLCR was checked using HELP 3 modeling, and found to prevent more than 12 inches of leachate from collecting above the primary liner, as shown in Table 3-6.

A geocomposite was selected as a drainage component primarily due to its economy when compared to a gravel layer. Perforated drainpipe embedded in a gravel drain layer has the advantage of common usage and design, but requires a minimum of 1 foot of cell depth. Geocomposites promote rapid transmission of liquids while requiring only 1/4 inch of cell depth. While the square-foot cost of geocomposite is comparable to drain gravel, the reduction in cell depth from use of the geocomposite in design resulted in major cost savings on the project.

The geocomposite drainage layer is laid on a 2 percent slope and drains to a collection trench along one edge of the CAMU Phase 2 Cell. The collection trench contains a corrugated HDPE perforated drain pipe enveloped in drain gravel. The corrugated HDPE perforated drain pipe collects leachate from the geocomposite layer and directs it to a sump consisting of a 24-inch diameter smooth HDPE pipe which extends vertically through the cap, allowing a submersible pump to be lowered in and out of the pipe for removal of any accumulated leachate. The 24-inch pipe will be embedded in a 12-inch thick concrete slab to provide structural support and a solid surface for pumping. Accordion style pipe boots will be used at all liner penetrations to provide a water tight seal and to relieve additional stress on the liner should settlement occur.

3.7.2.2 Leak Detection, Collection, and Removal (LDCR) System

This system is designed to detect and collect any leakage through the Primary FML within 24 hours. Another geocomposite layer was used for the LDCR for the same reasons discussed for the PLCR. In fact, the system is identical to the PLCR in design with the geonet used as a composite between two 8 oz. non-woven geotextiles. As for the PLCR, the geocomposite layer is sloped approximately 2 percent to a collection trench where leachate is directed to a sump for removal. Maximum travel time to the sump for this design is approximately three hours, which is less than the 24 hours required by performance standards. Appendix C contains this analysis.

3.7.3 Gas Collection System

This system is designed to collect and remove gas generated from the waste and consists of a series of 4-inch perforated corrugated HDPE pipes embedded in a 1-foot thick layer of ¼ -inch to ½-inch gravel. The piping directs the gas to one of five vent pipe risers located in the center and at each corner of the top of the cell. The vent pipe risers consist of 4-inch smooth HDPE pipe, which extend approximately 12-inches above the top of the cap. The risers will be shaped like a "candy cane" and will have screens over the open end of the pipe to prevent precipitation or objects from entering the pipe. Concrete collars will be place around the vent pipes for additional support.

3.7.4 Surface Water Collection and Removal (SWCR) System

This system allows surface precipitation to drain away from the surface of the Cap Composite Liner, and consists of a 1-foot thick layer of drain gravel on a 3 percent slope. This layer drains to a corrugated drain pipe embedded in a gravel-filled trench at the toe of the CAMU Phase 2 Cell cap slope. The drain pipe outlets to a shallow infiltration and evaporation pond adjacent to the CAMU Phase 2 Cell which prevents run-off from mixing with diverted run-on flows.

3.7.5 Cover System

This component provides frost protection to the cap composite liner and, after seeding, protects the surface of the CAMU Phase 2 Cell from erosion. It consists of 6-inches of seeded topsoil overlying 24-inches of subsoil. The project specifications require the organic rich topsoil to be salvaged and stockpiled separate from the underlying subsoil to ensure a proper medium for seeding with grasses. The combination of cover system and SWCR provides a total of 3.5-feet of frost protection to the cap composite liner. The CAMU cover has been designed with a top slope of 3 percent and fairly flat side slopes of 5:1 to resist erosion and minimize maintenance.

3.7.6 Groundwater Monitoring System

Finally, the CAMU Phase 2 Cell has been designed and will be constructed with monitoring systems that can detect a failure of the CAMU Phase 2 Cell. As described in section 3.5.2.2, the first line of detection takes place in the LDCR. A secondary line of monitoring, consisting of ten groundwater monitoring wells, has been constructed around the CAMU Phase 2 Cell site and will be monitored on a semi-annual basis. A statistical analysis of the data from this monitoring will detect any impacts to the groundwater quality associated with the CAMU Phase 2 Cell. The sampling and monitoring plan, contained in Appendix D of this report, establishes a detection monitoring program in compliance with 264 Subpart F requirements.

3.8 SEISMIC DESIGN

40 CFR 264.18 requires that the CAMU Phase 2 Cell may not be located within 200 feet of a fault that has had displacement in Holocene time. As discussed in the 2000 CAMU application, the U.S. Geologic Survey lists no record of a fault within 200 feet of the site. However, the U.S. Geologic Survey's seismic deaggregation website suggests that a 2500-year seismic event at the site proposed for the CAMU Phase 2 Cell will result in bedrock acceleration greater than 0.1 g (ARM 17.50.505). Therefore, the proposed location is in a seismic impact zone, and the CAMU Phase 2 Cell cap, leachate removal pipe, and gas extraction system pipe have been designed to resist the maximum horizontal acceleration in lithified earth material for the site. The CAMU Phase 2 Cell is to be located in Lewis and Clark County, Montana, which is listed in Appendix VI of 40 CFR 264. As shown in Figure 3-7 and based on data from the U.S. Geologic Survey, there is no known fault within 3,000 feet of the facility that has had displacement in Holocene time.

3.9 LINER COMPATIBILITY

HDPE was the selected liner material for the CAMU because of its resistance to inorganic chemicals, including acids (e.g. hydrochloric acid, sulfuric acid), bases (e.g. sodium hydroxide), metals (e.g. arsenic, cadmium and lead), and salts (e.g. calcium chloride or sodium sulfate). It is also generally resistant organic based acids. Review of chemical information provided by the manufacture (see Appendix C, attachment 1) shows the liner is resistant to most of the type of chemicals that have a potential to occur in CAMU leachate (inorganic acids, bases, metals and salts). (However, as discussed above, pH extremes in CAMU leachate are not expected and any leachate generated is expected to have a relatively neutral pH). HDPE was the liner material used in the CAMU Phase 1 Cell and is the most typical material selected for landfill liners because of its resistance to most inorganic acid and other inorganic chemicals.

Table 3-3 presents a list of sources of demolition materials and estimated quantities that would be disposed in the CAMU. Most of the materials associated with these structures are inorganic in nature and include:

- Residual lead based dusts associated with the cleaning and demolition project
- Concrete and brick masonry associated with building materials

FAULTS INFORMATION FROM
http://earthquake.usgs.gov/regional/qfaults/

DESIGN ANALYSIS REPORT
ASARCO EAST HELENA
CORRECTIVE ACTIONS MANAGEMENT UNIT
PHASE 2 CELL

QUATERNARY FAULTS WITHIN THE VICINITY OF THE PHASE 2 CELL

FIGURE
3-7

Hydrometrics, Inc.
Consulting Scientists and Engineers

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- Asbestos based building materials (transite etc).
- Wood, plastic, rubber, fiberglass and other miscellaneous building materials.
- Timbers associated with the highline trestle and removed railroad ties.

Most of these materials including residual lead based dusts, brick, concrete are inorganic in nature and corrosive leachate from the materials is not likely. Similarly, most of the organic based building materials (wood, plastic, rubber, etc.) are generally chemically stable and leachate from these materials is not likely. A potential exception is timbers associated with the highline trestle and railroad ties. Based on field observations, it is apparent these timbers were likely treated with creosote. However, the timbers are old and the constant exposure to over fifty years of weather has reduced any serious potential for leachate of creosote-based chemicals from these timbers.

As the chemical resistance information in Appendix C, Attachment 1 shows, HDPE is generally less resistant to strong oxidizing agents (e.g. nitric acid or hydrogen peroxide) and many organically based chemicals (hydrocarbon based chemicals, oils or fuels, see Attachment 1 and Attachment 2). However, since no free liquids are allowed in the CAMU these organic based materials are not part of the waste stream that will be stored in the CAMU Phase 2 cell.

As noted by the liner manufacture (see Appendix C, Attachment 1) the chemical compatibility of the liner for a given use is not only a function of the chemical type, but also the concentration. The chemical compatibility tables in Appendix C, Attachments 1 and 2, assume high concentration liquids in direct contact with HDPE materials. As discussed in Appendix C, while contact with 100% concentration of certain organic chemical may be unacceptable, concentrations at lower concentrations (0.1% is the example given) may be acceptable. Liner specific chemical compatibility testing was conducted by the Department of Energy (DOE) for a variety of organic chemicals, including creosote (see Appendix C, Attachment 3, Table B-1). The DOE's determination was that HDPE liner was acceptable for creosote concentrations in soils of 31,587 mg/kg or less, or for creosote leachate from the soils of 158,295 mg/l or less. It is unlikely the weathered timbers could generate creosote

leachate that would exceed 15.8%. However, prior to deposition of the timbers, representative samples will be collected, tested for leachate using the TCLP Method 1312.

4.0 PLACEMENT OF WASTE SOILS, SEDIMENTS AND DEMOLITION DEBRIS IN CELL

Materials will be placed and compacted in the cell to minimize voids, settlement, and damage to the liners. Smelter demolition debris and waste soils will be placed and compacted in the cell in lifts not to exceed 2 feet thick across the bottom of the cell. A detailed Waste Hauling Plan can be found in Appendix E.

All materials delivered to the cell for placement will require some segregation. This will allow consolidation of the materials during compaction and will result in a homogeneous mass with a minimal amount of voids. Specifically, bulk concrete and metal debris will be broken or otherwise reduced in size not to exceed a vertical dimension of 2 feet in diameter. There are no horizontal or width dimension restrictions other than the debris must fit in a haul truck to be transported to the CAMU Phase 2 cell. All material requiring size reduction will be resized at the structure demolition site using excavators with concrete breakers or shears before being transported to the CAMU Phase 2 Cell. Large organic material (e.g. timbers) and manufactured metal will be placed horizontally in the cell as flat as possible to minimize voids. Special care will be taken near the sides and bottom of the cell to place crushed slag or a minus 1/2” gravel as a cushion layer to protect the liner systems against puncture. The project specifications require the contractor to use a 1/2” to 1/4” graded material as a protective layer (12-inches thick) adjacent to the bottom and sides of the cell and an additional 12-inches of minus 1/2” material over that. This material shall be free of oversized material and sharp objects.

A dust control program will be required to minimize the creation and spread of dust during the excavation, loading, hauling, placement and compaction activities.

The contractor shall be required to have readily available pumps capable of pumping 400 gallons per minute in the event of a significant rainfall event and shall provide a temporary 20-mil RPE Liner for the waste material placed in the CAMU Phase 2 Cell. Special care must be taken to ensure that the waste is covered prior to significant occurrences of precipitation. In addition, the Contractor shall ensure that the waste is placed in a manner that will ensure that the water which falls on the temporary liner will drain to a sump without coming in contact with the waste material and without significant ponding of the water on the temporary liner. The water reaching the sump shall immediately be discharged to the storm

water retention pond shown on Sheets 26 and 27 of Appendix I. Therefore, the storm water retention pond shall be constructed prior to placing waste material into the CAMU Phase 2 Cell. Any storm water coming in contact with the waste material shall not discharged, but shall be removed to the Plant water treatment system, which has approximately one million gallons of excess storage capacity that will be reserved for this purpose.

5.0 TEMPORARY CLOSURE AND MONITORING

The construction of the CAMU Phase 2 Cell will begin in 2008. Once the cell is excavated and the liner, leak detection, and leachate collection systems are constructed the cell will be filled with waste materials from both 2006 and 2007 demolition work. Placement of waste materials generated from 2006 demolition work will free up containment building storage space that may be used to store waste materials generated from demolition work after temporary closure of the CAMU cell before the end of the 2008 construction season. By the end of the 2008 construction season, a temporary cap constructed from 20 mil Reinforced Polyethylene (RPE 25) with stitched z-fold seams will be placed over the waste, using sandbags to hold it in place. Prior to placement of the liner, the surface of the waste will be graded to drain, rolled smooth, and covered with a 10-ounce cushion fabric. Sandbags placed in a 5-foot grid will be installed to anchor the middle portion of the cap and edges will be anchored in trenches. The cell has been designed to contain 40,000 cubic yards of material in the excavated portion of the cell. This will allow the contractor to grade the waste material level with the existing ground surrounding the CAMU Phase 2 Cell which will help to promote runoff from the temporary cover. The temporary RPE 25 cap may also be used at the conclusion of subsequent construction seasons if it is stored carefully in between uses. However, the cushion fabric will need to be replaced. Freezing and wind and other weather related damage may limit the useful life of the temporary cap.

This temporary component of the CAMU Phase 2 Cell cap will help to reduce infiltration of precipitation into the waste material until final capping of the CAMU Phase 2 Cell is completed. If it is to be reused, the liner may be divided into small enough panels to remove from the CAMU and then reanchored with sandbags on adjacent land that is out of the way of construction. The liner will need to be inspected prior to reuse in order to insure that it is still in adequate condition for use. If it is determined that it is not in a sufficient condition to be reused, it will need to be well perforated so that it will not hold water, prior to placing it in the CAMU cell, or placed over the top of the waste material prior to capping the cell. The 10-ounce cushion fabric, which is not reusable, will be cut into pieces 36 square feet or smaller, placed flat and distributed evenly throughout the cell. The Operation and Maintenance Plan (O&M Plan) addresses temporary closure activities of the CAMU and is located in Appendix E.

6.0 FINAL CLOSURE AND MONITORING

Upon completion of placement of demolition debris and waste soils in the CAMU Phase 2 Cell, the CAMU cap will be constructed. This component of the CAMU Phase 2 Cell cap closes the CAMU Phase 2 Cell and prevents infiltration of precipitation. A copy of the Post Closure Care Plan is located in Appendix H.

7.0 STANDARD PLANS AND SPECIFICATIONS

Final design drawings for CAMU construction will be submitted pending EPA review of this Design Analysis Report. Designated Divisions and Sections of the 1996 Standard Specifications for Road, Bridge, and Municipal Construction as adopted by the Montana State Department of Transportation (MDOT, 1996) will be utilized for the construction specifications. Construction specifications and design drawings can be found in Appendix I and J, and a preliminary construction schedule is found in Appendix F.

8.0 REFERENCES

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Hydrometrics, 1990. Comprehensive Remedial Investigation/Feasibility Study, Asarco Inc., East Helena, Montana. January, 1990.

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Koerner, 1998. Designing With Geosynthetics, Fourth Edition. Prentice-Hall, Inc.

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U.S. EPA, 1979. Processing and Utilization of Gas from Sanitary Landfills. By Lockman Associates and R.K. Han. EPA-600/2-79-001. U.S. EPA, Cincinnati, Ohio.

U.S. EPA, 1986. "Design Construction, and Evaluation of Clay Liners for Waste Management Facilities." Report No. EPA/530/SW-86/007F.

U.S. EPA, 1989. "Requirements for Hazardous Waste Landfill Design, Construction, and Closure." Seminar Publication EPA/625/4-89/022.

U.S. EPA, 1993. "Quality Assurance and Quality Control for Waste Containment Facilities." Technical Guidance Document EPA/600/R-93/182.

U. S. Geological Survey (USGS), 1992. Hydrogeology of the Helena Valley-Fill Aquifer System, West-Central Montana. Water Resources Investigation Report 92-4023, April 1992.

Code of Federal Regulations

40 CFR 258 Subpart B, Criteria for Municipal Solid Waste Landfills – Location Restrictions.

40 CFR 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

40 CFR 265, Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

40 CFR 270, EPA Administered Permit Programs: The Hazardous Waste Permit Program.

Administrative Rules of Montana

17.50.505, Standards for Solid Waste Management Facilities.

17.50.506, Design Criteria for Landfills.

APPENDIX A

SURFACE WATER HYDROLOGY

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Hydrometrics, Inc.
Consulting Scientists and Engineers

100 YEAR FLOOD PLAIN MAP

FIGURE

SOIL SURVEY OF LEWIS AND CLARK COUNTY AREA, MONTANA

CAMU Phase 2 Cell Soils Information

USDA Natural Resources Conservation Service

Web Soil Survey 1.1
National Cooperative Soil Survey

1/9/2007
Page 1 of 3

Map Unit Legend Summary

Lewis and Clark County Area, Montana

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
33B	Sappington-Amesha loams, 1 to 4 percent slopes	71.8	49.2
33C	Sappington-Amesha loams, 4 to 8 percent slopes	16.8	11.5
137B	Musselshell-Crago complex, 2 to 8 percent slopes	40.4	27.7
433E	Crago-Musselshell gravelly loams, 4 to 35 percent slopes	17.0	11.7

RUSLE2 Related Attributes

Lewis and Clark County Area, Montana

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
33B:							
Sappington	60	B	.37	2	41.6	37.4	21.0
Amesha	35	B	.37	5	42.1	37.9	20.0
33C:							
Sappington	50	B	.37	2	41.6	37.4	21.0
Amesha	40	B	.37	5	42.1	37.9	20.0
137B:							
Musselshell	70	B	.37	2	39.2	37.3	23.5
Crago	25	B	.37	2	41.6	37.4	21.0
433E:							
Crago	50	B	.37	2	41.6	37.4	21.0
Musselshell	40	B	.37	2	39.2	37.3	23.5

Input Parameters for EFH 2 Software[1]

Upgradient Drainage Area

Drainage Area	23.7	acres
Curve Number	75	Small Grain Straight Row + Crop Residue Cover-Poor Condition, Soil Type B
Slope	0.039	ft/ft
Longest Flow Path	1437	ft
25 yr, 24 hr Precip	2.3	in
25 yr, 6 hr Precip	1.4	in
P_6/P_{24}	0.6087	since 0.518 < 0.6087 < 0.639 use Type I Distribution

CAMU Phase 2 Drainage Area - No Vegetation

Drainage Area	5.15	acres
Curve Number	86	Fallow - Bare, Soil Type B
Slope	0.04	ft/ft
Longest Flow Path	425	ft
25 yr, 24 hr Precip	2.3	in
25 yr, 6 hr Precip	1.4	in
P_6/P_{24}	0.6087	since 0.518 < 0.6087 < 0.639 use Type I Distribution

CAMU Phase 2 Drainage Area - with Vegetation

Drainage Area	5.15	acres
Curve Number	69	Pasture, Grassland-Fair Condtion, Soil Type B
Slope	0.04	ft/ft
Longest Flow Path	425	ft
25 yr, 24 hr Precip	2.3	in
25 yr, 6 hr Precip	1.4	in
P_6/P_{24}	0.6087	since 0.518 < 0.6087 < 0.639 use Type I Distribution

[1]Natural Resource and Conservation Services (NRCS), March 2003 Version 1.1.0

Client: Asarco, LLC
County: Lewis and Clark State: MT
Practice: CAMU Phase 2 Cell 25-yr, 24-hr Storm Runoff-Upgradient of site
Calculated By: M. Rhodes Date: 11/7/2006
Checked By: _____ Date: _____

Drainage Area:	23.7	Acres (user entered value)
Curve Number:	75	(user entered value)
Watershed Length:	1437	Feet
Watershed Slope:	3.9	Percent
Time of Concentration:	0.42	Hours (calculated value)
Rainfall Type:	I	

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	25						
24-Hr rainfall (in)	2.3						
Ia/P Ratio	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Used	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Runoff (in)	0.54						
(ac-ft)	1.07	0.00	0.00	0.00	0.00	0.00	0.00
Unit Peak Discharge (cfs/acre/in)	0.307	0.000	0.000	0.000	0.000	0.000	0.000
Peak Discharge (cfs)	4						

Client: Asarco, LLC
County: Lewis and Clark State: MT
Practice: CAMU Phase 2 Cell 25-yr, 24-hr Storm Runoff-Cap no Vegetation
Calculated By: M. Rhodes Date: 11/7/2006
Checked By: _____ Date: _____

Drainage Area:	5.15	Acres (user entered value)
Curve Number:	86	(user entered value)
Watershed Length:	425	Feet
Watershed Slope:	4	Percent
Time of Concentration:	0.11	Hours (calculated value)
Rainfall Type:	I	

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	25						
24-Hr rainfall (in)	2.3						
Ia/P Ratio	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Used	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Runoff (in)	1.08						
(ac-ft)	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Unit Peak Discharge (cfs/acre/in)	0.730	0.000	0.000	0.000	0.000	0.000	0.000
Peak Discharge (cfs)	4						

Client: Asarco, LLC
County: Lewis and Clark State: MT
Practice: CAMU Phase 2 Cell 25-yr, 24-hr Storm Runoff-Cap with Vegetation
Calculated By: M. Rhodes Date: 11/7/2006
Checked By: _____ Date: _____

Drainage Area:	5.15	Acres (user entered value)
Curve Number:	69	(user entered value)
Watershed Length:	425	Feet
Watershed Slope:	4	Percent
Time of Concentration:	0.18	Hours (calculated value)
Rainfall Type:	I	

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	25						
24-Hr rainfall (in)	2.3						
Ia/P Ratio	0.39	0.00	0.00	0.00	0.00	0.00	0.00
Used	0.39	0.00	0.00	0.00	0.00	0.00	0.00
Runoff (in)	0.33						
(ac-ft)	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Unit Peak Discharge (cfs/acre/in)	0.238	0.000	0.000	0.000	0.000	0.000	0.000
Peak Discharge (cfs)							

APPENDIX B

MONITORING WELL LOGS AND GROUNDWATER DATA

HYDROMETRICS INC.
Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-8

Date Hole Started: 9/25/06 Date Hole Finished: 9/26/06

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: Sec 36 T10N, R3W
Descriptive Location: South of CAMU; East of CAMU Phase II

Recorded By: John Bergin
Drilling Company: Boland Drilling
Driller: Rick & Chuck
Drilling Method: Air Rotary
Drilling Fluids Used: Air
Purpose of Hole: CAMU Monitoring Well
Target Aquifer:
Hole Diameter (in): 4.5"
Total Depth Drilled (ft): 70

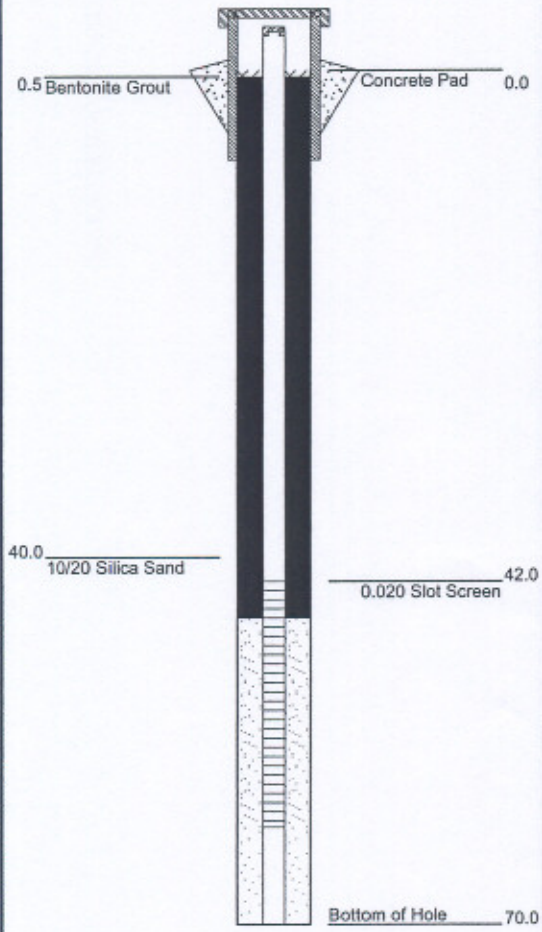
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	
Surface Casing Used?	Y	4" Steel	
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	45-65
Sand Pack?	Y	1020 Silica Sand	43-70
Annular Seal?	Y	Bentonite Chips	0 - 43
Surface Seal?	Y	Cement	0-0.5
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailer/pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		

Static Water Level Below MP: 50.91
Date: 11/2/06
MP Description: Top of Casing
MP Height Above or Below Ground (ft):

Surface Casing Height (ft):
Riser Height (ft):
Ground Surface Elevation (ft):
MP Elevation (ft):

Remarks:

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.5' **Silty Sand**
Top Soil, light brown, dry, loamy silt with sand and gravel (1/2"). Ash (white) layer approximately 0.5' thick at 15' bgs. Veins of ash @ 1.5'

1.5 - 21.0' **Silty Clayey Sand**
Light brown, moist (@5') clayey silt with sand to coarse sand. Some gravels (1/2")

21.0 - 23.0' **Sand**
Brown, moist silty sand - coarse sand (5%). Well graded / clean fine sand at approximately 21.5' bgs.

23.0 - 33.0' **Silty Gravel**
Gravel (1"), light brown moist silty sand (10%) (auger cuttings)
refusal @ 25' but ODEX through

33.0 - 70.0' **Silty Sand**
Volcanic Ash - Some gravel. Light Yellow, moist silty sand. Increasing sand with depth, moderate cohesion.

STANDARD REV1 K:\GINT\PROJECTS\10154.GPJ HYDHI N2.GDT 12/1/06

HYDROMETRICS INC.
Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-9

Date Hole Started: 9/26/06 Date Hole Finished:

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: Sec 36 T10N, R3W
Descriptive Location: Southwest of CAMU; South end of CAMU Phase II

Recorded By: John Bergin
Drilling Company: Boland Drilling
Driller: Rick & Chuck
Drilling Method: Air Rotary
Drilling Fluids Used: Air
Purpose of Hole: CAMU Monitoring Well
Target Aquifer:
Hole Diameter (in): 4.5"
Total Depth Drilled (ft): 70

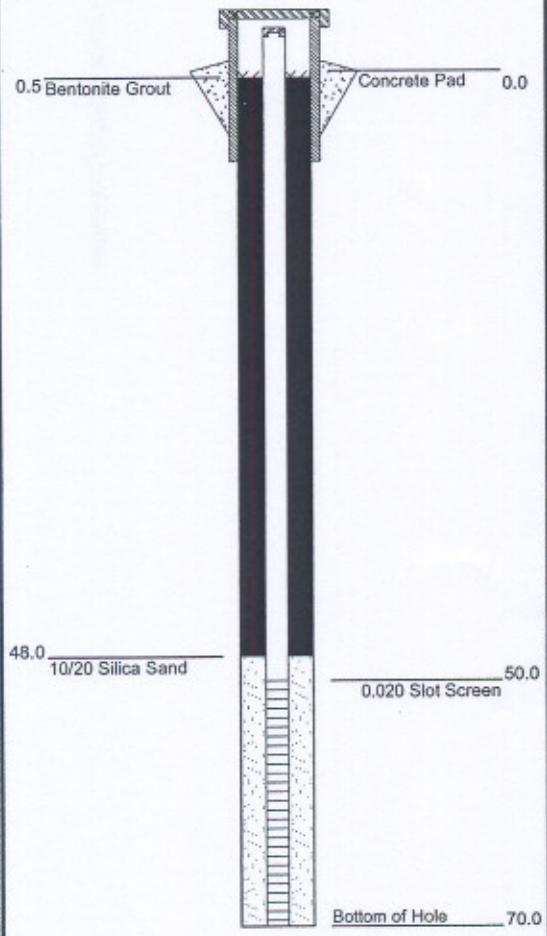
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	
Surface Casing Used?	Y	4" Steel	
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	50-70
Sand Pack?	Y	1020 Silica Sand	48-70
Annular Seal?	Y	Bentonite Chips	0.5-48
Surface Seal?	Y	Cement	0-0.5
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailer/pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		

Static Water Level Below MP: 56.90
Date: 11/2/06
MP Description: Top of Casing
MP Height Above or Below Ground (ft):

Surface Casing Height (ft):
Riser Height (ft):
Ground Surface Elevation (ft):
MP Elevation (ft):

Remarks:

WELL CONSTRUCTION



GEOLOGICAL DESCRIPTION

GRAPHICS

0.0 - 5.0' **Topsoil**
Brown with slight plasticity and slightly moist. Silty Sand (SM-SC)

5.0 - 10.0' **Silty Clay**
Light brown, very slightly moist, little plasticity, silty

10.0 - 23.0' **Silty Clay**
Light Brownish Red, Dry, Little plasticity, silty

23.0 - 25.0' **Silty Gravel**
Dark Brown, dry with slight plasticity

25.0 - 30.0' **Silty Gravel**
Gravel with some silt. Little plasticity.

30.0 - 34.0' **Silty Gravel**
Gravel with silt, Dry.

34.0 - 50.0' **Sandy Clay**
Light Yellow, moderate plasticity, slightly moist. Clay with sand; increasing sand and moisture with depth.

50.0 - 65.0' Water Injected. White slurry with occasional rock fragments.

65.0 - 70.0' Some reddish brown slurry in white slurry with occasional rock fragments.

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HYDROMETRICS INC.
Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-10

Date Hole Started: 9/27/06 Date Hole Finished:

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: Sec 36 T10N, R3W
Descriptive Location: Southwest of CAMU; Northeast edge of CAMU Phase II

Recorded By: John Bergin
Drilling Company: Boland Drilling
Driller: Rick & Chuck
Drilling Method: Air Rotary
Drilling Fluids Used: Air
Purpose of Hole: CAMU Monitoring Well
Target Aquifer:
Hole Diameter (in): 4.5"
Total Depth Drilled (ft): 70

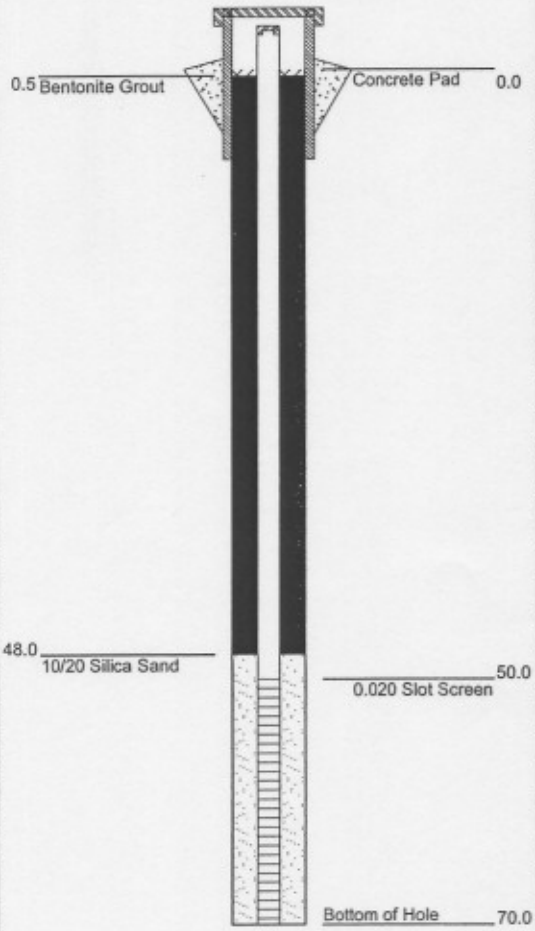
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	
Surface Casing Used?	Y	4" Steel	
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	42-62
Sand Pack?	Y	1020 Silica Sand	40-62
Annular Seal?	Y	Bentonite Chips	0.5-40
Surface Seal?	Y	Cement	0-0.5
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailer/pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		

Static Water Level Below MP: 38.24
Date: 11/3/06
MP Description: Top of Casing
MP Height Above or Below Ground (ft):

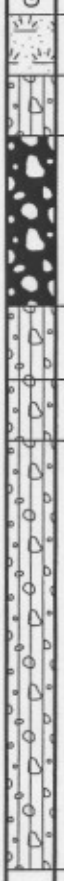
Surface Casing Height (ft):
Riser Height (ft):
Ground Surface Elevation (ft):
MP Elevation (ft):

Remarks:

WELL CONSTRUCTION



GRAPHICS



GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Topsoil**
Topsoil. Light brown silt with some rocks, dry, little plasticity.

5.0 - 10.0' **Silt and Gravel**
Dark brown, silt and gravel / broken rock. Very slight moisture, very little plasticity.

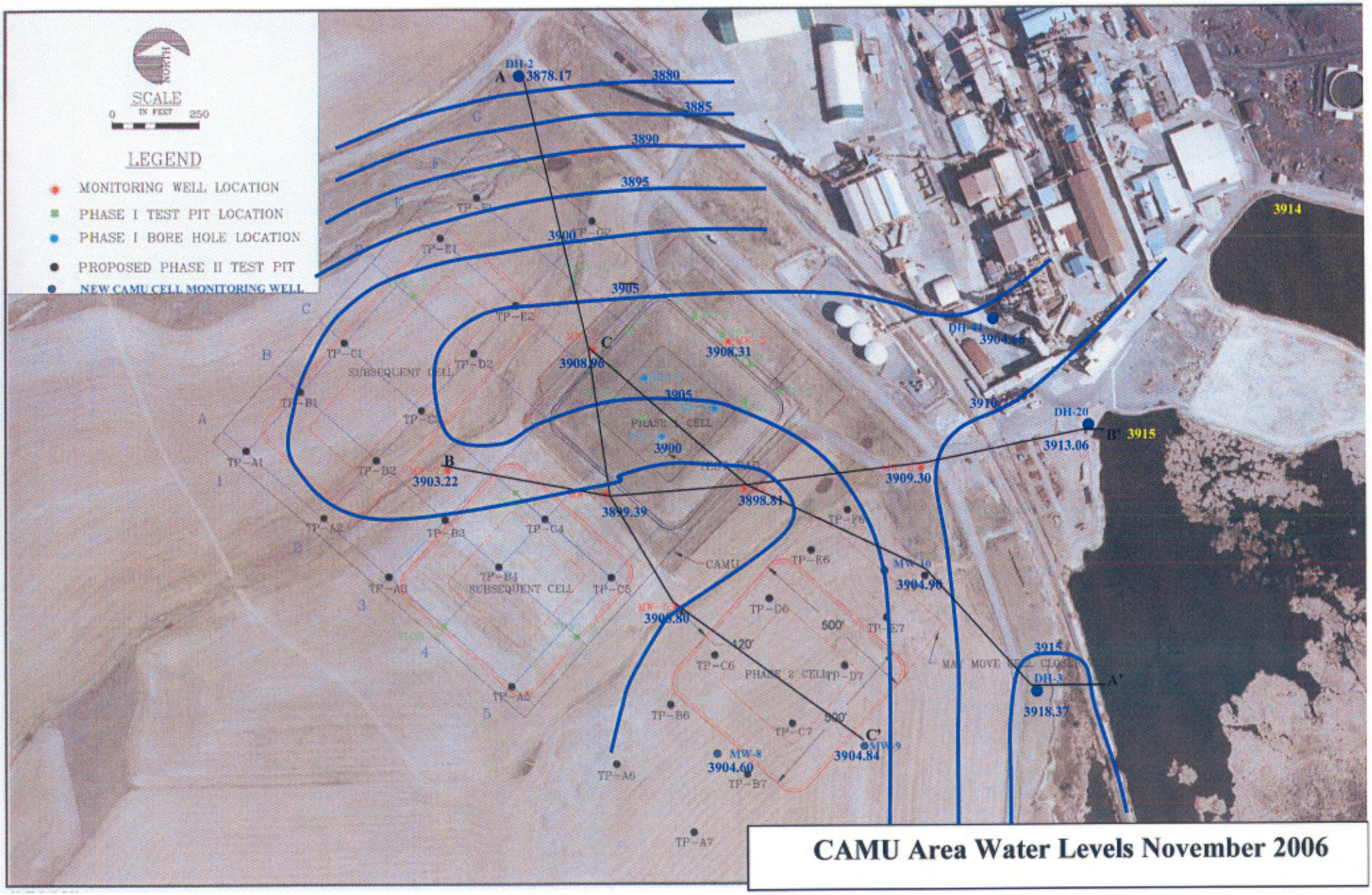
10.0 - 24.0' **Rock**
Rock with some silt, little plasticity.

24.0 - 30.0' **Silt with Gravel**
White silt with gravel mixed in. Volcanic Ash.

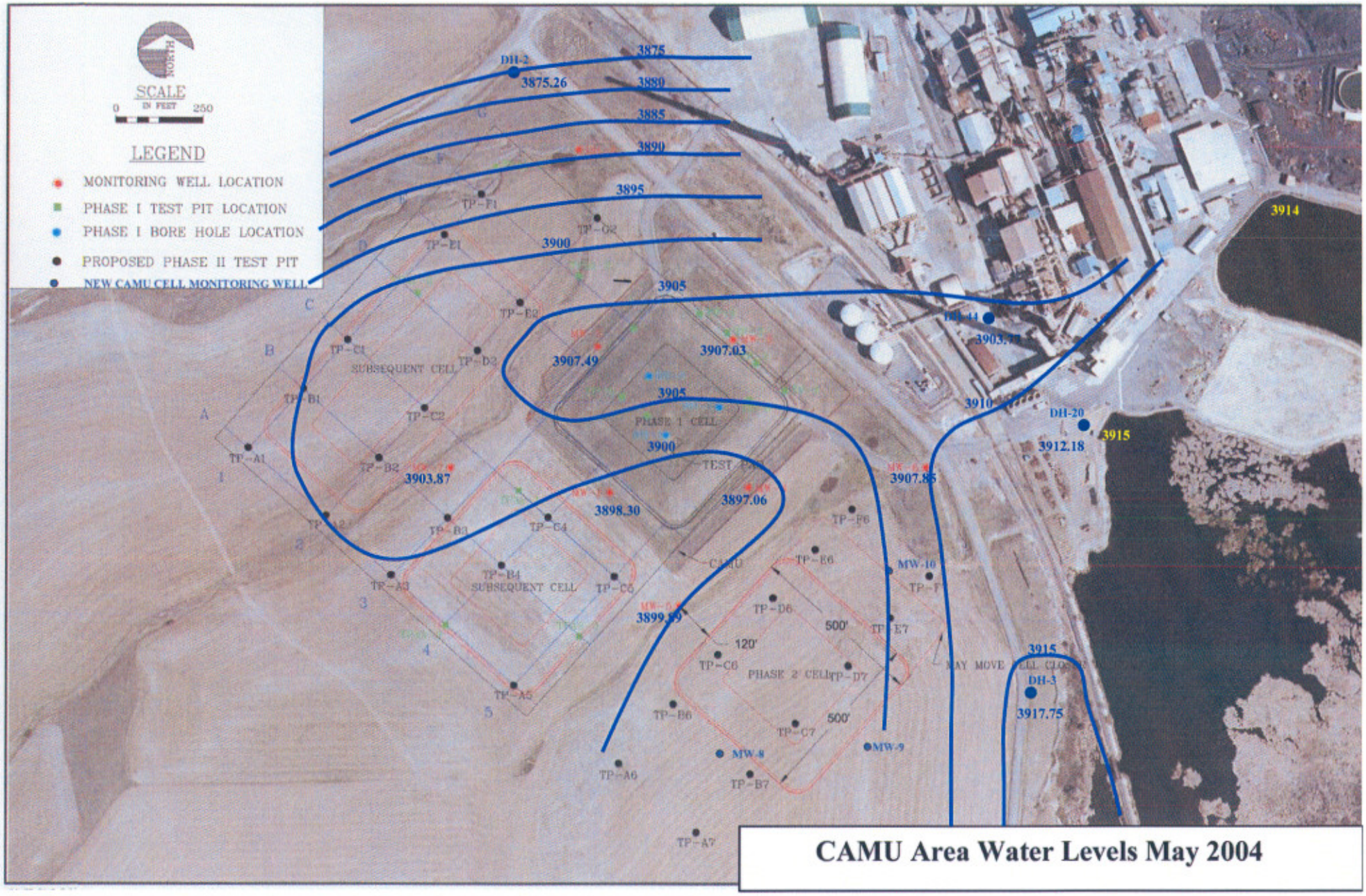
30.0 - 35.0' **Silt with gravel**
Light brown silt with some rocks, moderate plasticity, slightly moist. Volcanic Ash.

35.0 - 70.0' **Silt with gravel**
Light Yellow as above. Volcanic Ash.

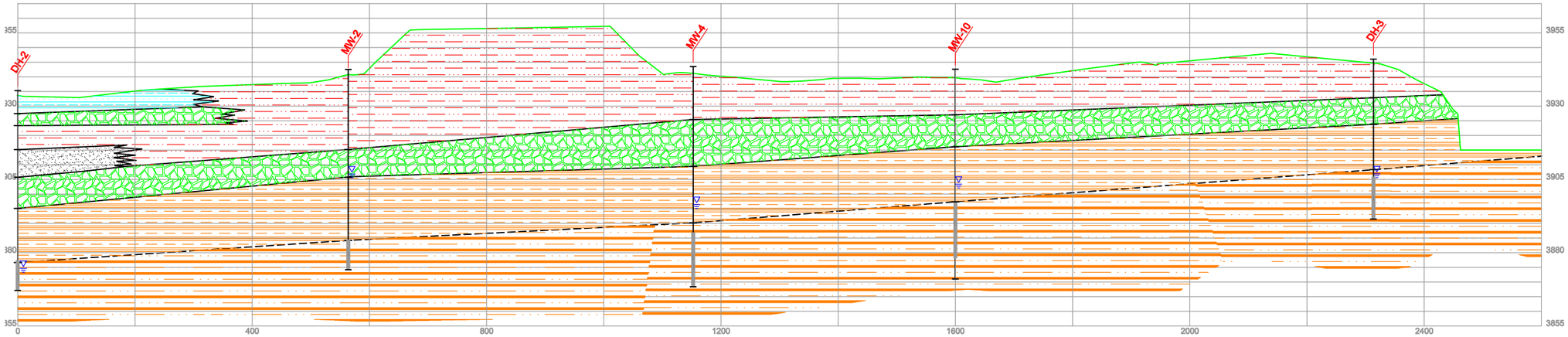
STANDARD REV1 K:\GINT\PROJECTS\11054.GPJ HYDHLN2.GDT 12/1/06



CAMU Area Water Levels November 2006

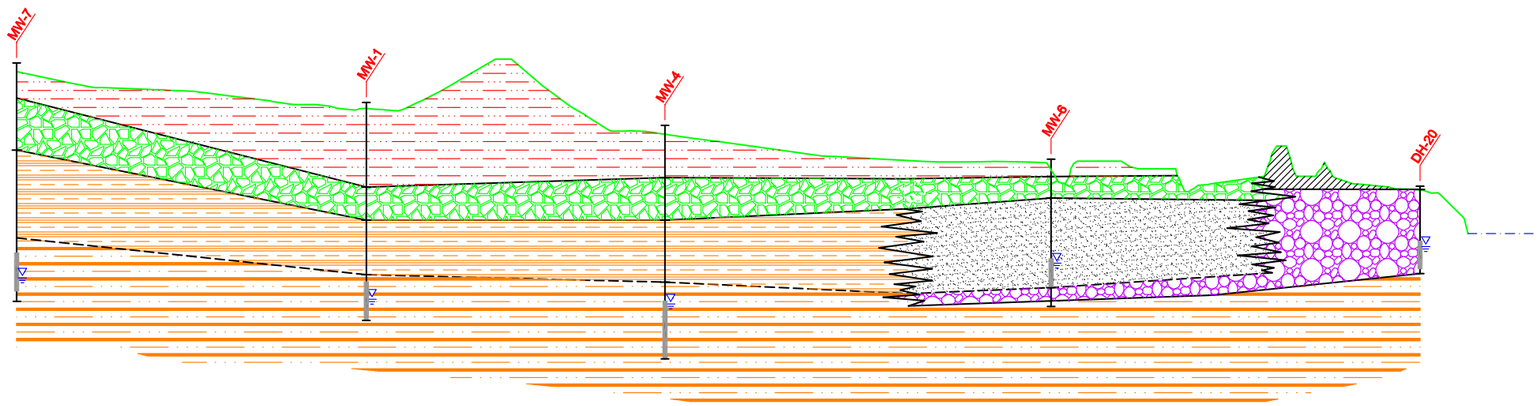


CAMU Area Water Levels May 2004



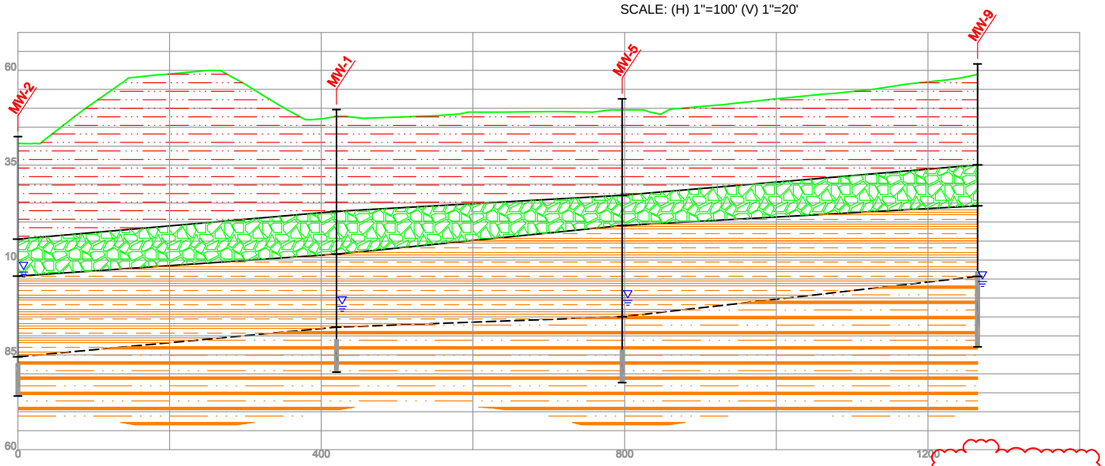
SECTION A-A'

SCALE: (H) 1"=100' (V) 1"=20'



SECTION B-B'

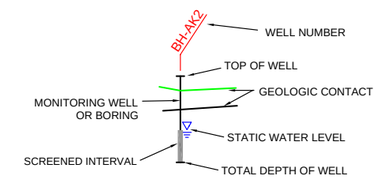
SCALE: (H) 1"=100' (V) 1"=20'



SECTION C-C'

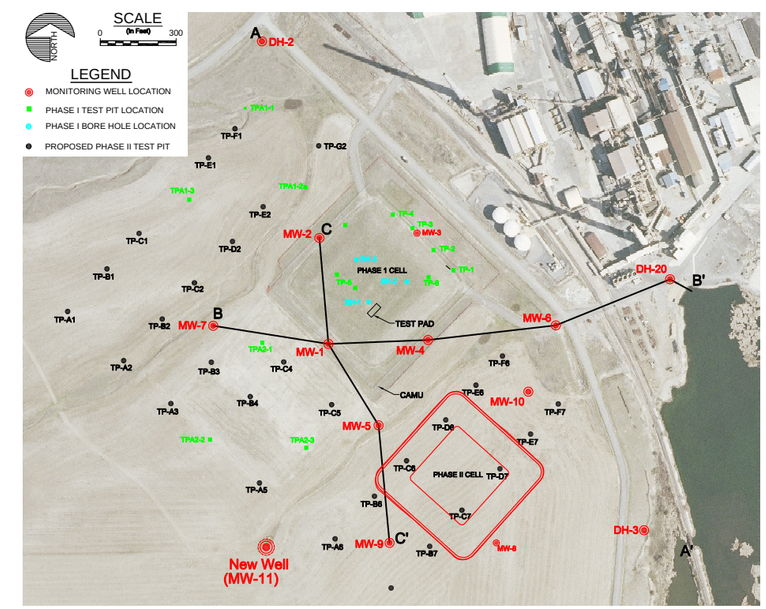
SCALE: (H) 1"=100' (V) 1"=20'

LEGEND



EXPLANATION

- FILL COMMONLY CONSISTS OF INTERMIXED SAND, SILT, CLAY AND GRAVEL. OFTEN INCLUDES WASTE CONSTITUENTS INCLUDING BRICKS, WOOD, COBBLES, SLAG, OTHER DEBRIS AND CONCRETE.
- FINE-GRAINED DEPOSITS CONSISTING OF INORGANIC SILTS
- ALLUVIAL GRAVEL AND COBBLES; HETEROGENEOUS, SAND, SILT OR CLAY MATRIX, VARIABLE WITH DEPTH AND LOCATION.
- FINE-GRAINED DEPOSITS CONSISTING OF INORGANIC SILTS AND CLAYS
- FINE-GRAINED DEPOSITS CONSISTING OF INORGANIC SILTS AND SAND
- ALLUVIAL SAND AND GRAVEL; HETEROGENEOUS, SAND, AND SILT MATRIX, VARIABLE WITH DEPTH AND LOCATION.
- FINE GRAINED SEDIMENTS CONSISTING OF VOLCANIC ASH-TUFF AS WELL AS CLAYS DERIVED FROM THESE VOLCANIC DEPOSITS. UNALTERED VOLCANIC ASH-TUFF DEPOSITS ARE GENERALLY GREENISH-YELLOW-WHITE IN COLOR. ASH DEPOSITS ARE GENERALLY AT LEAST PARTIALLY DECOMPOSED TO SMECTITE OR BENTONITE CLAY 2 - 5 FEET FROM TOP BECOMING LESS CLAYEY AND MORE INDURATED WITH DEPTH
- VOLCANIC ASH-TUFF AS DESCRIBED ABOVE, SANDIER WITH DEPTH.



PLEASE NOTE
PRINTED 1/2 SIZE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

GEOLOGIC
CROSS SECTIONS

DRAWING FILE NUMBER
604301H028.dwg
AUTOCAD 2000 DRAWING (DWG)
EXHIBIT
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APPENDIX C

DESIGN ANALYSIS

CHECK GCL LINER STRESS DURING SETTLEMENT

Installed Area of Liner = 208655.9762 sf

Installed Area of Liner After Settlement = 208731 sf

Strain, ε = (	208731 -	208656) sf /	208656 sf	
ε_{actual}=	75.02382 sf /	208656 sf		
ε_{actual}=	0.00036 in/in			
ε_{actual}=	0.035956 %			
GCL grab elongation (ε_{allow})=	50 %	From Manufacturer		
FS($\varepsilon_{allow}/\varepsilon_{actual}$) =	1390.598 **OK**			

Conclusion: Settlement of the Phase 2 cell will have no detrimental effect on the GCL liner.

ANCHORAGE

Calculate anchor capacity for GCL placed in various anchorage configurations

Friction Angle	= δ_L =	25 ^{o} to	30 ^{o}	use:	25 ^{o}
Soil f Angle	= ϕ =	25 ^{o} to	38 ^{o}	use:	30 ^{o}
Slope Angle	= β =	18.43 ^{o}			
Soil Unit Wt	= γ =	100 pcf to	130 pcf	use:	130 pcf
Embedment	= L_H =	3 ft			
"V"Embedment	= L_V =	2 ft			
"V"Depth	= d_V =	1 ft			
Cover Depth	= d_c =	2 ft			
Anchor Burial	= d_{AT} =	1 ft			

1. Horizontal Embedment Anchor Figure 3-8[2]

T_H = Anchor Capacity

$T_H = (q \times L_H \times \tan(\delta_L)) / (1.5 \times \cos(\beta) - \sin(\beta)\tan(\delta_L))$

$q = \gamma \times d_c$

= 130 pcf x 2 ft

= 260 psf

= (260 psf x 3 ft x tan(25 ^{o})) / (1.5x cos (18.43

= **285.1264 lb/ft** >= 256.8892 lb/ft **OK**

2. "V" Trench Figure 3-8[2]

T_V = Anchor Capacity

$$T_V = \frac{\tan(\delta_L)\,[\,q\,(L_H - L_V + L_V / \cos(i)) + (d_V \times L_V \times \gamma c / (2 \times \cos(i))]}{1.5 \times \cos(\beta) - \sin(\beta) \times \tan(\delta_L)}$$

i = 45 ^{O}

$$T_V = \frac{\tan(\ 25\ ^o)\ [\ 260\ \text{psf}\ (\ 3\ \text{ft}\ -\ 2}{1.5\cos(\ 0\ ^o) - \sin(\ 0\ ^o \times \tan(\ 0\ ^o)}$$

= **366.5921 lb/ft** >= 256.8892 lb/ft **OK**

3. Anchor Trench Figure 3-8[2] 2%

$$T_A = \frac{q \times L_H \times \tan(\delta_L) + (K' + K_A)\tan(\delta_L)(0.5 \times \gamma \times d_{AT}^2 + q \times d_{AT})}{1.5 \times \cos(\beta) - \sin(\beta) \times \tan(\delta)}$$

$$T_{Ap} = \frac{260\ \text{psf} \times 3\ \text{ft} \times \tan(\ 25\ ^o) + 3.33 \times \tan(\ 25}{1.5\cos(\ 18.43\ ^o) - \sin(\ 18.43\ ^o \times \tan(\ 25\ ^o)}$$

T_{Ap} = **680.7393 lb/ft** >= 256.8892 lb/ft **OK**

$$T_{Ao} = \frac{260\ \text{psf} \times 3\ \text{ft} \times \tan(\ 25\ ^o) + 0.833 \times \tan(\ 25}{1.5\cos(\ 18.43\ ^o) - \sin(\ 18.43\ ^o \times \tan(\ 25\ ^o)}$$

T_{Ao} = **384.089 lb/ft** >= 256.8892 lb/ft **OK**

[2] U.S. Environmental Protection Agency, "Requirements for Hazardous Waste Landfill Design, Construction, and Closure" (EPA/625/4-89/022), August 1989

ATTACHMENT 1

SEISMIC ANALYSIS

Tetra Tech EM Inc. (Tetra Tech) reviewed the April 10, 2007, calculation data sheets prepared by Hydrometrics Inc. Tetra Tech also performed an independent calculation of the approximate yield acceleration necessary to move a 1-foot square block of cover down an incline sloped at five horizontal to one vertical. This analysis calculated a yield acceleration of 0.11g, which compares favorably to the yield acceleration calculated by Hydrometrics of 0.104g.

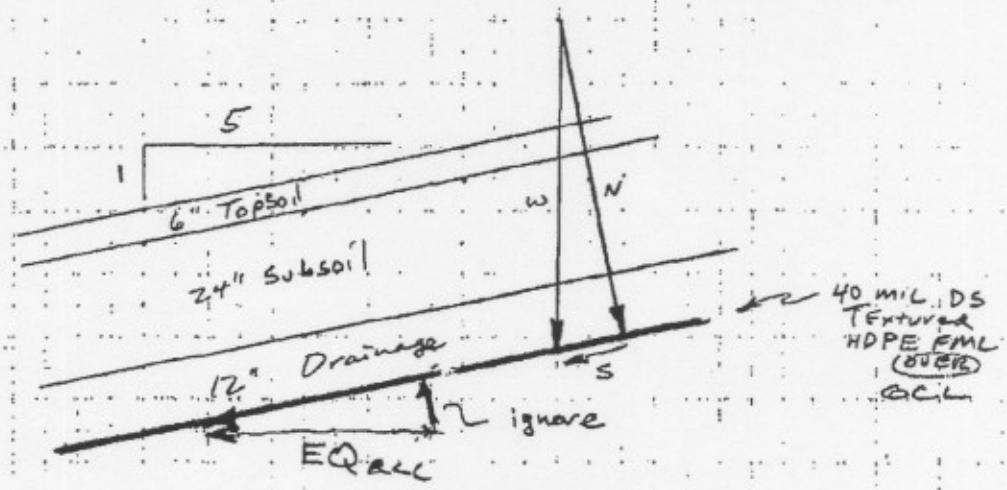
The output data sheets calculated by Hydrometrics indicate possible earthquake induced displacements on the order of 0.9 to 5.1 cm when subject to a magnitude 6.4 earthquake, with a peak ground acceleration of 0.30.

After entering the same earthquake magnitude and peak ground acceleration into a chart prepared by Makdisi and Seed (1977), a typical displacement of approximately 10 cm (4 inches) is read off of the chart (see attached). This presumes a friction angle of 17° using smooth HDPE (same as the Hydrometrics analysis). Hydrometrics correctly concludes that textured HDPE will offer greater resistance.

Hydrometrics, Inc., conducted their analysis using the USGS open file report 03-005, "Java programs for using Newmark's method and simplified decoupled analysis to model slope performance during earthquakes," 2003. The program models earthquake behavior and predicts movements in a more rigorous fashion. While the program output may or may not be more accurate than the less rigorous method used by Tetra Tech, we believe that the magnitude of displacements predicted by both methods suggest adequate earthquake performance of the landfill cover. Especially considering that a conservative friction angle was used for the smooth HDPE, when the project specified a textured HDPE.

REVIEW / INDEPENDANT CALC
NEWMARK ANALYSIS

JOHN BOECHE 45-222-8295
5-30-07
CAMU REVIEW
JN: 69022.008014 0102
ASARCO - EAST HELENA
PLANT
PHASE II CELL PROJ



$\beta = \arctan \frac{1}{5} = 11.3°$

$W = (42'' \text{ Soil}) \times \frac{ft}{12''} \times 120 \frac{\#}{ft} = 420 \#$

$u \times N =$ friction resistance

$\cos 11.3 = 0.98$

$N = 420$

$W = 420/.98 = 428$

$\sin 11.3 = \frac{S}{428} = 0.196$

$S = 84$

$\tan 17° = \mu_s = 0.306$

$m = \frac{428 \# - S^2}{32.2 \text{ ft}} = 13.3 \text{ slug}$

$F_y = m a_y$

$\mu_s \times N = S + F_y = S + m a_y$

$a_y (m) = \mu_s \times N - S$

$a_y = \frac{.306(428) - 84}{13.3} = \frac{125-82}{13} = 3.5 \frac{ft}{s^2} = 0.11 g$

Permanent Displacement

Material only to be used as part of the course
CE176 Waste Containment System. Prof. Juan M. Pestana

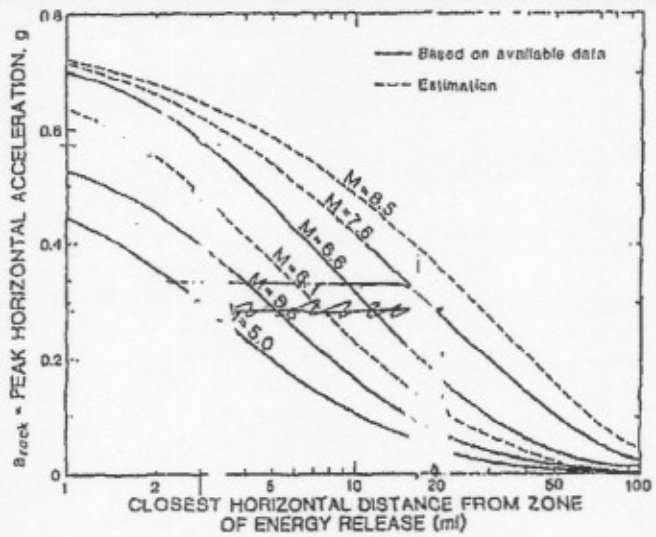


Figure 10.22 Average values of maximum accelerations in rock. (From Seed and Idriss, 1982. Reproduced by permission of Earthquakes Engineering Research Institute.)

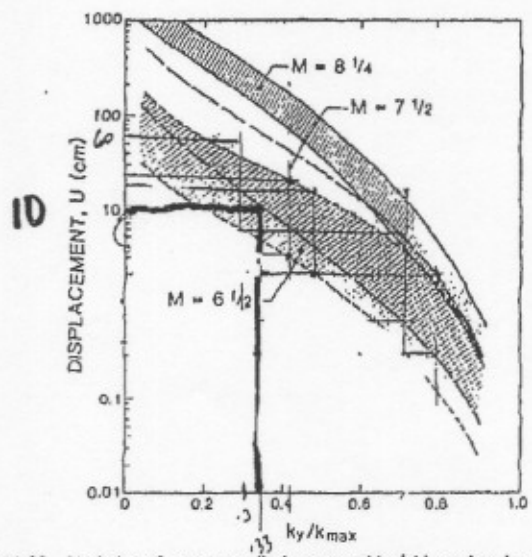


Figure 10.23 Variation of permanent displacement with yield acceleration. (From Makdisi and Seed, 1977.)

$K_y = 0.11$
$K_m = 0.3$

Ratio = 1/3

Displacement = Approx 10 cm
= 4 inches

Liner Design

Calculations for the flexible membrane liner (FML) include:

- Thickness Considerations
- Stress on FML from FML weight on side slopes
- Stress carried by FML during placement of waste
- Stress carried by FML from subsidence
- Liner Survivability

Assumptions used in the calculations:

- Assumed FML specific gravity = 0.94
- Assumed friction angle between FML and Soil = 25°
- Assumed friction angle between FML and GCL or Geotextile = 6°
- Assumed FML thickness = 60 mil
- Assumed average density of waste = 130 pcf
- Assumed internal friction angle of waste = 30°

The calculations were performed using guidance found in Koerner, R.M., Designing with Geosynthetics, Second Edition, 1990., and Koerner, R.M.,Designing with Geosynthetics, Fourth Edition, 1998.

The following calculations show the selected 60 mil HDPE liner has sufficient thickness, strength, and survivability characteristics for application in the Phase 2 cell.

TEXTURED FLEXIBLE MEMBRANE LINER DESIGN												
			TABLE OF DESIGN PARAMETERS									
FML Specific Gravity			= G_s =	0.94	to	0.95	use:	0.94		Appendix D[1]		
FML Friction Angles												
	CL/FML		= δ_1 =	25	° to	30	° use:	25	°	Table 5-6[1]		
	FML/GCL or Geotextile		= δ_2 =	6	° to	11	° use:	6	°	Table 5-5[1]		
FML Thickness			= t =	30	mil to	120	mil	use:	60	mil		
FML Yield Sress			= σ =	2300	psi to	3200	psi use:	126	lb/in	From Manufacturer		
			126	lb/in /	0.06	in x	0.95	=	1995	psi		
				50000	psf to	400000	psf	=	287280	psf		
Modulus			= E =	25000	psi					Table 5-3[1]		
Cell Slope Angle			= β =	18.43	°							
Depth of Cell			= D =	8	ft							
Design Lift Thickness			= D_L =	2.5	ft							
Density Waste			= γ =	80	pcf to	150	pcf	use:	130	pcf		
Cell Side Slope			= S =	3	: 1							
Height of Cap			= H =	11	ft							
Waste Internal Friction			= ϕ =	0	° to	40	°	use:	30	°		
1. Calculate the required liner thickness for settlement.							Section 5.3.4 & 5.6.6[1]					
	$t_{REQUIRED}$ = p / cos(β) x X / $\sigma_{ALLOWABLE}$ x (tan(δ)$_1$ + tan(δ)$_2$)											
		p =	γ x (D + H)									
		=	130	pcf x (	8	ft +	11	ft)				
		=	2470	psf								
		=	17.153	psi								
		X =	Deformation Distance									
		=	2	inches	(see Figure 5.9, Koerner, 1990)							
	t =	17.15277778	psi	x	2	in.	x [tan(	25	°)+tan(	6	°)]	
		cos (	18.43	°)	1995	psi						
	=	0.010357074	inches		2%							
	$t_{REQUIRED}$ =		10	mils	<=	60	mils	**OK**				
	FS = $\sigma_{ALLOWABLE}$ / σ											
		σ =	p / cos(β) x X / t x (tan(δ)$_1$ + tan(δ)$_2$)									
		=	17.153	psi	x	2	in.	x [tan(	25	°)+tan(	6	°)]
			cos (	18.43	°)	0.06	in.					
		=	344.37	psi								
	FS =	1995	psi /	344.37	psi							
	=	5.79314201	>=	1	**OK**	Table 5.17[1]						
2. Check FML Stress, σ, Before Waste Placement From FML Weight On Slopes.										Figure 3-6[2]		
		Steepest side slopes are in the bottom cell.										
σ =	T / A											
	T =	W x sin(β) - F										
		W =	Liner weight									
		=	[G_s x δ_w x t][1x D / sin(β)]									
		= [	0.94	x	62.4	pcf x	60	/1000/12]x[1ftx	8	ft / sin(	18.43	°)
		=	7.42	lb/ft								
		F =	Friction Force between liner and slope									
			Least an	0.02								
		=	W x cos(β) x tan(δ_2)									
		=	7.42	lbxcos(	18.43	°)xtan(	6	°)				
		=	0.74	lb/ft								

	T =	7.42	lbxsin(	18.43	°) -	0.74	lb						
	=	2.35	-	0.74									
	=	1.606227666	lb/ft										
	A =	1'xt											
	=	1ft x	60	/1000/12									
	=	0.005	sf										
σ =	1.6062	lb/ft /	0.005	sf									
=	321.25	psf/ft											
	FS =	287280	psf /	321.25	psf								
	=	894.2692438	>=	10	**OK**	Table 5.17[1]							
3. Check Tension Stress, σ, Carried By Primary Geomembrane During Filling										Section 5.6.8[1]			
σ =	(F_{Above} - F_{Below}) / t												
	F_{Above} =	W x cos(β) x tan(δ_1)											
		W=	W_W - T_W =		Weight of waste - Internal Friction Force on Edge of Waste								
			W_W =	0.5 x D_L^2 x S x γ									
			=	0.5 x (	2.5	ft)^2 x	3	x	130	pcf			
			=	1218.8	lb/ft								
			T_W =	σ_H x tan(ϕ) x D_L									
				σ_H =	K_O x σ_V								
					K_O =	1 - sin ϕ							
					=	1 - sin(	30	°)					
					=	0.5							
					σ_V =	γ xD_L/ 2							
					=	130	pcf x	2.5	ft / 2				
					=	162.5	psf						
				σ_H =	0.5	x	162.5	psf					
				=	81.25	psf							
			T_W =	81.25	psf x	tan(	30	°) x	2.5	ft			
			=	469.1	lb / ft								
		W=	1218.8	lb/ft -	469.1	lb/ft							
		=	749.65	lb/ft									
		W x cos(β) =		749.65	lbxcos(	18.43	°)						
			=	711.2	lb/ft								
	=	711.2036646	lb/ft x	tan(	25	°)							
	=	331.6397153	lb/ft										
	F_{Below} =	W x cos(β) x tan(δ_2)											
	=	711.2036646	lbxtan(	6	°)								
	=	74.75051729	lb/ft										
σ = (	331.64	lb/ft -	74.751	lb/ft) / (	60	/1000"	/12"/')						
=	256.89	lb/ft /	0.005	ft									
=	51378	psf											
	FS=	σ / σ_{actual}											
	=	287280	psf /	51378	psf								
	=	5.591515763	>=	0.5	**OK**	Table 5.17[1]							
4. Check Minimum Thickness for General Membrane Installation Survivability										Table 5.11[3]			
t_{MIN} =	40	mil for High Survivability, typical of landfill liners and covers.											
	60	mil	>=	40	mil	**OK**							
5. Check Tension Stress, σ, After Filling Due to Subsidence													
Settlement of bottom of Landfill Due to 19 foot Height of Fill =							ρ						

	ρ =	2	inches (see settlement calculation)									
Installed Area of Liner =			208,656	sf								
Installed Area of Liner After Settlement =					208,731	sf						
Strain, ε = (		208,731	-	208,656	) sf /	208,656	sf					
	ε =	75	sf /	208,656	sf							
	ε =	0.000359558	in/in									
σ =	ε x E											
σ =	0.0004	x	25000	psi								
σ =	8.9889	psi <	126	psi								
FS=	σ / σ_{actual}											
=	126	psf /	8.9889	psf								
=	14.017	>=	10	**OK**		Table 5.17[1]						
*Friction angle of 6° assumed for FML interface with either geocomposite or GCL												
[1] Koerner, Robert M., *Designing With Geosynthetics, Second Edition*, Prentice Hall, 1990.												
[2] U.S. Environmental Protection Agency, "Requirements for Hazardous Waste Landfill Design,												
	Construction, and Closure" (EPA/625/4-89/022), August 1989											
[3] Koerner, Robert M., *Designing With Geosynthetics, Fourth Edition*, Prentice Hall, 1998.												

Geonet Design

Calculations for the geonet include:

- Stresses on the geonet during placement of waste
- Maximum fluid travel time through geonet to collection sump

Assumptions used in the calculations:

- Geonet thickness of 250 mil
- Geonet has 8 oz. heat bonded non-woven geotextile on both sides
- Transmissivity of the geonet = 0.2 gal/min/ft

The calculations were performed using guidance found in Koerner, R.M., Designing with Geosynthetics, Second Edition, 1990., and U.S. Environmental Protection Agency, "Requirements for Hazardous Waste Landfill Design, Construction, and Closure" 1989.

The following calculations show the selected geonet has sufficient strength, and flow capacity for application in the Phase 2 cell.

GEONET DESIGN									
Normal Stess,		$\sigma_{N\text{-}ALLOWABLE}$ =		118	psi to	250	psi	use:	134 psi
Geonet thickness, t =			160	mils to	910 mils			use:	250 mils
		t =							0.25 inches
$\tau_{ALLOWABLE}$ =		1500	psi						
Cell Side Slope			= S =	3	: 1				
Cell Slope Angle			= β =	18.43	°				
Transmisivity,		$T_{@3900PSF}$ =		0.2	gal/min/ft				
1. Calculate the normal stress on the geonet							Section 5.6.8[1]		
$\sigma_{N\text{-}ACTUAL}$ =	γ x (H + D)								
	γ =	130	pcf						
	H =	10	ft						
	D =	8	ft						
$\sigma_{N\text{-}ACTUAL}$ =	130	pcf x (	10	ft +	8	ft)			
=	2340	psf							
=	16.25	psi							
	FS =	134	psf /	16.25	psi				
	=	8.24615	>=	1	**OK**				
2. Calculate the shear stress on the geonet							Section 5.6.8[1]		
τ =	F_{BELOW} / t								
	F_{BELOW} =	74.7505	lb/ft						
τ =	74.75052	lb/ft / 12 /	0.25	in					
=	24.91684	psi							
	FS =	1500	psi /	24.916839	psi				
	=	60.2003	>=	1	**OK**				
3. Calculate required slope				try:	2%		Figure 4-15[2]		
t=	maximum travel time to sump.								
=	Distance to sump / Seepage Velocity								
=	D_{slope} / V_{slope} + D_{bottom} / V_{bottom}								
	D_{slope} =	25.2982	feet						
	D_{bottom} =	sqrt(2) x cell bottom length							
	=	sqrt(2)x	407	feet					
	=	575.585	ft						
	V_{slope} =	T / t							
		T =	f(i, σ)						
			i =	1 / sqrt(1 + S^2)					
			=	1 / sqrt(1+	3	^{2})			
			=	0.3162278					
			σ =	H / 2 * γ * acos(β)					
			=	10	ft / 2 x	130	pcf x cos(	18.43	°)
			=	616.6619	psf				
		T =	0.2	gal/min/ft =		0.0267	sf/min		

GEONET-DESIGN

	V_{slope} =	0.03	sf/min/(	0.25	/12 ft)					
	=	1.3	ft/min							
	V_{bottom} =	T / t								
		T =	f(i, σ)							
			i =	0.02						
			σ =	$\sigma_{N\text{-}ACTUAL}$						
			=	2340	psf					
		T =	0.5	gal/min/ft =		0.0668	sf/min			
	V_{bottom} =	0.1	sf/min/(	0.25	/12 ft)					
	=	3.2	ft/min							
t=	25.29822	ft /	1.3	ft/min +	575.58	ft /	3.2	ft/min		
=	199.1022	minutes								
=	3.318369	hours	<=	24	hours	**OK**				
	2%	**OK**								
[1] Koerner, Robert M., *Designing With Geosynthetics, Second Edition* , Prentice Hall, 1990.										
[2] U.S. Environmental Protection Agency, "Requirements for Hazardous Waste Landfill Design,										
	Construction, and Closure" (EPA/625/4-89/022), August 1989									

Liner Anchor Trench Design

Calculations for the Anchor Trench Design include:

- Anchor trench anchorage capacity for various anchor trench configurations

Assumptions used in the calculations:

- Assumed friction angle between FML and Soil = 25°
- Assumed soil internal friction angle = 30°
- Unit weight of the soil = 130 pcf

The calculations were performed using guidance found in U.S. Environmental Protection Agency, "Requirements for Hazardous Waste Landfill Design, Construction, and Closure" 1989.

The following calculations show a "V" trench 1-foot deep with and embedment of 2-feet is adequate for application in the Phase 2 cell.

ANCHORAGE

Calculate anchor capacity for FML placed in various anchorage configurations

Friction Angle	$= \delta_L =$	25	° to	30	°	use:	25 °
Soil ϕ Angle	$= \phi =$	25	° to	38	°	use:	30 °
Slope Angle	$= \beta =$	18.43	°				
Soil Unit Wt	$= \gamma =$	100	pcf to	130	pcf	use:	130 pcf
Embedment	$= L_H =$	3	ft				
"V"Embedment	$= L_V =$	2	ft				
"V"Depth	$= d_v =$	1	ft				
Cover Depth	$= d_c =$	2	ft				
Anchor Burial	$= d_{AT} =$	1	ft				

1. Horizontal Embedment Anchor — Figure 3-8[2]

$T_H =$ Anchor Capacity

$T_H = (q \times L_H \times \tan(\delta_L)) / (1.5 \times \cos(\beta) - \sin(\beta)\tan(\delta_L))$

$q = \gamma \times d_c$

= 130 pcf x 2 ft

= 260 psf

= (260 psf x 3 ft x tan(25 °)) / (1.5x cos (18.43 °) - sin(18.43 °)x tan(25 °))

= **285.1264 lb/ft** >= 256.8892 lb/ft OK

2. "V" Trench — Figure 3-8[2]

$T_V =$ Anchor Capacity

$T_V = \tan(\delta_L) [q (L_H - L_V + L_V / \cos(i)) + (d_V \times L_V \times \gamma c / (2 \times \cos(i))]$

$1.5 \times \cos(\beta) - \sin(\beta) \times \tan(\delta_L)$

i = 45 °

$T_V =$ tan (25 °) [260 psf (3 ft - 2 ft + 2 ft/ cos(45 °)) + (1 ft x 2 ft x 130 pcf / (2 x cos (45 °))]

1.5cos(18.43 °) - sin(18.43 ° x tan(25 °)

= **431.0668 lb/ft** >= 256.8892 lb/ft OK

3. Anchor Trench — Figure 3-8[2] 2%

$T_A = q \times L_H \times \tan(\delta_L) + (K' + K_A) \tan(\delta_L)(0.5 \times \gamma \times d_{AT}^2 + q \times d_{AT})$

$1.5 \times \cos(\beta) - \sin(\beta) \times \tan(\delta)$

$T_{Ap} =$ 260 psf x 3 ft x tan(25 °) + 3.33x tan(25 °)(0.5 x 130 pcf x 1 ft² + 260 psf x 1 ft)

1.5cos(18.43 °) - sin(18.43 ° x tan(25 °)

$T_{Ap} =$ **680.7393 lb/ft** >= 256.8892 lb/ft OK

$T_{Ao} =$ 260 psf x 3 ft x tan(25 °) + 0.833x tan(25 °)(0.5 x 130 pcf x 1 ft² + 260 psf x 1 ft)

1.5cos(18.43 °) - sin(18.43 ° x tan(25 °)

$T_{Ao} =$ **384.089 lb/ft** >= 256.8892 lb/ft OK

[2] U.S. Environmental Protection Agency, "Requirements for Hazardous Waste Landfill Design, Construction, and Closure" (EPA/625/4-89/022), August 1989

0.02

Coversoil Design

Calculations for the Coversoil Design include:

- Static finite slope analysis of proposed cover over FML
- Seismic Newmark sliding block analysis of proposed cover over FML

Assumption used in the calculations:

- Assumed friction angle of soil on FML = 17°
- Assumed soil internal friction angle = 26°
- Unit weight of the soil = 130 pcf
- Cap slope = 5:1
- Cover thickness = 3.5 ft
- Assumed no cohesion of soil
- Assumed Peak Ground Acceleration (PGA) = .3035 g
- Assume magnitude of earthquake = 6.4

The calculations were performed using guidance found in Koerner, R.M., Designing with Geosynthetics, Second Edition, 1998., and U.S. Geological Survey, Open File Report 03-005, "Java programs for using Newmark's method and simplified decoupled analysis to model slope performance during earthquakes" 2003.

The following calculations show the cover soil has a factor of safety greater than 1.5 (analysis shows FS for Phase 2 cell = 1.59) using a smooth 60-mil HDPE, however a textured HDPE liner will be used in the Phase 2 cell and will most likely provide an even higher factor of safety for static conditions. Calculations also show the cover soil has a factor of safety of 1.53 for seismic conditions which is higher than 1.0, the recommended factor of safety for seismic design.

SLIDING[1]											
Verify that soil cover will not slide on FML (FS>1.5)											
Liner Friction Angle		= δ =	10	° to	45	°	use:	17	°[2]	0.297	radians
Weight of Soil		=γ=	130	pcf							
Cap Slope Angle		= β_2 =	11.30993	°	0.197396	radians					
Cap Slope		= S_2 =	5	:1							
Slope Length		=L=	48.4	ft	9.5 feet high at highest point						
Cover Thickness		=h=	3.5	ft							
Soil Friction Angle		=ϕ=	26	°	0.453786	radians					
Assume no cohesion - Ca and C = 0											
Finite Slope Analysis											
Wa=	total weight of active wedge										
Wa=	$gh^2(L/h-1/\sin\beta-\tan\beta/2)$										
Wa=	27797.46	lb/ft									
Na=	effective force normal to the failure plane of the active wedge										
Na=	$Wa*\cos\beta$										
Na=	27257.65	lb/ft									
Wp=	total weight of passive wedge										
Wp=	$gh^2/\sin 2\beta$										
Wp=	1025.57	lb/ft									
a =	$(Wa-Na*\cos\beta)*\cos\beta$										
a=	1048.371	lb/ft									
b=	$-([Wa-Na*\cos\beta)*\sin\beta*\tan\delta+(Na*\tan\delta+Ca)*\sin\beta*\cos\beta+\sin\beta(C+Wp*\tan\phi)]$										
b=	-1766.98	lb/ft									
c=	$(Na*\tan\delta+Ca)*\sin^2\beta*\tan\phi$										
c=	156.3277	lb/ft									
FS =	$[-b+(b^2-4ac)^{.5)}/2a$										
FS =	1.59	**'>1.5 OK'**									
[1] Koerner, Robert M., *Designing With Geosynthetics, Fourth Edition*, Prentice Hall, 1998 pg. 481.											
[2] Koerner, Robert M., *Designing With Geosynthetics, Fourth Edition*, Prentice Hall, 1998 pg. 439.											
	used lowest value given in Table 5.7 for smooth HDPE. Design calls for textured, so										
	this assumption is conservative.										

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NEWMARK RIGID BLOCK ANALYSIS

FROM USGS PLOT: $M_w = 6.40$ @ 10.5 Km

$$I_a = M_w - 2\log R - 4.1$$

$$I_a = (6.40) - 2\log(10.5) - 4.1 = \underline{\underline{0.26 \text{ m/s}}}$$

$$\log D_{5\text{-}95\%} = 0.43\,M - 1.83 \qquad M \approx M_w \text{ for } M_w < 6.5$$

$$\log D_{5\text{-}95\%} = 0.43(6.40) - 1.83 = \underline{\underline{8.4 \text{ seconds}}}$$

FIND EARTHQUAKE IN USGS RECORDS WITH:

$M_w = 6.40$
PGA = .3035
ARIAS INTENSITY = 0.26 m/s
DURATION = 8.4 s.

SEARCH CRITERIA

M_w -	5.5	TO	7.5
PGA -	0.3	TO	0.5
I_a -	0.2	TO	0.8
D -	6	TO	12

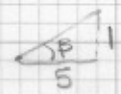
CRITICAL ACCELERATION

$$a_n = (FS - 1)\,g \sin\beta$$

USE FS = 1.53
β = Slope angle = 11.3°

$$a_n = (1.53 - 1)(9.8)\sin(11.3) = 1.02 \text{ m/s}^2 = \underline{\underline{0.104\,g}}$$

Liner-Soil Cover Slope Factor of Safety



$$FS = \frac{\overset{0}{c_c} + \gamma_m T \cos^2\beta \tan\phi}{\gamma_m T \sin\beta \cos\beta}$$

$\phi = 17°$ assumed friction angle of liner-soil*
$\beta = 11.3°$ (5:1 slope)
$T = 3$
$\gamma_m = 106.4$ - from soil testing proctor
Assume 90% compaction of cover soil with $\gamma_{dmax} = 96.9$ @ 22.4% moist

$$FS = \frac{(106.4)(3)[\cos^2(11.3)][\tan 17°]}{(106.4)(3)\sin(11.3)\cos(11.3)}$$

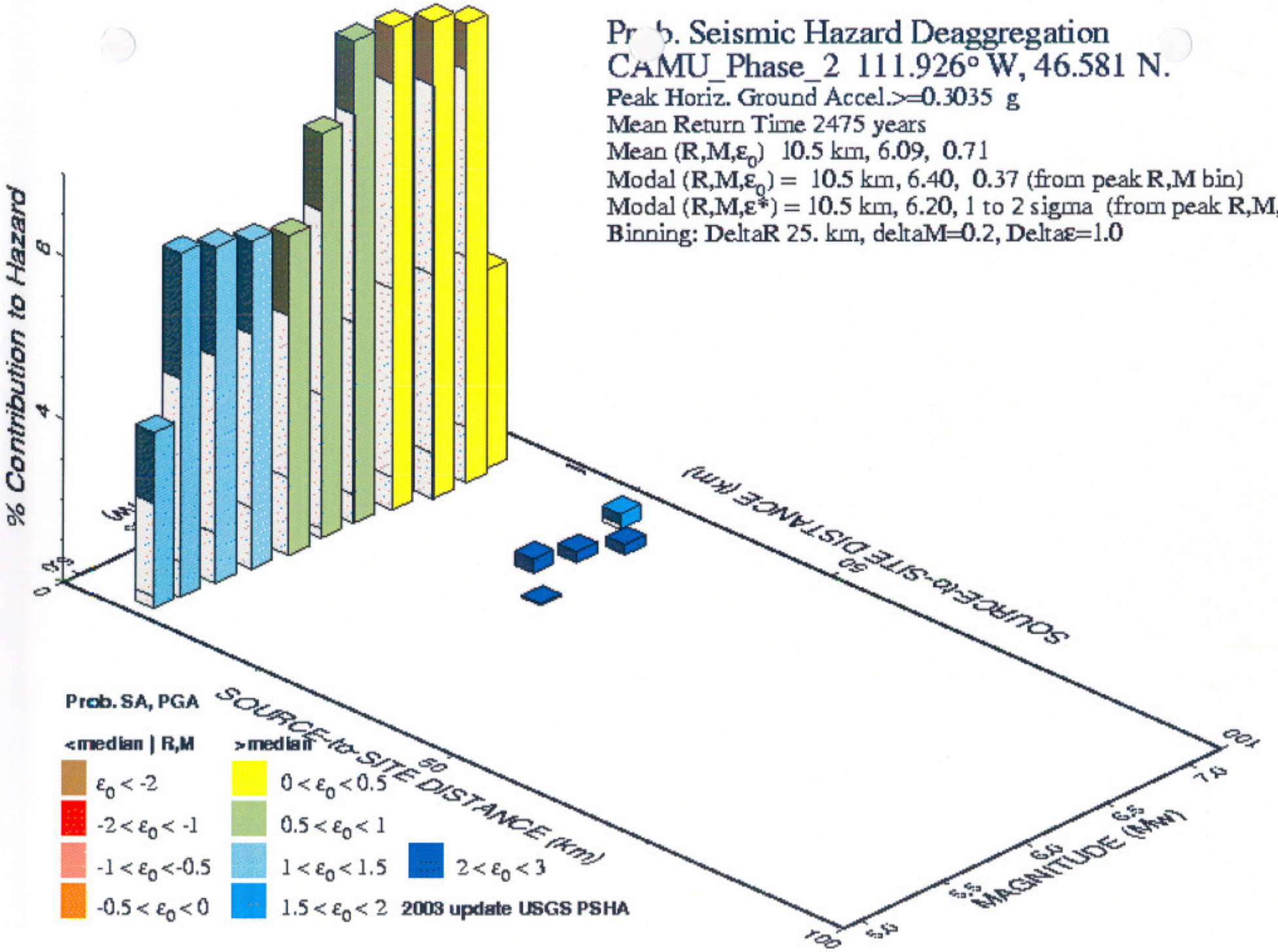
$$FS = \underline{\underline{1.53}} \geq 1.5 \quad \underline{\underline{OK}}$$

* From Koerner for soil-liner interface friction angle for smooth HDPE - no available data for textured HDPE which generally has a higher ϕ, so the lowest ϕ for smooth HDPE was used.

Earthquake	Record	Digitization Interval (s)	Moment Magnitude	Arias Intensity (m/s)	Duration (5-95%) (s)	Peak Acceleration (g)	Mean Period (s)	Epicentral Distance (km)	Focal Distance (km)	Rupture Distance (km)	Focal Mechanism
Mammoth Lakes-1 1980	MLS-270	0.005	6.3	0.678	7.6	0.321	0.25	12.8	15.6		5
Morgan Hill 1984	AND-250	0.005	6.2	0.683	6.8	0.423	0.43	16.5	18.7	2.6	1
Northridge 1994	ELD-168	0.005	6.7	0.772	7.6	0.363	0.43	40	44	18.3	3
Northridge 1994	ELD-258	0.005	6.7	0.792	8.1	0.352	0.48	40	44	18.3	3
Parkfield 1966	C05-355	0.01	6.1	0.626	7.4	0.367	0.42	32	32	9.3	1
Whittier Narrows 1987	BRD-130	0.005	6	0.417	7	0.313	0.27	23.4	25.3	23.3	5
Whittier Narrows 1987	CAS-000	0.02	6	0.68	8	0.332	0.51	21	23	16.9	5
Whittier Narrows 1987	CAS-270	0.02	6	0.536	8.4	0.333	0.31	21	23	16.9	5
Whittier Narrows 1987	LUR-090	0.005	6	0.747	7	0.36	0.22	9.3	13.3	15.5	5

Pr b. Seismic Hazard Deaggregation
CAMU_Phase_2 111.926° W, 46.581 N.

Peak Horiz. Ground Accel.>=0.3035 g
Mean Return Time 2475 years
Mean (R,M,ε_0) 10.5 km, 6.09, 0.71
Modal (R,M,ε_0) = 10.5 km, 6.40, 0.37 (from peak R,M bin)
Modal (R,M,ε^*) = 10.5 km, 6.20, 1 to 2 sigma (from peak R,M,ε b.
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



May 3 20:53 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on ROCK avg Vs=760 m/s top 30 m USGS CGHT PSHA2002v3 UPDATE Bins with lt 0.05% contrib. omitted

LOCATION 46.58161 Lat. -111.92611 Long.

The interpolated Probabilistic ground motion values, in %g, at the requested point are:

	10%PE in 50 yr	2%PE in 50 yr - 2500
PGA	14.72	30.34
0.2 sec SA	34.93	73.34
1.0 sec SA	9.78	21.79

.15g use this

½ would be 250yr

.0487 ?

Analysis Options page
Ground Motion page

CAMU-NEMARK ANALYSIS USING SCALED PGA OF .3035 g

Mean value is: 1.6 cm
Median value is: 1.3 cm
Standard Deviation is: 1.0 cm

		Disp1	Disp2	Avg. Disp
Whittier Narrows 1987	BRD-130	0.9	1.6	1.2
Mammoth Lakes-1 1980	MLS-270	0.6	1.2	0.9
Whittier Narrows 1987	CAS-000	3.4	4.5	4.0
Whittier Narrows 1987	CAS-270	0.9	0.8	0.9
Northridge 1994	ELD-258	3.8	0.9	2.4
Whittier Narrows 1987	LUR-090	1.0	0.8	0.9
Northridge 1994	ELD-168	1.0	1.7	1.4
Parkfield 1966	C05-355	2.1	1.1	1.6
Morgan Hill 1984	AND-250	1.7	0.9	1.3

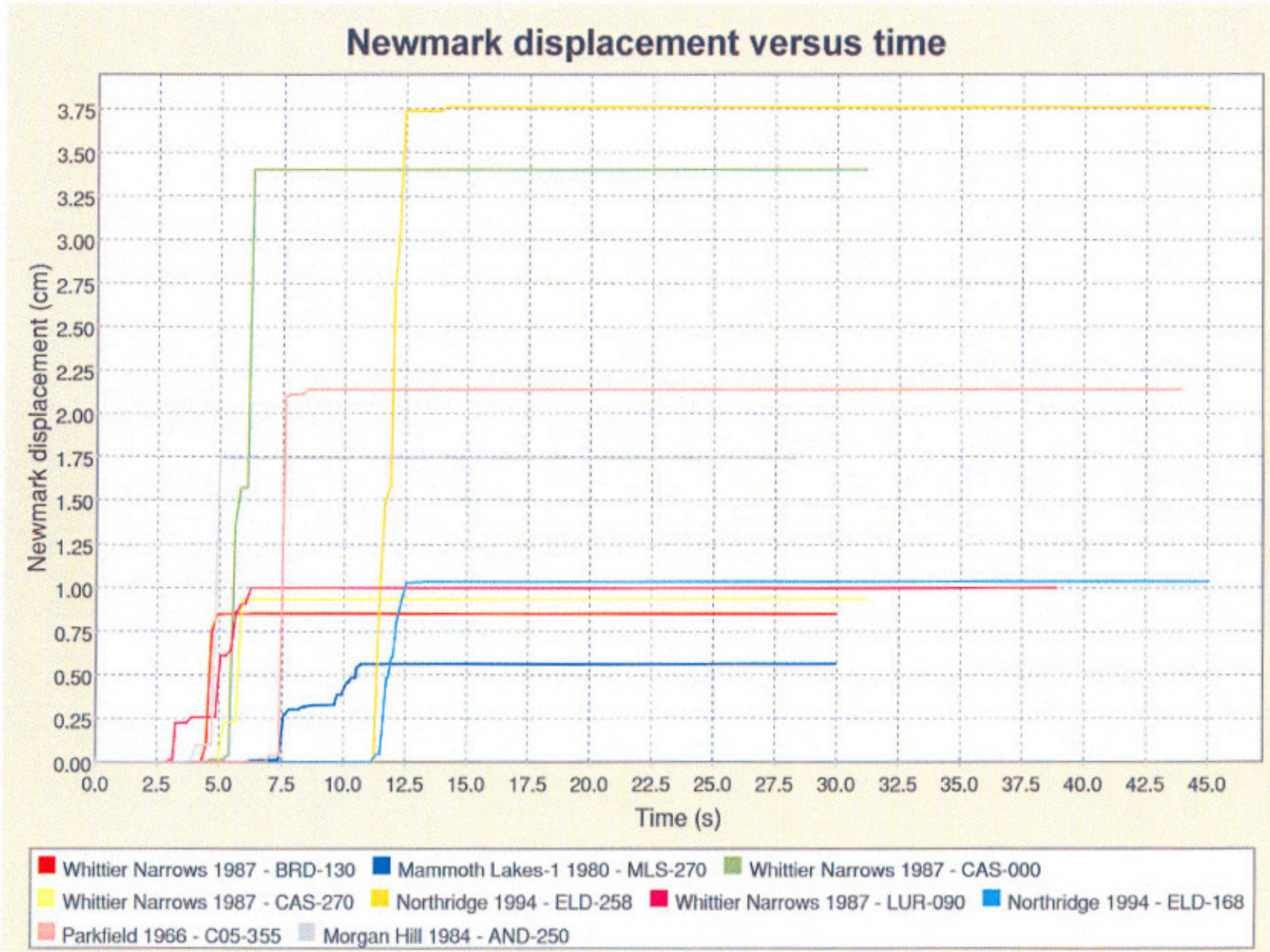
Displacements based on FS calculation for smooth HDPE of 1.53

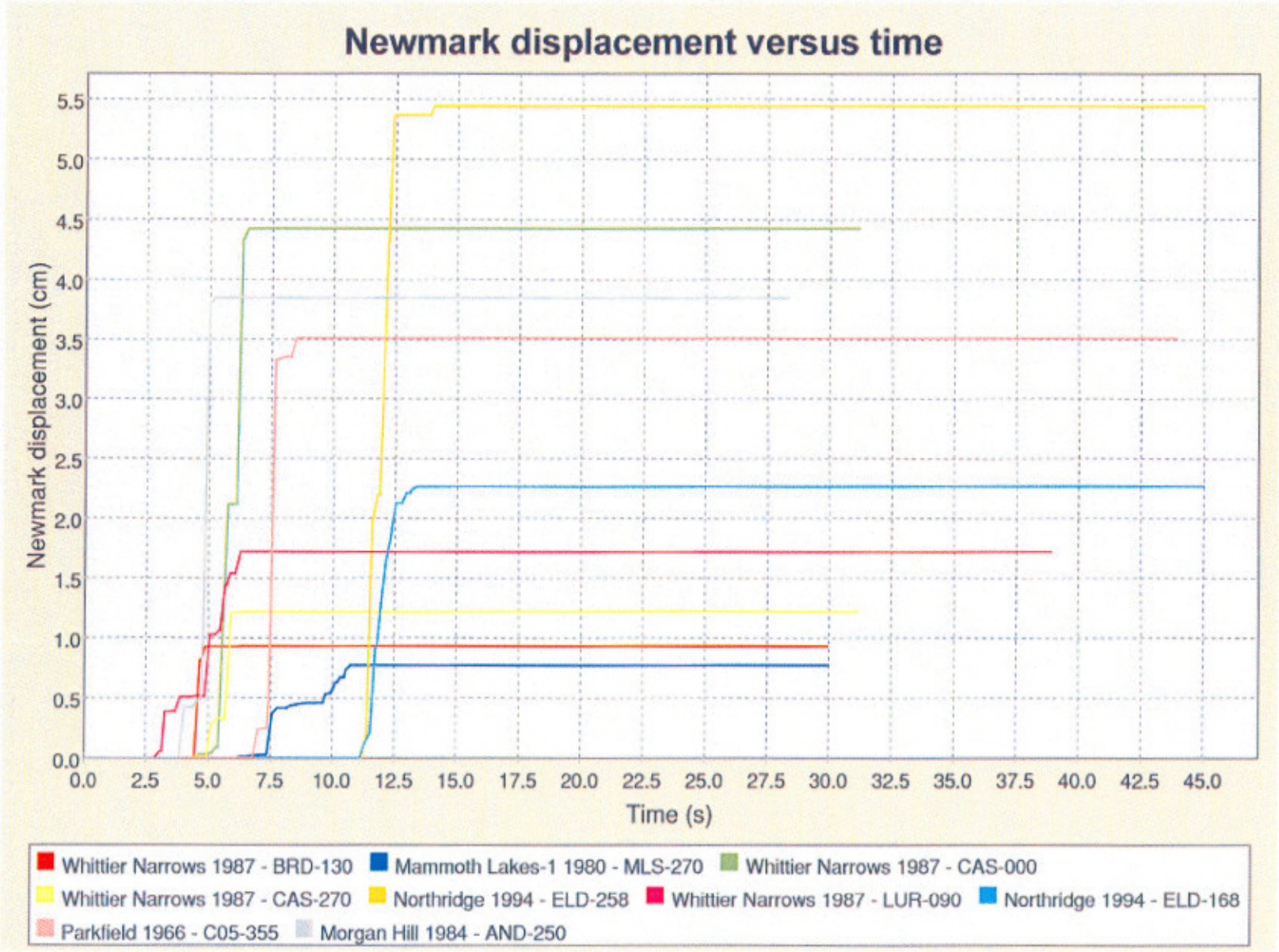
CAMU NEWMARK ANALYSIS

Mean value is: 2.6 cm
Median value is: 2.5 cm
Standard Deviation is: 1.4 cm

		Disp1	Disp2	Avg. Disp
Whittier Narrows 1987	BRD-130	0.9	1.8	1.4
Mammoth Lakes-1 1980	MLS-270	0.8	1.5	1.2
Whittier Narrows 1987	CAS-000	4.4	5.8	5.1
Whittier Narrows 1987	CAS-270	1.2	1.2	1.2
Northridge 1994	ELD-258	5.4	1.7	3.6
Whittier Narrows 1987	LUR-090	1.7	1.5	1.6
Northridge 1994	ELD-168	2.3	2.7	2.5
Parkfield 1966	C05-355	3.5	2.2	2.8
Morgan Hill 1984	AND-250	3.8	3.6	3.7

Displacements based on FS calculation for Smooth HDPE of 1.53


Newmark displacement versus time
Newmark displacement (cm)
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
35.0
37.5
40.0
42.5
45.0
Time (s)
Whittier Narrows 1987 - BRD-130
Mammoth Lakes-1 1980 - MLS-270
Whittier Narrows 1987 - CAS-000
Whittier Narrows 1987 - CAS-270
Northridge 1994 - ELD-258
Whittier Narrows 1987 - LUR-090
Northridge 1994 - ELD-168
Parkfield 1966 - C05-355
Morgan Hill 1984 - AND-250


Newmark displacement versus time
Newmark displacement (cm)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0 42.5 45.0
Time (s)
Whittier Narrows 1987 - BRD-130
Mammoth Lakes-1 1980 - MLS-270
Whittier Narrows 1987 - CAS-000
Whittier Narrows 1987 - CAS-270
Northridge 1994 - ELD-258
Whittier Narrows 1987 - LUR-090
Northridge 1994 - ELD-168
Parkfield 1966 - C05-355
Morgan Hill 1984 - AND-250

Seismic Analysis of Concrete Sumps

Calculations for the concrete footing in the sumps include:

- Deflection of the footing during an earthquake
- Shear on the footing during an earthquake

Assumption used in the calculations:

- Assumed unit weight of concrete = 150 pcf
- Assumed effective Peak Ground Acceleration (PGA) = ½*PGA = .15 g

The following calculations were performed using guidance found in ACI 318-99

The calculations show the functionality of the concrete sump will not be affected during a seismic event.

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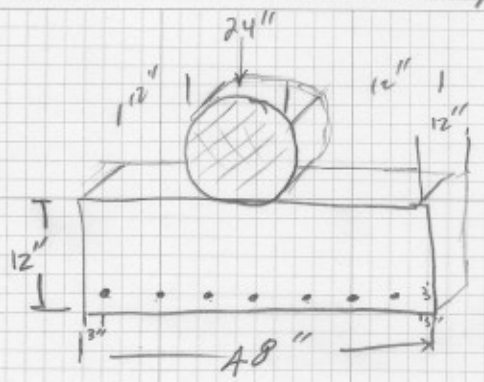
Deflection of Conc. Footing in CAMU LDS



24" HDPE

200 lbs per 20 ft

10 lbs/ft

wt of water

$A = \pi r^2 = 3.14\ ft^2$

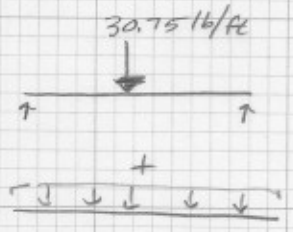
$62.4\ lb/ft^3 \cdot 3.14\ ft^2$

$w_{water} = 195\ lb$

- Wt of Full pipe = 205 lbs/ft us .15 g as horizontal acceleration
  use 30.75 lb/ft

ACI 95a - $h_{min} = \frac{l}{16} = \frac{48''}{16} = 3$ inches

$\gamma_{conc} = 150\ lbs/cf$



$w_{Bm} = 1' \times 1' (150) = 150\ lbs/ft$

$w_D = 150\ lb/ft$

$w_L = 30.75\ lb/ft$

$$U = 1.4D + 1.7L = \underbrace{1.4(150)}_{w_u\ (210)} + \underbrace{1.7(30.75)}_{F_u\ (52.275)} = 262.275\ lb/ft$$

$$M_{u\,max} = \frac{2(F_u)L}{4} + \frac{1}{8} w_u L^2 = \frac{2(52.275)(4}{4} + \frac{1}{8}(210)(4)^2 = \underline{\underline{524.6\ ft\text{-}lb}}$$

$$(bd^2)_{reqd} = \frac{M_u}{\phi \rho f_y (1 - 0.59 \rho (f_y/f_c'))}$$

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$\rho = \frac{A_s}{(bd)}$ $\quad A_s = (.192)^2(\pi/2)(7) = .405 \text{ in}^2$

6 gauge mesh dia = .192 in

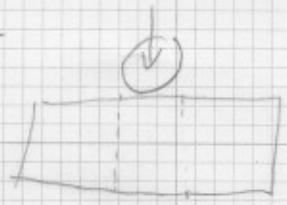
$\rho = \frac{.405}{(12)(48)} = .0007$

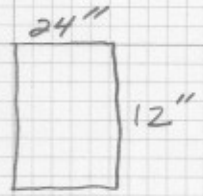
$(bd^2)_{req'd} = \frac{524.6 \text{ ft-lb} \cdot 12}{(0.9)(0.0007)(60{,}000 \text{ psi})(1 - 0.59(0.0007)(60/4))} = 167.57 \text{ in}^3$

$bd^2_{req} = 167.57 \text{ in}^3$

$bd^2_{design} = 1728 \text{ in}^3$ $\quad$ OK

Check for Shear





$\phi V_n = \phi V_c$

$V_c = 2\sqrt{f'_c}\, b_w d$ $\quad f'_c = 4000 \text{ psi}$

$V_c = 2\sqrt{4000}(24")(12") = 36{,}429 \text{ lbs} = 36.4 \text{ Kips/ft of width}$

$V = 30.75 \text{ lbs}$

$V_u = 30.75(1.7) = \underline{52.28 \text{ lb}}$

$V_{1c} = 0.85(36.4) = 30.94 \text{ Kips}$

$V_{1c} >> V_u$ $\quad$ OK

Settlement

Calculations for the cell settlement include:

- Amount of anticipated settlement of the cell

Assumption used in the calculations:

- Assumed blow count data from Phase 1 cell was same for Phase 2 cell
-

The following calculations show the settlement of the compacted clay liner may range from 1 to 3 inches which is within acceptable limits.

Settlement

Settlement of Landfill								
Based on standard penetration testing for Phase 1 Cell								
B = 455 feet > 4 feet								
$\rho = \Delta q_s \times 12 / (N \times ((B+1)/B)^2$								
	$\Delta q_s =$	20	ft x	105	pcf -	10	ft x	103.0629
	=	2100	psf -	1030.629	psf			
	=	1069.371	psf					
	$\Delta q_s =$	0.534685	tsf					
$\rho =$	0.534685	tsf x 12 / (	3.21	x ((	455	ft + 1) /	455	ft)^2)
$\rho =$	2	inches						
Based on Consolidation Testing of Phase 1 Cell								
$\Delta\sigma =$	20	ft x	124.5	pcf -	10	ft x	103.0629	
=	2490	psf -	1030.629	psf				
=	1459.371	psf						
Borehole	γ_d (pcf)	e	ε_1	ε_2	σ_1 (psf)	σ_2 (psf)	Δe	C_c
BH-2	108	0.358974	0.03	0.057	950	2300	0.027	0.070312
BH-3	100.5	0.40349	0.11	0.146	950	2300	0.036	0.093749
BH-4	112	0.335233	0.052	0.07	950	2300	0.018	0.046874
BH-5	96.9	0.424858	0.138	0.187	950	2300	0.049	0.127603
BH-7	105	0.376781	0.04	0.057	950	2300	0.017	0.04427
Average		0.379867						0.076562
St Dev		0.035428						0.03487
90%					2%			0.12125
p =	$\frac{H \times C_c}{(1 + e_o)}$	x log	$\frac{\sigma_o + \Delta\sigma}{\sigma_o}$					
=	7	ft x	0.12125	x log	1030.629	psf +	1459.371	psf
	(1 +	0.379867)				1030.629	psf	
=	0.615093	x log (	2.415999)					
p =	0.23564	ft						
p =	3	inches						
Range of p								
=	7	ft x	0.127603	x log	1030.629	psf +	1459.371	psf
	(1 +	0.424858)				1030.629	psf	
=	0.626883	x log (	2.415999)					
p =	0.240157	ft						
=	7	ft x	0.04427	0.02	1030.629	psf +	1459.371	psf
	(1 +	0.335233)				1030.629	psf	
=	0.232089	x log (	2.415999)					
p =	0.088912	ft						
p =	1	to	3	inches				

Capacity of the Leachate Collection System

Calculations for the capacity of the leachate collection system include:

- Flow capacity of the geocomposite
- Capacity of the sumps

Assumption used in the calculations:

- Geonet thickness of 250 mil
- Geonet has 8 oz. heat bonded non-woven geotextile on both sides
- Transmissivity of the geonet = 0.2 gal/min/ft

The following calculations show the selected geocomposite has a flow capacity of 79 gal/min and the sumps have a capacity of 36,000 gallons each.

Capacity of PLCR and LDCR systems

Effective Cross Sectional Area of each Sump	12.68 ft^2			
Length of Sump	379 ft			
Total Volume of PLCR	4805.7 ft^3	=	35951.6 gallons	
Total Volume of LDCR	4805.7 ft^3	=	35951.6 gallons	
Maximum leakage rate to the Sump	0.2 gal/min/ft			Transmissivity of Geocomposite
Length of Cell	395 ft			
Maximum Delivery Rate to Sump	79 gal/min			

Liner Leachate Compatibility

The following documents are liner compatibility information from the liner manufacturer and from the EPA chemical compatibility table for liners that have been referenced in determining the compatibility of the proposed waste to be placed in the Phase 2 cell with the selected HDPE liner. Additional compatibility information was included from testing conducted by the Department of Energy (DOE) for the ICDF Landfill.

ATTACHMENT 1

CHEMICAL RESISTANCE INFORMATION FOR HDPE LINERS

CHEMICAL COMPATIBILITY OF POLY-FLEX LINERS

Chemical compatibility or resistance as applied to geomembranes is a relative term. Actually compatibility would mean that one material will dissolve in the other such as alcohol in water or grease in gasoline. An example of incompatibility would be oil and water. In liners it is undesirable to have the chemicals dissolve in the liner hence the term compatibility is the reverse of what is normally meant in the chemical industry. In the strictest sense and from a laboratory prospective, chemical compatibility, as the term applies to this industry, would imply that the chemical has no effect on the liner. On the other hand, from an engineering prospective, chemical compatibility means that a liner will survive the exposure to a given chemical even though the chemical could have some effect on the performance of the liner, but not enough to cause failure. Therefore, one must understand and define chemical compatibility for a specific project.

Generally polyethylene will be effected by chemicals in one of three ways.

1. No effect—This means that the chemical in question and the polyethylene do not interact. The polyethylene does not gain (lose) weight, swell, and the physical properties are not significantly altered.
2. Oxidizes (cross linking)—Chemicals classed as oxidizing agents will cause the polyethylene molecules to cross link and cause irreversible changes to the physical properties of the liner. Basically it makes the liner brittle.
3. Plasticizes—Chemicals in this classification are soluble in the polyethylene structure. They do not change the structure of the polyethylene itself but will act as a plasticizer. In doing so, the liner will experience weight gain of 3-15%, may swell by up to 10%, and will have measurable changes in physical properties (i.e. the tensile strength at yield may decrease by up to 20%). Even under these conditions the liner will maintain its integrity and will not be breached by liquids, provided the liner has not been subjected to any stress. These effects are reversible once the chemicals are removed and the liner has time to dry out.

Aside from the effect that chemicals have on a liner is the issue of vapor permeation through the liner. Vapor permeation is molecular diffusion of chemicals through the liner. Vapor transmission for a given chemical is dependent primarily on liner type, contact time, chemical solubility, temperature, thickness, and concentration gradient, but not on hydraulic head or pressure. Transmission through the liner can occur in as little as 1-2 days. Normally, a small amount of chemical is transmitted. Generally HDPE has the lowest permeation rate of the liners that are commercially available.

As stated above chemical compatibility is a relative term. For example, the use of HDPE as a primary containment of chlorinated hydrocarbons at a concentration of 100% may not be recommended, but it may be acceptable at 0.1% concentration for a limited time period or may be acceptable for secondary containment. Factors that go into assessment of chemical compatibility are type of chemical(s), concentration, temperature and the type of application. No hard and fast rules are available to make decisions on chemical compatibility. Even the EPA 9090 test is just a method to generate data so that an opinion on chemical compatibility can be more reliably reached.

A simplified table on chemical resistance is provided to act as a screening process for chemical containment applications.

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CHEMICAL RESISTANCE INFORMATION

CHEMICAL CLASS	CHEMICAL EFFECT	PRIMARY CONTAINMENT (LONG TERM CONTACT) HDPE	PRIMARY CONTAINMENT (LONG TERM CONTACT) LLDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) HDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) LLDPE
CARBOXYLIC ACID	1				
- Unsubstituted (e.g. Acetic acid)		B	C	A	C
- Substituted (e.g. Lactic acid)		A	B	A	A
- Aromatic (e.g. Benzoic acid)		A	B	A	A
ALDEHYDES	3				
- Aliphatic (e.g. Acetaldehyde)		B	C	B	C
- Hetrocyclic (e.g. Furfural)		C	C	B	C
AMINE	3				
- Primary (e.g. Ethylamine)		B	C	B	C
- Secondary (e.g. Diethylamine)		C	C	B	C
- Aromatic (e.g. Aniline)		B	C	B	C
CYANIDES (e.g. Sodium Cyanide)	1	A	A	A	A
ESTER (e.g. Ethyl acetate)	3	B	C	B	C
ETHER (e.g. Ethyl ether)		C	C	B	C
HYDROCARBONS	3				
- Aliphatic (e.g. Hexane)		C	C	B	C
- Aromatic (e.g. Benzene)		C	C	B	C
- Mixed (e.g. Crude oil)		C	C	B	C
HALOGENATED HYDROCARBONS	3				
- Aliphatic (e.g. Dichloroethane) +A4		C	C	B	C
- Aromatic (e.g. Chlorobenzene)		C	C	B	C
ALCOHOLS	1				
- Aliphatic (e.g. Ethyl alcohol)		A	A	A	A
- Aromatic (e.g. Phenol)		A	C	A	B
INORGANIC ACID					
- Non-Oxidizers (e.g. Hydrocloric acid)	1	A	A	A	A
- Oxidizers (e.g. Nitric Acid)	2	C	C	B	C
INORGANIC BASES (e.g. Sodium hydroxide)	1	A	A	A	A
SALTS (e.g. Calcium chloride)	1	A	A	A	A
METALS (e.g. Cadmium)	1	A	A	A	A
KETONES (e.g. Methyl ethyl ketone)	3	C	C	B	C
OXIDIZERS (e.g. Hydrogen Peroxide)	2	C	C	C	C

Chemical effect (see discussion on Chemical Resistance)

1. No Effect–Most chemicals of this class have no or minor effect.

2. Oxidizer--Chemicals of this class will cause irreversible degradaton.
3. Plasticizer--Chemicals of this class will cause a reversible change in physical properties.

Chart Rating

A. Most chemicals of this class have little or no effect on the liner.
Recommended regardless of concentration or temperature (below 150° F).

B. Chemicals of this class will effect the liner to various degrees.
Recommendations are based on the specific chemical, concentration and temperature.
Consult with Poly-Flex, Inc.

C. Chemicals of this class at high concentrations will have significant effect on the physical properties of the liner.
Generally not recommended but may be acceptable at low concentrations and with special design considerations.
Consult with Poly-Flex, Inc.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. PolyFlex, Inc. assumes no responsibility in connection with the use of this data. Consult with PolyFlex, Inc. for specific chemical resistance information and liner selection.

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ATTACHMENT 2

CHEMICAL COMPATABILITY TABLE
FOR NON AQUEOUS PHASE LIQUIDS
(Source: EPA Groundwater Issue, EPA/540/S-95/503, July 1995)

CHEMICAL COMPATIBILITY TABLE

For All Non- Metals

R = Resistant
A = Excellent - No effect
B = Good - Minor effect
C = Fair - Moderate effect
U = Unsatisfactory
X = Conflicting Data
- = No Data Available

For Metals

E < 2 mils Penetration/Year
G < 20 mils Penetration/Year
S < 50 mils Penetration/Year
U > 50 mils Penetration/Year
(1 mil = .001 inch)
A = Excellent - No effect*
B = Good - Minor effect*
C = Fair - Moderate effect*
* No corrision rate reported

	Plastics											Elastopolymers										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Acetaldehyde	U	A	U	R	U	U	A	A	U	U	X	A	A	C	U	U	A	U	U	-	R	E	E	G	E	G	U	U
Acetamide	-	A	-	R	R	R	A	A	U	-	C	A	A	B	A	U	B	U	B	-	-	G	G	-	-	G	-	-
Acetate Solvent	U	-	U	R	R	R	B	A	U	U	A	A	A	C	U	-	A	U	U	-	-	E	E	G	E	E	S	G
Acetic Acid 10%	X	X	C	R	U	R	B	A	U	-	C	A	A	C	C	-	C	U	R	A	R	E	E	U	E	G	U	G
Acetic Acid, Glacial	U	U	U	R	U	R	A	A	U	U	B	U	A	X	X	U	B	U	U	A	R	E	E	U	E	E	U	U
Acetone	U	A	U	R	R	R	A	A	U	U	U	A	A	U	U	U	B	U	U	A	R	E	E	G	E	E	G	E
Acetonitrile	U	-	-	R	R	-	R	R	-	-	R	R	-	-	-	-	-	-	-	-	-	G	G	G	-	E	G	G
Acetophenone	U	-	-	R	R	U	R	R	U	U	R	R	-	U	U	-	-	-	U	-	-	G	G	G	G	G	G	G
Acetyl Chloride	U	-	U	R	U	U	U	A	U	U	R	U	-	U	U	U	-	-	R	-	R	G	G	G	-	U	U	U
Acetylene	R	-	R	R	R	-	R	R	R	R	R	R	-	R	R	-	-	-	R	-	-	E	E	G	G	E	U	U
Acrylonitrile	U	-	X	R	R	R	A	A	X	U	A	X	-	C	U	-	U	-	U	-	-	G	G	G	G	E	G	G
Adipic Acid	R	-	A	R	-	R	B	A	R	R	A	A	A	B	X	-	U	-	X	-	-	G	G	G	E	G	-	G
Aldrin (1 oz/gal)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	G	-	E	-	-
Allyl Alcohol	U	-	R	R	R	R	R	R	R	R	R	R	-	R	R	-	-	-	R	-	-	E	E	G	G	G	G	E
Allyl Chloride	U	-	U	R	-	R	R	R	U	U	R	U	-	U	U	-	-	-	-	-	R	G	E	U	-	U	-	-
Ammonium Acetate	-	-	A	R	A	-	A	A	R	R	R	A	-	A	B	-	-	A	A	-	-	G	G	-	-	G	U	U
Ammonium Oxalate 10%	-	-	-	R	-	-	R	R	R	-	-	R	-	-	-	-	-	-	-	-	-	G	G	U	E	E	-	U
Amyl Acetate	U	B	U	R	R	R	X	A	U	U	A	A	A	U	U	U	U	U	U	A	R	E	E	G	E	E	E	G
Amyl Alcohol	R	A	A	R	A	R	B	A	R	U	A	A	A	A	B	U	U	A	B	A	R	G	G	G	G	G	G	G
Amyl Chloride	U	-	U	R	U	U	U	R	U	U	U	R	-	U	U	-	-	-	R	-	-	G	G	U	E	U	G	G
Aniline	U	A	X	R	X	R	X	A	U	U	A	X	A	U	U	U	U	C	B	A	R	E	E	G	G	G	U	U
Aniline Hydrochloride	U	-	U	R	U	U	X	A	X	U	A	B	-	U	U	-	U	U	A	-	R	U	U	U	U	U	U	G
Antifreeze	B	U	A	-	U	-	U	-	A	-	-	A	-	C	A	-	C	B	A	-	-	-	A	-	-	A	-	-
Aroclor 1248	-	-	-	R	A	U	U	A	-	-	-	B	A	U	X	-	B	-	A	-	-	G	G	G	E	E	E	E
Asphalt	-	B	X	R	A	R	B	A	A	-	A	U	A	U	X	-	U	-	A	-	-	G	G	G	-	E	E	E
Benzaldehyde	X	A	U	R	A	U	X	A	U	U	A	A	A	U	U	U	U	U	U	A	R	G	G	U	G	G	G	G
Benzene	U	A	U	R	A	U	X	A	U	U	A	U	B	U	U	U	U	C	A	A	R	G	G	G	G	E	G	G
Benzo Sulfonic Acid 10%	R	-	R	R	U	R	R	R	R	R	R	U	-	R	U	U	-	-	R	-	R	G	G	U	G	U	G	-
Benzyl Alcohol	U	A	X	R	B	U	A	A	U	U	A	B	A	X	X	U	-	U	A	A	R	E	E	G	G	G	G	E
Benzoic Acid	R	B	A	R	X	B	R	A	R	R	A	U	A	B	U	U	B	A	A	A	R	G	G	U	E	G	G	G
Benzol	U	A	U	R	X	U	U	A	U	U	A	U	A	U	U	U	U	C	A	A	R	G	G	G	G	E	G	G
Benzonitrile	-	-	-	R	R	A	-	A	-	-	-	-	A	-	-	-	A	-	-	-	-	U	U	-	C	-	-	-
Benzyl Chloride	U	A	U	R	R	-	C	R	R	-	R	U	-	U	U	-	U	-	A	-	-	G	G	U	-	U	U	U
Bromobenzene	-	-	-	R	-	-	U	R	-	-	R	U	-	U	U	-	-	-	R	-	-	-	-	-	-	-	-	-
Butadiene	U	A	A	R	R	U	U	A	R	U	A	X	A	B	X	U	U	-	B	-	-	G	G	G	G	G	G	G
Butane	B	A	C	R	R	U	U	A	R	R	A	U	A	A	A	R	U	C	A	-	-	G	G	E	G	G	G	G
Butyl Alcohol	U	A	A	R	B	B	R	A	R	U	A	A	A	A	X	-	B	B	A	-	R	E	E	G	G	E	G	G
n-Butyl Amine	-	X	U	R	R	U	U	A	U	U	X	-	U	U	R	-	B	U	U	-	-	-	G	G	G	G	-	-
Butyl Ether	-	U	U	R	A	-	-	A	R	-	A	U	A	U	B	-	U	A	U	-	-	-	E	E	-	E	-	-
Butyl Phenol	U	-	U	R	-	-	U	R	U	U	R	-	-	U	-	-	-	-	U	-	-	G	E	-	G	G	-	-
Butyl Phthalate	-	-	U	R	R	-	R	R	R	-	R	B	A	D	U	-	A	-	C	-	-	G	G	-	G	U	G	G

	Plastics											Elastopolymers										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Butylacetate	U	A	X	R	A	R	X	A	U	U	B	B	A	X	U	-	U	U	U	-	R	G	G	G	G	E	G	G
Butyric Acid	U	A	U	R	U	U	R	R	U	U	A	B	A	U	U	-	U	U	B	-	R	G	G	U	E	G	G	G
Carbon Tetrachloride	U	B	U	R	X	U	U	R	U	U	R	U	A	U	U	U	U	B	A	A	R	E	E	G	E	U	G	E
Carbonic Acid	R	B	A	R	R	R	A	A	R	R	A	B	A	X	X	R	A	-	A	A	-	G	G	G	E	E	G	G
Chloroacetic Acid	U	U	U	R	U	U	C	A	R	R	A	B	A	U	U	U	U	A	U	-	-	U	U	U	E	U	U	U
Chlorobenzene	U	X	U	R	R	U	U	B	U	U	A	U	A	U	U	-	U	A	A	A	R	G	G	G	E	G	G	G
Chlorobromomethane	-	-	-	-	C	-	A	A	U	-	-	B	-	U	U	-	U	-	A	A	-	-	-	-	-	-	B	-
Chlordane (1/4 lb/gal)	U	-	-	-	-	-	-	R	-	-	-	U	-	C	B	-	U	-	A	-	-	G	G	G	-	-	-	-
Chloroethane	U	A	U	R	R	R	X	A	U	U	A	X	A	U	U	-	U	-	B	-	-	G	G	G	-	-	-	G
Chloroform	U	A	U	R	R	U	X	A	U	U	A	U	B	U	U	U	U	B	A	A	R	E	E	U	G	G	G	G
Chloronaphthalene	U	-	-	-	-	-	-	-	R	-	-	-	-	U	U	-	-	-	-	-	-	-	G	-	E	U	-	-
Chlorophenol 5% (aq.)	-	R	U	R	U	-	-	R	U	U	R	-	-	-	-	-	-	-	-	-	-	G	G	S	E	-	-	-
Citric Acid	U	B	B	R	R	A	A	A	R	-	A	A	A	A	A	-	A	-	A	A	R	E	E	U	E	E	-	E
Cresol	U	U	U	R	U	U	U	R	X	U	R	U	A	U	U	U	U	U	X	-	R	E	G	G	G	G	-	-
Cresylic Acid 50%	U	U	U	R	U	R	X	R	R	R	R	X	-	U	U	U	U	-	A	-	-	G	G	G	G	G	-	-
Crude Oil	R	R	R	R	R	U	R	U	U	U	U	U	-	U	R	R	-	-	R	-	-	E	E	G	E	E	G	G
Cyclohexane	R	A	U	R	R	R	U	A	X	-	R	U	A	U	B	R	U	U	A	-	-	G	G	G	G	G	G	G
Cyclohexanone	U	A	U	R	R	U	U	A	U	U	R	B	U	U	U	-	U	U	U	A	-	G	G	U	G	G	G	G
DDT 5%	-	-	U	-	-	-	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	E	E	G	-	E	-	-
Detergents (general)	B	A	A	R	R	R	A	A	R	R	A	A	A	B	A	-	A	A	A	A	-	E	G	G	E	G	G	E
Diacetone Alcohol	-	A	U	R	R	R	R	A	R	-	A	A	B	U	U	-	U	B	U	-	-	G	G	G	E	E	E	E
Dibutyl Phthalate	U	-	U	R	R	U	R	R	U	U	U	R	-	U	U	U	-	-	U	-	-	G	G	G	G	G	G	G
Dichlorobenzene	U	-	U	R	X	U	C	A	U	U	A	U	-	U	U	-	U	-	C	-	-	-	G	-	E	G	-	-
Dichloroethane	U	A	U	R	R	R	X	A	U	U	A	U	A	U	U	-	-	U	C	A	R	G	G	G	G	G	G	-
Dichloroethylene	U	-	-	R	R	-	R	R	U	U	R	U	-	U	U	-	-	-	R	-	-	G	G	-	G	G	-	-
Dichlorofluoromethane	-	-	-	R	-	-	-	R	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diesel Fuel	-	A	A	R	R	R	A	A	R	-	A	U	A	B	A	-	U	-	A	-	-	E	E	G	G	E	E	-
Diethanolamine	-	-	-	R	R	-	R	R	U	U	U	-	-	R	-	-	-	-	-	-	-	E	E	E	E	E	-	G
Diethyl Amine	U	B	U	R	R	U	A	X	U	-	X	B	A	A	C	-	B	C	A	-	-	G	G	U	-	G	-	-
Diethyl Ether	U	R	U	R	R	U	R	A	U	U	R	U	C	U	U	-	U	-	U	-	-	G	G	G	G	G	G	G
Diethyl Phthalate	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diethylene Glycol	B	A	A	R	R	R	A	A	X	-	A	A	-	A	A	-	B	C	A	-	-	E	E	E	G	G	-	G
Dimethyl Aniline	U	U	U	R	R	-	X	A	U	U	A	B	A	U	U	-	U	U	U	-	-	B	B	-	B	A	-	-
Dimethyl Ether	-	-	-	R	-	-	-	R	-	-	-	-	-	U	R	-	-	-	-	-	-	G	G	-	G	-	G	G
Dimethyl Formamide	U	X	U	R	R	R	A	X	U	U	U	X	A	X	U	-	C	U	X	-	-	-	G	U	-	E	-	-
Dimethyl Phthalate	U	-	-	R	R	-	R	R	U	U	R	-	-	U	U	-	-	-	R	-	-	E	E	E	-	E	-	-
Dimethyl Sulfoxide	-	R	U	R	R	R	R	R	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene	-	-	-	-	-	-	-	R	-	-	-	U	-	U	U	-	U	-	X	-	-	G	G	-	-	-	-	-
Dioctyl Phthalate	U	-	U	R	R	U	U	R	U	U	R	R	-	U	U	U	-	-	R	-	-	G	G	G	-	E	-	-
Dioxane	U	R	-	R	R	U	R	R	U	-	U	U	-	U	U	-	-	-	U	-	-	G	G	G	G	G	G	G
Diphenyl	-	-	-	R	R	-	U	A	U	-	-	U	-	B	U	R	U	-	A	-	-	G	G	G	G	G	G	G
Diphenyl Oxide	-	U	-	-	-	-	U	A	U	-	B	U	-	U	A	-	C	U	A	-	-	B	A	-	B	B	-	A
Esters (general)	-	-	U	R	R	-	-	R	U	U	R	-	-	-	-	-	-	-	-	-	-	-	G	-	-	-	-	-
Ethane	-	A	A	-	U	-	U	A	A	-	A	U	-	B	A	-	U	A	A	-	-	A	A	-	-	-	-	A
Ethanolamine	-	U	U	R	R	-	X	A	U	-	X	B	U	B	B	-	B	-	U	A	-	E	E	G	G	G	-	-
Ethers (general)	U	A	U	-	R	U	U	A	U	U	R	C	B	U	X	-	U	C	X	-	R	E	E	G	G	G	G	G
Ethyl Acetate	U	A	U	R	R	R	A	A	U	U	X	B	A	U	U	U	B	U	U	A	R	G	G	G	G	-	G	G
Ethyl Alcohol	B	A	B	R	R	R	A	A	R	R	R	A	B	A	C	U	B	C	A	A	R	G	G	G	E	E	G	G
Ethyl Benzene	-	R	-	R	-	U	U	R	U	U	R	U	-	U	U	-	-	-	R	-	-	S	G	U	E	G	-	-
Ethyl Benzoate	U	-	U	-	-	U	B	A	U	-	U	-	-	U	U	-	U	U	A	-	-	-	-	-	-	-	-	-
Ethyl Chloride	U	R	U	R	R	U	U	R	U	U	R	R	-	U	R	U	-	-	B	-	R	E	E	G	G	-	-	G
Ethyl Ether	U	A	U	R	R	U	U	A	U	U	R	U	A	U	X	U	U	-	U	-	R	G	G	G	G	G	G	G

	Plastics											Elastopolymers										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Ethyl Sulfate	-	-	-	-	-	-	-	A	-	-	-	-	A	-	A	-	-	-	A	-	-	U	U	-	-	-	-	B
Ethylene Bromide	U	-	U	R	R	U	U	A	U	U	A	X	B	X	U	-	U	U	A	-	-	E	E	-	E	-	-	-
Ethylene Chloride	U	A	U	R	R	R	X	A	U	U	A	X	A	U	U	-	U	-	B	-	-	G	G	G	-	-	-	G
Ethylene Chlorohydrin	U	U	U	R	U	U	X	A	U	U	A	B	-	X	U	U	C	U	A	-	-	G	G	G	G	G	G	G
Ethylene Diamine	U	X	U	R	U	-	R	A	U	U	B	A	U	X	A	-	A	-	B	-	-	G	G	G	U	G	U	U
Ethylene Dibromide	-	-	-	R	-	-	R	R	-	-	R	-	-	-	-	-	-	-	-	-	-	-	G	-	G	-	G	-
Ethylene Glycol	A	B	A	R	R	R	A	A	R	R	A	A	A	A	A	R	A	B	R	A	-	G	G	G	E	E	G	G
Ethylene Oxide	U	U	X	R	R	R	U	A	U	U	A	X	C	U	U	U	U	-	U	-	R	G	G	G	E	E	U	-
Formaldehyde 100%	B	A	A	-	U	-	C	A	A	-	A	A	A	C	C	-	B	B	U	-	-	C	A	-	A	A	-	A
Formaldehyde 37%	A	A	A	R	R	R	A	A	R	R	A	A	A	B	X	U	-	-	R	-	R	E	E	U	G	G	E	G
Formic Acid 5%	-	U	R	R	U	R	R	R	R	-	R	R	-	R	U	-	-	-	R	-	-	G	E	-	E	U	S	E
Fuel oils	U	A	-	R	R	R	A	B	R	R	B	U	A	B	X	R	U	A	A	-	-	G	G	G	G	G	G	G
Gasoline (high-aromatic)	U	B	A	-	-	-	A	B	A	-	A	U	A	A	A	-	U	A	A	A	-	A	A	-	A	U	-	-
Gasoline (leaded)	U	A	U	R	R	U	X	A	R	-	A	U	A	B	A	R	U	C	A	A	-	G	G	G	E	G	G	G
Gasoline (unleaded)	U	A	X	R	R	U	X	A	R	-	A	U	A	B	A	R	U	C	A	-	-	G	G	G	E	G	G	G
Glycolic Acid	B	A	A	R	-	R	A	A	R	R	B	A	B	A	A	-	A	A	A	-	-	G	G	U	G	G	-	-
Heptane	X	A	A	R	R	R	C	A	R	R	A	U	A	B	A	U	U	B	A	-	-	G	G	G	E	G	G	G
Hexachloroethane	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	G	G	-	G	G	S	G
Hexamine	-	-	-	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	E	E	-	E	E	G	-
Hexane	U	A	B	R	R	U	B	A	R	R	A	U	A	B	A	R	U	U	A	-	-	E	E	G	E	G	G	-
Hexyl Alcohol	-	A	-	-	A	-	-	A	A	-	-	C	-	A	A	-	B	A	C	-	-	A	A	-	A	A	-	-
Hydraulic Oil (petro.)	-	B	-	-	A	-	U	A	A	-	A	U	-	A	A	-	B	A	A	-	-	A	A	-	A	A	A	A
Hydraulic Oil (synthetic)	-	-	-	-	A	-	U	A	A	-	A	A	-	A	U	-	B	A	A	-	-	A	A	-	A	A	A	A
Hydrazine	-	B	U	-	-	U	C	C	-	-	A	A	-	B	B	-	B	-	A	-	-	A	A	-	-	-	-	A
Hydrogen Peroxide (dilute)	R	R	U	R	R	R	R	R	R	-	R	R	-	U	R	-	-	-	R	-	-	G	G	U	E	E	U	U
Hydroquinone	X	A	A	R	U	-	A	A	R	R	R	U	-	A	X	-	-	-	B	-	-	G	G	G	G	G	G	-
Hydroxyacetic Acid 70%	-	A	A	-	-	-	-	A	U	-	A	A	-	A	A	-	-	-	A	-	-	-	-	-	-	-	-	-
Iodoform	-	-	-	R	-	-	R	C	-	-	C	A	-	A	U	-	-	C	R	-	R	E	E	U	U	G	-	G
Isobutyl Alcohol	B	A	-	-	A	-	A	A	A	-	-	A	-	A	B	-	A	A	A	-	-	-	-	-	-	-	-	-
Isooctane	-	-	-	-	A	B	A	A	A	-	A	U	A	B	A	-	U	A	A	-	-	A	A	-	-	A	A	-
Isopropyl Acetate	U	U	U	R	R	R	B	A	U	U	X	B	-	U	U	-	U	-	U	-	-	E	G	E	G	G	-	-
Isopropyl Alcohol	R	A	C	R	U	R	A	A	R	R	R	A	-	B	B	U	A	A	A	A	-	G	G	G	G	G	G	G
Isopropyl Ether	-	U	R	R	R	-	X	A	R	R	X	U	A	U	B	R	U	A	U	-	-	E	G	-	-	-	G	G
Isotane	-	-	-	-	U	-	U	-	A	-	A	-	-	U	A	-	-	-	-	A	-	-	-	-	-	U	-	-
Jet Fuel JP-4, JP-5	-	A	R	R	R	-	A	A	R	R	A	U	A	U	A	U	U	A	A	-	-	G	G	G	E	G	E	-
Kerosene	X	A	R	R	R	R	R	A	R	R	A	U	A	A	A	U	U	U	A	A	-	G	G	G	G	G	G	G
Lacquer thinners	A	U	-	-	A	-	U	A	U	-	-	U	-	U	U	-	U	U	U	-	-	-	G	-	-	G	-	-
Lacquers	A	U	-	-	A	-	U	A	U	-	U	U	-	U	U	-	U	A	U	-	-	E	E	-	-	-	-	-
Lactic Acid	U	B	A	R	R	-	B	A	R	R	B	A	A	A	X	-	A	A	A	A	-	G	G	U	G	G	G	G
Lead Acetate	B	B	A	R	R	R	A	A	R	R	A	A	A	A	B	-	A	B	U	A	-	G	G	U	G	U	U	G
Linoleic Acid	A	B	A	R	U	U	B	A	R	R	A	U	-	U	B	-	B	A	B	-	-	G	G	U	G	G	U	U
Maleic Acid	R	A	A	R	X	R	R	A	R	R	A	X	-	U	U	-	-	C	A	-	R	G	G	U	G	-	G	-
Malic Acid	R	A	R	R	X	R	A	A	R	R	A	U	-	X	A	-	B	A	A	-	-	E	E	U	G	G	-	U
Melamine	-	A	A	-	A	-	A	A	U	-	-	A	-	U	C	-	C	U	A	-	-	-	U	-	-	-	-	-
Methane	-	A	-	R	R	-	A	A	R	R	A	X	-	B	A	-	U	-	A	-	-	E	E	G	E	E	E	G
Methyl Acetate	U	X	U	R	R	R	X	A	U	U	B	X	A	X	U	-	U	A	U	-	-	G	G	S	E	G	-	-
Methyl Acetone	-	U	-	-	A	-	-	A	U	-	U	A	-	U	U	-	-	A	U	-	-	A	A	-	-	A	A	-
Methyl Acylate	-	B	-	-	-	-	U	-	-	-	B	B	-	B	U	-	U	-	U	-	-	A	-	-	-	-	-	-
Methyl Alcohol	U	A	A	R	R	R	A	A	R	R	A	A	A	A	A	U	A	A	U	A	R	G	G	G	E	G	G	G
Methyl Alcohol 10%	U	A	A	-	B	B	A	A	-	-	A	A	A	A	A	-	A	A	A	A	-	-	-	-	-	-	-	-
Methyl Amide	U	U	-	-	-	-	A	A	U	-	C	A	A	-	B	-	-	U	U	-	-	A	A	-	-	A	U*	-
Methyl Bromide	U	U	U	R	U	R	X	A	U	U	A	U	-	U	B	-	-	-	A	-	-	G	G	G	-	U	-	-
Methyl Butyl Ketone	-	U	-	-	U	U	U	-	-	-	U	A	-	U	U	-	U	-	U	-	-	A	A	-	-	-	-	-

	Plastics											Elastopolymers										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Methyl Chloride	U	B	U	R	R	U	U	A	U	U	A	U	A	U	U	U	U	U	A	-	-	E	E	U	G	U	E	G
Methyl Chloroform	U	-	U	R	-	-	U	R	U	U	R	U	-	U	U	-	-	-	R	-	-	-	-	-	-	-	-	-
Methyl Dichloride	-	U	-	-	C	-	U	-	-	-	U	U	-	-	U	-	-	-	A	-	-	-	-	-	-	-	-	-
Methyl Ethyl Ketone	U	U	U	R	R	U	B	A	U	U	U	A	A	U	U	U	U	U	U	A	-	G	G	G	G	G	G	G
Methyl Isopropyl Ketone	-	-	-	-	A	-	-	A	U	-	-	C	-	U	U	-	C	-	U	-	-	A	A	-	-	A	-	A
Methyl Methacrylate	-	U	R	R	-	-	X	R	R	U	B	U	-	U	U	-	C	-	U	-	-	G	G	U	-	G	-	-
Methyl Pentanone	U	-	U	R	R	R	R	A	U	U	X	B	A	U	U	-	U	-	U	-	-	G	G	G	G	G	G	G
Methylene Chloride	U	B	U	R	U	U	B	A	U	U	B	X	A	U	U	U	-	U	B	-	R	G	G	G	E	E	G	G
Monochloroacetic acid U*	-	U	-	-	U	U	-	A	-	-	B	C	B	A	U	-	-	-	C	-	-	A	A	-	A	U*	B	
Monoethanolamine	-	U	-	R	R	-	B	A	U	U	U	B	-	X	B	-	B	-	X	-	-	E	E	G	G	G	G	G
Motor Oil	C	B	A	R	R	U	U	A	R	R	B	U	A	B	A	-	-	A	R	A	-	G	G	G	-	-	G	G
Napthalene	U	X	U	R	R	U	R	A	U	U	A	U	A	U	U	R	U	C	A	A	-	E	E	G	G	G	G	G
Nitrobenzene	U	X	U	R	R	U	B	A	U	U	A	U	A	U	U	U	U	U	B	-	R	G	G	G	G	E	G	G
Nitromethane	U	A	U	R	U	-	R	A	R	R	A	B	A	U	U	-	U	B	U	-	-	G	G	G	-	G	-	-
Nitrophenol	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	G	G	-	-	G	-	G
Octane	-	-	-	R	-	R	R	R	U	U	R	U	-	R	R	-	-	-	R	-	-	-	G	G	-	G	G	G
Octyl Alcohol	A	A	B	-	A	-	-	-	-	-	-	B	-	B	B	-	B	-	B	-	-	A	A	-	C	A	-	A
Oleic Acid	X	A	A	R	R	U	B	A	R	R	A	B	B	X	B	R	U	C	B	A	-	E	E	G	G	G	S	G
Oxalic Acid 5%	R	U	R	R	U	R	R	R	R	R	R	R	-	R	U	-	-	-	R	-	-	U	G	U	G	G	S	G
Palmitic Acid 10%	A	A	A	R	R	R	B	A	R	R	A	B	-	U	A	R	U	B	A	-	-	-	G	-	-	G	G	G
Pentachlorophenol	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	E	-	-	-	-
Pentane	-	B	-	-	A	-	U	A	A	-	A	U	-	B	A	-	U	A	A	-	-	C	C	-	A	B	-	-
Petroleum	B	B	A	R	-	U	B	A	R	-	A	U	-	B	A	-	U	-	A	-	-	G	G	-	-	G	G	G
Phenol 10%	U	X	A	R	U	R	B	A	U	U	A	B	B	U	U	U	U	C	A	A	-	G	G	G	G	E	G	G
Phthalic Acid	B	C	X	R	R	-	A	A	U	U	A	A	-	A	U	-	B	-	A	-	-	G	E	S	G	G	G	G
Phthalic Anhydride	B	C	U	R	-	-	U	A	U	-	A	A	-	A	U	-	-	B	A	-	-	E	E	G	E	E	G	-
Picric Acid	X	A	U	R	U	U	A	A	U	U	A	A	-	A	X	-	B	-	A	-	R	G	G	U	G	E	U	U
Propyl Alcohol	X	A	A	R	U	R	A	A	R	R	A	A	A	A	A	-	A	A	A	A	-	E	E	G	E	G	G	G
Propylene	B	-	-	-	-	-	-	A	B	-	-	U	-	U	U	-	U	B	A	-	-	B	A	-	-	A	-	A
Propylene Glycol	B	B	X	R	R	R	A	A	U	U	A	A	-	C	A	-	A	-	A	A	-	G	G	G	G	G	G	G
Propylene Oxide	-	-	-	R	-	R	R	R	U	U	U	R	-	U	U	-	-	-	U	-	-	E	E	-	-	-	-	-
Pyridine	-	B	U	R	R	R	A	A	U	U	U	X	A	U	U	-	U	U	U	A	-	G	G	G	E	G	G	G
Sodium Acetate	B	B	A	R	R	R	A	A	R	R	A	A	A	B	B	-	U	-	U	A	-	G	G	U	G	E	G	G
Sodium Benzoate	A	-	A	R	R	R	A	A	R	R	A	A	-	A	B	-	-	B	A	-	-	-	-	-	G	G	-	E
Sodium Hypochlorite 20%	R	U	R	R	U	R	R	R	R	R	R	R	A	U	U	-	B	C	A	-	U	U	U	U	U	G	G	S
Stearic Acid	U	A	B	R	R	R	A	A	R	R	A	X	-	B	B	R	B	B	A	-	R	G	E	S	E	G	S	G
Styrene	-	A	U	-	A	U	-	A	U	-	-	U	-	U	U	-	U	-	B	-	-	A	A	-	U*	A	A	B
Tartaric Acid	-	B	A	-	B	-	A	A	A	-	B	B	A	A	A	-	A	B	A	A	-	C	C	-	B	B	U*	A
Tetrachloroacetic Acid	R	-	R	R	R	R	R	R	R	R	R	U	-	R	R	R	-	-	R	-	-	E	E	-	G	G	S	U
Tetrachloroethane	-	A	X	R	R	-	C	A	U	U	A	U	A	U	U	-	U	-	A	-	R	E	E	E	E	G	-	S
Tetrachloroethylene	U	A	U	R	R	U	U	A	U	U	R	U	A	U	U	U	U	-	A	-	-	E	E	G	G	G	G	G
Tetrachlorophenol	-	-	-	-	-	-	R	R	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetraethyl Lead	U	-	R	R	-	U	R	R	R	R	R	U	-	-	U	-	-	-	R	-	-	G	G	G	-	G	G	-
Tetrahydrofuran	U	A	U	R	R	U	C	A	U	U	B	U	A	U	U	-	U	-	X	A	-	E	G	E	E	U	-	-
Toluene	U	X	U	R	R	U	C	A	U	U	A	U	B	U	X	U	U	U	C	A	-	E	E	E	E	E	E	E
Toxaphene-Xylene 10-90%	-	-	U	R	-	-	R	R	U	-	-	-	-	-	-	-	-	-	-	-	-	G	G	S	-	S	-	-
Trichloroacetic Acid	-	-	R	R	U	R	A	A	R	-	B	B	A	U	R	-	U	C	C	A	-	U	U	U	G	U	G	G
Trichlorobenzene	-	-	-	-	-	-	-	R	U	-	-	-	-	U	U	U	-	-	R	-	-	-	-	E	-	-	-	-
Trichloroethane	-	A	-	-	-	-	C	A	C	-	A	U	A	U	U	-	U	-	A	-	-	-	-	-	-	-	-	-
Trichloroethylene	U	U	U	R	R	U	C	A	U	U	B	U	A	U	U	U	U	-	X	A	-	G	G	G	E	E	G	G
Trichlorofluoromethane	-	-	-	-	-	-	-	-	U	-	-	-	-	U	U	-	-	-	-	-	-	-	G	-	-	G	-	-
Trichloropropane	U	A	-	-	-	-	-	A	-	-	-	-	A	A	U	-	-	U	A	-	-	A	A	-	A	U*	-	A

	Plastics											Elastopolymers										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Triethanolamine	R	U	R	R	R	U	R	R	U	U	R	R	-	R	U	U	-	-	R	-	-	G	G	G	G	G	U	E
Triethylamine	U	U	A	R	R	-	U	A	R	R	A	A	A	A	C	-	-	A	X	B	-	G	G	-	-	-	-	-
Trimethylpropane	U	-	R	R	-	-	U	R	R	R	R	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-
Turpentine	U	A	A	R	R	U	X	A	X	U	A	U	A	U	R	U	U	B	A	A	-	E	E	G	G	G	S	G
Vinyl Acetate	U	-	U	R	-	U	B	A	U	U	A	B	-	X	X	-	U	U	A	B	-	E	E	G	E	E	G	-
Vinyl Chloride	U	-	U	-	A	-	-	A	U	-	B	C	-	U	U	-	-	U	A	A	-	B	A	-	A	B	-	B
White liquor (Pulp mill)	X	U	R	R	R	-	R	R	R	R	R	R	-	R	R	-	-	-	R	-	-	G	G	S	G	G	-	-
White Water (Paper mill)	R	B	-	-	R	-	R	-	R	-	-	-	-	A	-	-	-	-	A	-	-	A	A	-	-	-	-	-
Xylene	U	A	U	R	R	U	B	A	U	U	A	U	A	U	U	U	U	U	X	A	-	G	G	G	E	G	G	G

This table should only be used as a guide since it is difficult to duplicate operating conditions. To fully guarantee the suitability of a particular material, chemical resistance tests should be conducted under actual operating conditions.

No data was found on the following environmentally important chemicals:

Acenaphthene [1]
Acenapthalene [1]
Acrolein
Anthracene [1]
Benzidine
Benzo(a)athracene [1]
Benzo(b)fluoranthene [1]
Benzo(g,h,i)perylene [1]
Benzo(a)pyrene [1]
Bromophenylphenylether
Butylbenzylphthalate
Chlorodibromomethane
Chloroethoxymethane
Chloroethylether
Chloroethylvinylether
Chloroisopropylether
Chloromethylether
Chlorophenylphenylether
Chrysene [1]
DDD [2]
DDE [2]
Dichlorobenzidine
Dichlorobromomethane
Dichlorophenol
Dichlorophenoxyacetic acid
Dichloropropane
Dichloropropylene
Dieldrin [2]
Dinitrophenol
Diphenylhydrazine
Endosulfan
Endrin [2]
Fluoranthene [1]
Fluorene [1]
Heptachlor [2]
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclohexane
Indeno(1,2,3-c,d)pyrene [1]
Isophorone
2-Methylnapthalene
Parachlorometa cresol
Phenanthrene [1]
Phenylenepyrene
Pyrene [1]
Trichlorophenol
Trichlorophenoxyacetic acid

[1] *Component of cresotoe and coal tar. At room temperature and below, these compounds are solid in pure form.*
[2] *Pesticides*

ATTACHMENT 3

LINER COMPATABILITY TESTING CONDUCTED BY THE DEPARTMENT OF ENERGY

Department of Energy
Idaho Operations Office
1955 Fremont Avenue
Idaho Falls, ID 83401

April 26, 2005

Nicholas Ceto, INEEL Project Manager
EPA Region 10
309 Bradley Landing, Suite 115
Richland, WA 99352

Daryl F. Koch, Remediation Manager
Waste and Remediation Division
Idaho Department of Environmental Quality
1410 North Hilton
Boise, Idaho 83706-1255

SUBJECT: Transmittal of Request to Change the Existing PM-2A V-14 Staging Area to Temporary Unit and Proposed New Constituents for ICDF Landfill and Evaporation Pond Waste Acceptance Criteria (FMDP-RFDP-05-024)

Dear Mr. Ceto and Mr. Koch:

This letter transmits a request for a change in designation for the existing PM-2A V-14 tank storage area and also the proposed new constituents for addition to the ICDF Complex Waste Acceptance Criteria.

The first attachment is a request for a change in designation of the existing PM-2A V-14 tank storage area near the INL CERCLA Disposal Facility (ICDF) evaporation ponds from a staging area to a temporary unit. The attached drawing identifies the area for change just north of the evaporation ponds. This is needed to allow treatment of the contents of this tank prior to final disposal into the ICDF landfill. Upon your review and concurrence the Staging Area designation will be changed.

The second attachment includes the proposed new constituents for addition to the ICDF Complex Waste Acceptance Criteria (WAC). The new constituents were identified in the semiannual data call submitted by all the Waste Area Groups (WAGs). Upon your review and approval the new constituents will be updated into the respective WACs.

If you have questions regarding either attachments, please contact me at 208-526-7001 or verwolmc@id.doe.gov.

Sincerely,

Mary C. Verwolf

Mary C. Verwolf
ICDF Project Manager
Environmental Restoration Program

Enclosures

cc: M. Spomer, Idaho Department of Environmental Quality, 1410 N. Hilton, Boise, ID 83706
D. Einan, EPA Region X, 309 Bradley Landing, Suite 115, Richland, WA 99352

UFC: 6102.RFDP.313
FMDP-RFDP-05-024

EXTERNAL bcc DISTRIBUTION:
ARDC, BBWI, MS3922, w/o enc.
Jack Simonds, MS 3950, w/o enc.
M. Heileson, MS 3950, w/o enc.

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M. Verwolf, MS 4149, w/ enc.
K. Hain, MS 1222, w/o enc.
A. Kraupp, MS 1226, w/o enc.

CONCURRENCE:
EM_____

RECORD NOTES:

1. This letter transmitted the Request to Change the Existing PM-2A V-14 Staging Area to Treatment Unit and Proposed New Constituents for ICDF Complex to EPA and IDEQ.

2. This letter was written by Mary C Verwolf

3. This letter/memo closes OATS number N/A

4. The attached correspondence has no relation to the Naval Nuclear Propulsion Program.

[Author] [Acronym for the AM/DIR] Mary C Verwolf, 6-7001, April 26, 2005, O:\NE-ID\EM-ICP\FMDP\RFDP\RFDP letters 2005\FMDP-RFDP-05-024.doc

40 CFR 264.553 (C) In establishing standards to be applied to a temporary unit, the Regional Administrator shall consider the following factors:

(1) Length of time such unit will be in operation; *January to September 30, 2005*

(2) Type of unit; *CERCLA storage and treatment*

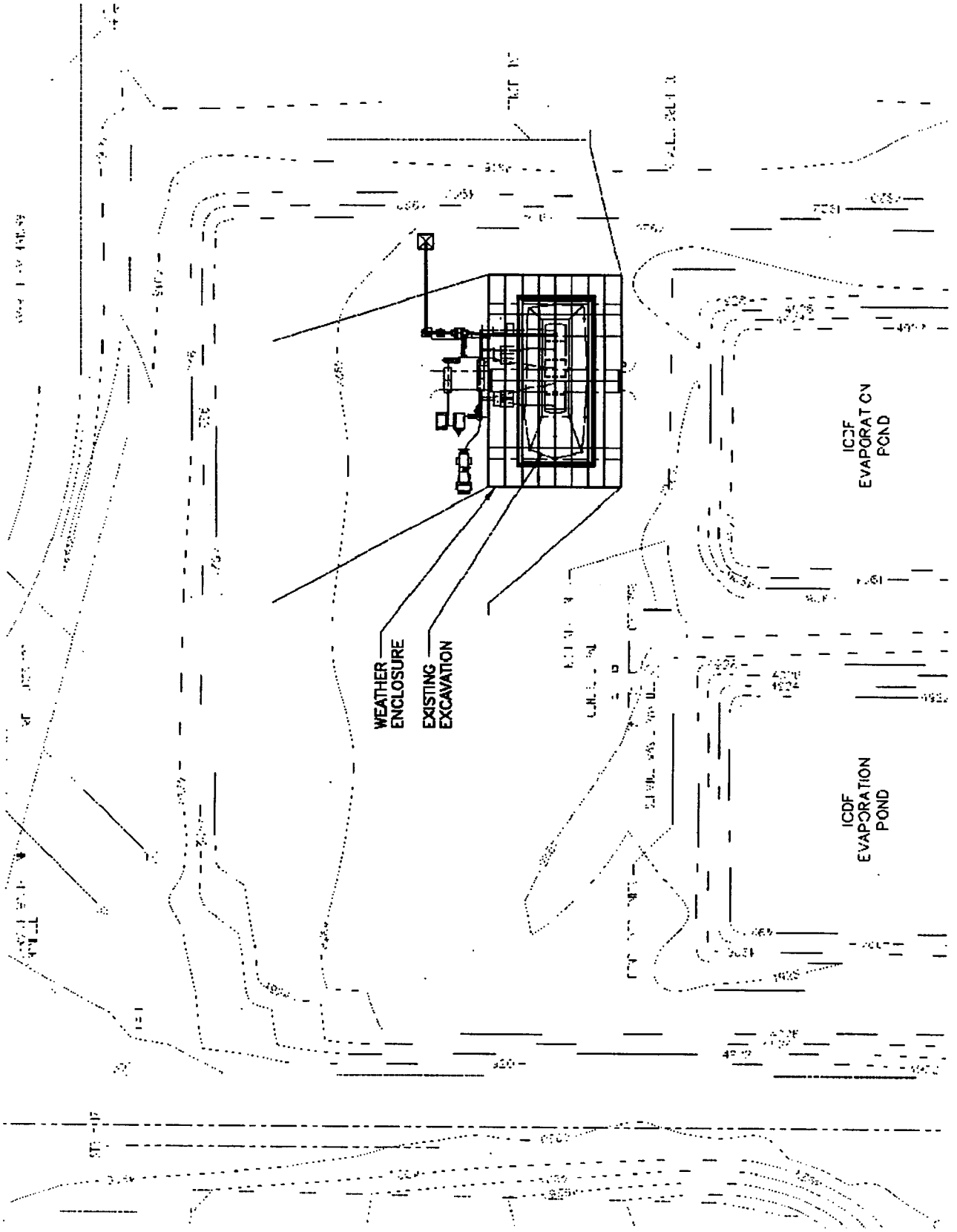
(3) Volumes of waste to be managed; *V-14 contents (approximately 46,000 lbs.)*

(4) Physical and Chemical Characteristics of the wastes to be managed in the unit: 20 to 25 *weight percent diatomaceous earth, 20 to 25 percent dark wet sludge, and 50-60 percent water. F001 Tetrachloroethylene that will be reduced through treatment from approximately 100-100 mg/kg to less than 6 mg/kg.*

(5) Potential for releases from the unit: *Residue will be treated in the tank via air sparging and the off gas will be filtered through granular activated carbon to remove volatilized organic constituents (primarily tetrachloroethylene). Then the treated contents will be solidified. The tank is adequate containment but is also contained within an impermeable secondary containment system to prevent the release of waste materials.*

(6) Hydro geologic and other relevant environmental conditions at the facility which may influence the migration of any potential releases; *None, the tank is placed in a lined depression on a man made soil berm next to the ICDF Evaporation ponds.*

(7) Potential for exposure of humans and environmental receptors if releases were to occur from the unit. *The enclosure for the tank is located within the AOC for OU 3-13 on the INL. Public access is limited and only trained workers are allowed access within the area during the treatment process. . Potential for exposure during the treatment process is controlled by the filtration and treatment process design to limit the increase in exposure potential to be within the approved risk basis for the existing CERCLA facility.*


WEATHER ENCLOSURE
EXISTING EXCAVATION
ICDF EVAPORATION POND
ICDF EVAPORATION POND

ICDF-WAC Recommendations – April 2005

Prepared for: ICDF Implementation Project

Prepared by: BBWI, James M. McCarthy and Paul Ritter

Date: April 13, 2005

The purpose of this report is to present waste acceptance criteria (WAC) for several constituents that may be placed in the Idaho CERCLA Disposal Facility (ICDF) landfill and evaporation ponds. The constituents to be considered are listed in Table A. The generators reported the soil concentration shown in Table A. Although the soil concentrations are listed as the design inventory in other tables of this report, the concentrations are generally the same as the RCRA treatment standards found in the table of universal treatment standards (40CFR 268.48).

Table A. List of constituents requested for WAC calculation.

Constituent	CAS #	Soil Concentration Reported by the Generators (mg/kg)
Carbon Tetrachloride	56-23-5	6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	30
Chloroform	67-66-3	6
PCBs	1336-36-3	10
Trichlorofluoromethane	75-69-4	30
Pyridine	110-86-1	16
Bromoform	75-25-2	15
Trans-Acetylene Dichloride (1,2-Dichloroethene)[a]	156-60-5	30
Ether (ethyl ether)	60-29-7	160
m-Cresol (mixed isomers)[b]	108-39-4	5.6
Creosote oil	8001-58-9	6
Methanol (methyl alcohol)	67-56-1	1

a. There is a current WAC for 1,2-dichloroethene of 0.32 mg/kg. The current WAC was set to 1,000 the design inventory identified when the WAC was developed. Since this is not a performance based WAC value, the WAC is being updated.
b. Only m-cresol is not listed in WAC

A. BACKGROUND

The INEEL is disposing of remediation wastes at the ICDF and planned disposals have identified constituents that were not included in the original WAC and constituents for which the waste has soil concentrations greater than the original WAC. Since for many constituents, the WAC was simply set to 1000 times the original design soil concentration, a reevaluation is needed to calculate a WAC based on the predicted leachate and future peak groundwater concentrations.

B. METHODOLOGY

The WAC formulation processes are described in DOE/ID-10865, "Waste Acceptance Criteria for the ICDF Landfill and DOE/ID-10866, "Waste Acceptance Criteria for ICDF Evaporation Pond" were followed to establish WAC limits.

C. RESULTS AND DISCUSSION

Based on the documentation in DOE/10865 and DOE/ID-10866 tables were identified that need to be updated with the new constituents or new soil concentration estimates. The results are presented in the next two sections.

D. DOE/ID-10865, "WASTE ACCEPTANCE CRITERIA FOR ICDF LANDFILL"

DOE/ID-10865, "Waste Acceptance Criteria for ICDF Landfill" including the main document and appendices should be amended with the following tables.

Table 3-3. in REV 7 and Table 5-2. ICDF Landfill Waste Acceptance Criteria

Constituent	Selected WAC Concentration Guideline (mg/kg)	Landfill WAC Maximum Mass[a] (kg)	Source of WAC Concentration Guideline
Carbon Tetrachloride	500	3.79E+05	Regulatory Limit
1,1,2-Trichloro-1,2,2-trifluoroethane	100,000	7.59E+07	Regulatory Limit
Chloroform	285	2.16E+05	Liner Compatibility
PCBs	500	3.79E+05	Regulatory Limit
Trichlorofluoromethane	500	3.79E+05	Regulatory Limit
Pyridine	500	3.79E+05	Regulatory Limit
Bromoform	500	3.79E+05	Regulatory Limit
Trans-Acetylene Dichloride (1,2-Dichloroethene)[b]	500	3.79E+05	Regulatory Limit
Ether (ethyl ether)	358	2.72E+05	Liner Compatibility
m-Cresol (mixed isomers)	100,000	7.59E+07	Regulatory Limit
Creosote oil	31,587	2.40E+07	Liner Compatibility
Methanol (methyl alcohol)	500	3.79E+05	Regulatory Limit

a. From soil conc.(mg/kg) WAC (Table D-1) * bulk density (1946 Kg/m^3) * total ICDF soil volume (389,923 m^3)/1E6 mg/Kg)
b. There is a current WAC for 1,2-dichloroethene of 0.32 mg/kg. The current WAC was set to 1,000 the design inventory identified when the WAC was developed. Since this is not a performance based WAC value, the WAC is being updated.

Table A-2. Selected Allowable Waste Soil Concentrations Based on RAOs.

Constituent	Type[a]	Design Inventory Concentration[b] (pCi/kg or mg/kg)	Adjusted Maximum Inventory to Not Exceed Groundwater RAOs in 1E+06 yrs[a] (mg/kg)	Basis for Adjusted Maximum Inventory
Carbon Tetrachloride	Volatile Organic	6	No Limit	Decays before reaching aquifer
1,1,2-Trichloro-1,2,2-trifluoroethane	Organic	30	No Limit	Decays before reaching aquifer
Chloroform	Volatile Organic	6	No Limit	Decays before reaching aquifer
PCBs	PCB	10	No Limit	Decays before reaching aquifer
Trichlorofluoromethane	Volatile Organic	30	No Limit	Decays before reaching aquifer
Pyridine	Volatile Organic	16	No Limit	Decays before reaching aquifer
Bromoform	Volatile Organic	15	No Limit	Decays before reaching aquifer
Trans-Acetylene Dichloride (1,2-Dichloroethene)	Volatile Organic	30	No Limit	Decays before reaching aquifer
Ether (ethyl ether)	Volatile Organic	160	No Limit	Decays before reaching aquifer
m-Cresol (mixed isomers)	Organic	5.6	No Limit	Decays before reaching aquifer
Creosote oil	Organic	10,000	No Limit	Decays before reaching aquifer
Methanol (methyl alcohol)	Volatile Organic	1	No Limit	Decays before reaching aquifer

a. For purposes of this analysis, the definition of VOC is taken from 40 CFR 265.1081 (definition) and the table in 40 CFR 265 Appendix VI is used to define whether or not a constituent is a VOC. If a constituent is not on the list, it is defined as a VOC.

b. The constituents are all predicted to decay completely in the ICDF landfill and vadose zone, during transport to the aquifer. The following are the biodegradation half-lives assumed for the calculations. The predicted water travel time to the aquifer is 30,000 years. The contaminant half lives are as follows

Carbon Tetrachloride	1 yr	
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	2 yr	
Chloroform	5 yr	
PCBs	0.5 yr	
Trichlorofluoromethane	2 yr	
Pyridine	0.04 yr	
Bromoform	1 yr	
Trans-Acetylene Dichloride (1,2-Dichloroethene)	1.1 yr	
Ether (ethyl ether)	100 yr	No data conservative estimate
m-Cresol (mixed isomers)	0.13 yr	
Creosote oil	100 yr	No data conservative estimate
Methanol (methyl alcohol)	0.019 yr	

Table B-1. Maximum Allowable Concentration in Soil for Liner Compatibility

Constituents	Average Leachate Concentration[a], C_{Liquid} (mg/L)	Design Inventory Concentration in Soil, C_{Soil} (mg/kg)	Waste Soil to Leachate Ratio, C_{Soil}/C_{Liquid} (L/kg)	Max Concentration Allowed in Leachate for Compatibility (mg/L)	Maximum Allowable Concentration in Soil For Compatibility [a] (mg/kg)
Carbon Tetrachloride	2.80	6	2.14	2,000	4.29E+03
1,1,2-Trichloro-1,2,2-trifluoroethane	1.53	30	19.7	500,000	9.83E+06 (No Limit)
Chloroform	42	6	0.14	2,000	2.85E+02
PCBs	0.00032	10	31,193	2,000	6.24E+07 (No Limit)
Trichlorofluoromethane	96	30	0.31	2,000	6.27E+02
Pyridine	1.03	16	15.6	100,000	1.56E+06 (No Limit)
Bromoform	24.04	15	0.62	2,000	1.25E+03
Trans-Acetylene Dichloride (1,2-Dichloroethene)	47	30	0.64	2,000	1.27E+03
Ether (ethyl ether)	894	160	0.18	2,000	3.58E+02
m-Cresol (mixed isomers)	1.20	6	4.66	100,000	4.66E+05
Creosote oil	158,295	10,000	0.063	500,000	3.16E+04
Methanol (methyl alcohol)	0.031	1	32.4	500,000	1.62E+07 (No Limit)

a. If the maximum allowable concentration were greater than 1E6 mg/kg or 1kg/kg then the ICDF liner would be compatible with the entire ICDF filled with that constituent. Therefore there is no limit.

Table D-1. WAC Concentration Selection

Constituent	Groundwater RAO Guidance Concentration [a] (mg/kg)	Liner Compatibility [b] (mg/kg)	Regulatory Limitation [c] (mg/kg)	Background [d] (mg/kg)	Selected WAC Concentration (mg/kg)	Source of WAC Concentration
Carbon Tetrachloride	No Limit	4,288	500	NA	500	Regulatory Limit
1,1,2-Trichloro-1,2,2-trifluoroethane	No Limit	No Limit	100,000	NA	100,000	Regulatory Limit
Chloroform	No Limit	285	500	NA	285	Liner Compatibility
PCBs	No Limit	No Limit	500	NA	500	Regulatory Limit
Trichlorofluoromethane	No Limit	627	500	NA	500	Regulatory Limit
Pyridine	No Limit	No Limit	500	NA	500	Regulatory Limit
Bromoform	No Limit	1,248	500	NA	500	Regulatory Limit
Trans-Acetylene Dichloride (1,2-Dichloroethene)	No Limit	1,270	500	NA	500	Regulatory Limit
Ether (ethyl ether)	No Limit	358	500	NA	358	Liner Compatibility
m-Cresol (mixed isomers)	No Limit	465,547	100,000	NA	100,000	Regulatory Limit
Creosote oil	No Limit	31,587	100,000	NA	31,587	Liner Compatibility
Methanol (methyl alcohol)	No Limit	No Limit	500	NA	500	Regulatory Limit

a. From Table A-2 in the ICDF Landfill WAC.
b. From last column of Table B-1, "Maximum Allowable Concentration in Soil for Compatibility"
c. Total organic constituents cannot exceed 10% by weight (100,000 mg/kg) per 40 CFR 264.1050(f), total volatile organic constituents cannot exceed 500 ppm per 40 CFR 264.108(c)(1). And Total PCBs cannot exceed 500 mg/kg (40 CFR 761.60).
d. No organic background expected.

Table F-1. Comparison of Design Inventory and Waste Acceptance Criteria Concentrations.

Constituent	Design Inventory (DI) Mass or Activity [a] (kg)	Waste Acceptance Criteria (WAC) Mass or Activity [b] (kg)	Mass or Activity Comparison (DI/WAC) %
Carbon Tetrachloride	4.55E+03	3.79E+05	1.2%
1,1,2-Trichloro-1,2,2-trifluoroethane	2.28E+04	7.59E+07	0.0%
Chloroform	4.55E+03	2.16E+05	2.1%
PCBs	7.59E+03	3.79E+05	2.0%
Trichlorofluoromethane	2.28E+04	3.79E+05	6.0%
Pyridine	1.21E+04	3.79E+05	3.20%
Bromoform	1.14E+04	3.79E+05	3.0%
Trans-Acetylene Dichloride (1,2-Dichloroethene)	2.28E+04	3.79E+05	6.0%
Ether (ethyl ether)	1.21E+05	2.72E+05	45%
m-Cresol (mixed isomers)	4.25E+03	7.59E+07	0.01%
Creosote oil	7.59E+06	2.40E+07	32%
Methanol (methyl alcohol)	7.59E+02	3.79E+05	0.20%

a. From design inventory soil conc.(mg/kg) (Table A-2) * bulk density (1946 Kg/m^3) * total ICDF soil volume (389,923 m^3 / 1E6 mg/Kg)
b. From soil conc.(mg/kg) WAC (Table D-1) * bulk density (1946 Kg/m^3) * total ICDF soil volume (389,923 m^3 / 1E6 mg/Kg)

E. DOE/ID-10866, "WASTE ACCEPTANCE CRITERIA FOR ICDF EVAPORATION POND"

DOE/ID-10866, "Waste Acceptance Criteria for ICDF Evaporation Pond" including the main document and appendices should be amended with the following tables.

Table 5-2. Chemical Waste Acceptance Criteria for Evaporation Pond.

Constituent	ICDF Evaporation Pond WAC [a]	Source of ICDF Evaporation Pond WAC
	(mg/L)	
Carbon Tetrachloride	500	Regulatory Limit
1,1,2-Trichloro-1,2,2-trifluoroethane	100,000	Regulatory Limit
Chloroform	500	Regulatory Limit
PCBs	50	Regulatory Limit
Trichlorofluoromethane	500	Regulatory Limit
Pyridine	500	Regulatory Limit
Bromoform	500	Regulatory Limit
Trans-Acetylene Dichloride (1,2-Dichloroethene)	500	Regulatory Limit
Ether (ethyl ether)	500	Regulatory Limit
m-Cresol (mixed isomers)	100,000	Regulatory Limit and Liner Compatibility
Creosote oil	100,000	Regulatory Limit
Methanol (methyl alcohol)	500	Regulatory Limit

a. ICDF Evaporation Pond WAC - the WAC comes from Table B-1.

Table A-1. Suggested Maximum Leachate Concentrations for Organic Constituents for Liner Compatibility.

Constituent	Predicted Peak Concentration in Leachate [a]	Compatible Concentration For HDPE [bc]	Compatible Concentration for GCL [bc]	Compatible Concentration for Clay [bc]	Suggested Maximum Leachate Concentration [d]
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Carbon Tetrachloride	29	2,000	-	-	2,000
1,1,2-Trichloro-1,2,2-trifluoroethane	7.98	500,000	-	-	500,000
Chloroform	100	2,000	-	-	2,000
PCBs	0.007	2,000	-	-	2,000
Trichlorofluoromethane	500	2,000	-	-	2,000
Pyridine	267	100,000	-	-	100,000
Bromoform	250	2,000	-	-	2,000
Trans-Acetylene Dichloride (1,2-Dichloroethene)	446	2,000			2,000
Ether (ethyl ether)	941	2,000	-	-	2,000
m-Cresol (mixed isomers)	93.3	100,000	-	-	100,000
Creosote oil	166,667	500,000	-	-	500,000
Methanol (methyl alcohol)	17	500,000	-	-	500,000

a. Predicted peak leachate concentration of the ICDF landfill operation (basic methodology described in EDF-ER-274).
b. "-" indicates that a specific test value was not available, compatibility issues are not anticipated.
c. From manufacturers specifications. (Table 5 in EDF-ER-278 pages 74 – 78 lists compatible concentration for HDPE liners.)
d. The suggested maximum concentration selected for the ICDF liner system is based on the lowest of the concentrations listed for HDPE, GCL, and clay materials and are applicable for the leachate in the landfill and the waste liquids in the evaporation ponds.

Table B-1. Maximum Allowable Evaporation Pond Liquid Concentration.

Constituent	Pond Liner Maximum Concentrations [a]	Regulatory Limitations [b]	ICDF Evaporation Pond WAC [c]	Source of ICDF Evaporation Pond WAC
	(mg/L)	(mg/L)	(mg/L)	
Carbon Tetrachloride	2,000	500	500	Regulatory Limit
1,1,2-Trichloro-1,2,2-trifluoroethane	500,000	100,000	100,000	Regulatory Limit
Chloroform	2,000	500	500	Regulatory Limit
PCBs	2,000	50	50	Regulatory Limit
Trichlorofluoromethane	2,000	500	500	Regulatory Limit
Pyridine	100,000	500	500	Regulatory Limit
Bromoform	2,000	500	500	Regulatory Limit
Trans-Acetylene Dichloride (1,2-Dichloroethene)	2,000	500	500	Regulatory Limit
Ether (ethyl ether)	2,000	500	500	Regulatory Limit
m-Cresol (mixed isomers)	100,000	100,000	100,000	Regulatory Limit and Liner Compatibility
Creosote oil	500,000	100,000	100,000	Regulatory Limit
Methanol (methyl alcohol)	500,000	500	500	Regulatory Limit

a. From Table A-1, Column 6.
b. Regulatory Limitations - comes from 40 CFR 264.1050(b) (organics are limited at 10% by weight, 40 CFR 1082(c)(1) (Total VOC concentration cannot exceed 500 mg/L, and the . Toxic Substances Control Act (PCB concentrations in water cannot exceed 50 mg/L).
c. Minimum between the pond liner and regulatory limitations.
d. Liquid PCB limit of 50 ppm is from the US Code, Title on Public Health and Welfare, chapter on Solid Waste Disposal. The reference is Title 42, Chapter 82, Subchapter III, 6924(d)(2)(D). "Liquid hazardous wastes containing polychlorinated biphenyls at concentrations greater than or equal to 50 ppm."

APPENDIX D

SAMPLING AND MONITORING PLAN

APPENDIX D

DESIGN ANALYSIS REPORT
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
SAMPLING AND MONITORING PLAN

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

May 2007

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DESIGN ANALYSIS REPORT
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)
SAMPLING AND MONITORING PLAN

1.0 INTRODUCTION

This Sampling and Monitoring Plan (SMP) for the Asarco East Helena Corrective Action Management Unit (CAMU) is intended to provide guidance on the collection, analysis, and reporting of groundwater data for the suite of monitoring wells installed for the specific purpose of evaluating potential impacts from the CAMU Phase 1 and Phase 2 Cells. The SMP has been prepared as Appendix D to the Design Analysis Report for the CAMU Phase 2 Cell (Hydrometrics, 2007a). In accordance with the CAMU regulations at 40 CFR §264.551 and §264.552, the SMP provides "requirements for sampling and monitoring and corrective action that are sufficient to (i) continue to detect and to characterize the nature, extent, concentration, direction, and movement of existing releases of hazardous constituents in ground water from sources located within the CAMU; (ii) detect and subsequently characterize releases of hazardous constituents to ground water that may occur from areas of the CAMU in which wastes will remain in place after closure of the CAMU; and (iii) require notification to the Regional Administrator and corrective action as necessary to protect human health and the environment for releases to ground water from the CAMU." The groundwater monitoring procedures set forth in this plan also address the 40 CFR §264 Subpart F requirements for detecting, characterizing, and responding to releases from solid waste management units to the uppermost aquifer beneath the unit.

At the same time, the procedures and methodologies outlined in this SMP have been developed to be generally consistent with the recently revised (April 2007) post-RI groundwater monitoring encompassing the Asarco East Helena site and the community of

East Helena. A significant dataset has been established for the CAMU monitoring wells over the last six years, under the post-RI semiannual monitoring program. Therefore, to maintain data comparability, the CAMU SMP is based on revised post-RI program.

1.1 PROJECT BACKGROUND

Environmental investigations and remedial activities at the Asarco LLC (Asarco) East Helena Smelter site in East Helena, Montana, are currently proceeding under a Consent Decree with the United States Environmental Protection Agency (EPA). In January 1998, the EPA and Asarco entered into a Consent Decree (CV 98-3-H-CCL) under the Resource Conservation and Recovery Act (RCRA) that required Asarco to investigate and correct releases of arsenic and metals in groundwater and soils at the East Helena Smelter.

The CAMU Phase 1 Cell, a Subtitle C landfill located southwest of the East Helena Smelter, was constructed in 2001 to accept soils, sediments and demolition debris resulting primarily from remedial cleanup activities at the plant. The cell is constructed as follows (from bottom to top:

1. A well-compacted subgrade is covered by a three-foot compacted clay liner;
2. Above the clay liner are a 60-mil HDPE liner and 250-mil geonet drainage layer (the leak detection layer), and an additional 60-mil HDPE liner and 250-mil geonet drainage layer (the leachate collection layer);
3. The leachate collection layer is overlain by a geotextile layer;
4. Above the geotextile layer is a layer of waste material up to 20 feet thick;
5. A composite cap of geosynthetic clay and a 40-mil HDPE liner covers the waste material; and
6. A drainage layer (one foot of clean sand) above the cap is covered by two feet of cover soil and six inches of topsoil, vegetated with a grass cover.

The leachate collection and leak detection layers drain to 4-inch perforated HDPE pipes and subsequently to collection sumps, which are accessible from the surface via 4-inch HDPE pipes with removable screw caps to allow removal of any leachate by pumping.

Under a Consent Decree with the State of Montana, process unit cleaning and building demolition is occurring at the East Helena plant (the conditions of the Montana Consent Decree officially expired on December 31, 2006). A key component of facility process unit material removal and site demolition is the construction of a CAMU Phase 2 Cell for containment of demolition debris. Engineering design and analysis was recently completed for the CAMU Phase 2 Cell (Hydrometrics, 2007a), which will contain plant site soil and demolition debris generated through the implementation of the Montana Consent Decree and the RCRA Consent Decree.

1.2 GENERAL SITE DESCRIPTION

The East Helena plant is a custom lead smelter situated on an approximately 142-acre site. The plant is described in detail in other documents, particularly the Comprehensive Remedial Investigation/Feasibility Study (RI/FS, Hydrometrics, 1990), the Current Conditions Release Assessment (CCRA, Hydrometrics, 1999), and the RCRA Facility Investigation (RFI, ACI, 2003). The plant is bounded to the south by Upper Lake and Lower Lake, to the east and northeast by Prickly Pear Creek, and to the north by the City of East Helena and American Chemet. The existing CAMU Phase 1 Cell and the proposed CAMU Phase 2 Cell are located in open fields south-southwest of the plant site near Upper Lake (Figure 1-1).

1.3 GROUNDWATER MONITORING OBJECTIVES

Ten groundwater monitoring wells (designated MW-1 through MW-10) have been installed in the immediate vicinity of the existing and proposed CAMU cells to assess potential releases of constituents of concern (arsenic and other metals) to groundwater. An additional monitoring well (MW-11) was installed in May 2007 to aid in defining groundwater flow directions. Monitoring well locations are shown on Figure 1-2, along with the most recent groundwater elevation data collected in November 2006. As noted in the Technical Inspection Report for the CAMU Phase 1 Cell (Hydrometrics, 2007b), a CAMU-specific groundwater monitoring program has not previously been implemented for the Asarco East Helena site. Instead, from 2001 through 2006 the CAMU monitoring well network was

incorporated into the post-RI sampling program, sampled and analyzed on a semiannual basis for the same parameters as other site monitoring wells.

The SMP for the Asarco East Helena CAMU is structured as follows:

- Section 2.0 provides an overview of site hydrogeology and groundwater quality;
- Section 3.0 discusses monitoring locations and frequency;
- Section 4.0 presents sampling methodology for the CAMU monitoring wells;
- Section 5.0 discusses sample handling and analysis procedures;
- Section 6.0 presents statistical evaluation and reporting requirements;
- Section 7.0 provides a Quality Assurance Plan for the CAMU groundwater monitoring; and
- Document references are contained in Section 8.0.

2.0 HYDROGEOLOGIC SETTING AND GROUNDWATER QUALITY

The Asarco plant and the East Helena community are underlain by unconsolidated alluvium deposited by ancestral Prickly Pear Creek. The alluvial deposits are highly variable in composition containing mixtures of cobbles, gravel, sand, silt and clay within this unit. Underlying the alluvium, and present in exposures west and north of the plant and the East Helena community, are fine-grained Tertiary volcanic ash tuff deposits. These tuff deposits have low permeabilities and have weathered to fine clay in some locations.

Groundwater is present in the unconsolidated Quaternary deposits throughout most of the site with the exception of the western edge of the plant site where the Tertiary ash deposits form a shallow ridge. A perched groundwater system is also found in surficial slag/fill deposits on portions of the Asarco plant site where the slag and fill are underlain by relatively low permeability marsh deposits. Depth to groundwater in the vicinity of the Asarco plant site ranges from 10 feet to 60 feet, becoming deeper to the north and in areas away from Prickly Pear Creek. The general groundwater flow direction is to the north and northwest. Asarco plant site groundwater receives recharge from Upper Lake and Lower Lake in the Asarco plant area, and from Prickly Pear Creek in the area immediately downstream.

Monitoring well logs for the ten CAMU monitoring wells (designated MW-1 through MW-10) are in Attachment A. Groundwater flow patterns in the immediate vicinity of the CAMU are complex and difficult to interpret consistently from groundwater elevation data, presumably due to impacts on the local water table from Upper Lake and the effect of layered or perched groundwater zones within the volcanic ash unit, overlying a more extensive regional Tertiary alluvial aquifer. Groundwater elevations and flow directions were evaluated at some length in the Technical Inspection Report (Hydrometrics, 2007b). This discussion is summarized below.

Wells MW-6, MW-2, and MW-3 have consistently shown the highest water levels in the CAMU monitoring well network, based on data collected from 2000 through 2006. Well

MW-6 is also the only CAMU monitoring well completed in the unconsolidated alluvial deposits rather than the volcanic ash unit. The water levels in CAMU wells and site well DH-2 (Figure 1-2) suggest a northward groundwater flow direction along the northern portion of the CAMU area, which is generally consistent with regional groundwater flow. Prior to 2006 (and the installation of wells MW-8, MW-9, and MW-10) there also appeared to be a localized southerly flow direction along the southern boundary of the CAMU Phase 1 Cell.

Groundwater data collected in 2006 show lower potentiometric surface elevations in the CAMU Phase 2 Cell area (Figure 1-2). This apparent low may be misleading since water levels in the ash unit are layered or perched, and may not be representative of groundwater flow in a single site-wide groundwater system. In many cases, wells that were drilled the deepest have lower groundwater elevations, suggesting that the ash unit behaves as a layered perched unit with variable water elevations that are dependent on well depths and screened intervals.

Groundwater quality in the CAMU monitoring wells has been measured as part of the post-RI/FS monitoring program since November 2000. Table 2-1 is a statistical summary of observed water quality at wells MW-1 through MW-7 from Fall 2000 through Spring 2006. Wells MW-8, MW-9, and MW-10 were installed in 2006 and sampled during the most recent (November 2006) monitoring event.

As shown in Table 2-1, overall water quality in the CAMU monitoring wells is good, with low to moderate concentrations of major ions, near-neutral pH values (averaging 6.90 to 7.46), and dissolved metals concentrations that are generally below or near laboratory reporting limits. Cadmium, copper, lead, and zinc are nearly always below laboratory detection limits. Cadmium has been reported one time at a concentration of 0.002 mg/L in well MW-4, copper has been reported one time in well MW-6 at a concentration of 0.004 mg/L, lead has been reported twice, at 0.007 mg/L (MW-1) and 0.009 mg/L (MW-6), and zinc has never been above the laboratory detection limit of 0.01 or 0.02 mg/L. Dissolved arsenic concentrations show considerable variability among wells, with average concentrations ranging from 0.004 mg/L at well MW-4 to 0.159 mg/L at well MW-6.

Similarly, average manganese concentrations range from 0.019 mg/L at wells MW-4 and MW-5 to 4.99 mg/L at MW-6, and average iron concentrations range from 0.025 mg/L at MW-5 to 0.219 mg/L at MW-6. Major ions also show substantial variability among wells, with the following average concentration ranges observed for the CAMU well dataset: calcium (18.7 to 93.6 mg/L), magnesium (5.5 to 20.3 mg/L), sulfate (21.8 to 72.3 mg/L), and bicarbonate (109 to 351 mg/L). Well MW-6 typically shows higher concentrations than other CAMU wells for most chemical constituents tested. As shown on Figure 1-2, this well also has a higher groundwater elevation than other CAMU wells, and may be influenced by flow from the east. In fact, concentrations of arsenic and manganese at MW-6 are similar to those observed at well DH-20, located about 450 feet east-northeast of MW-6.

3.0 DETECTION MONITORING PROGRAM

This Section of the SMP outlines a detection monitoring program for the CAMU Phase 1 and Phase 2 Cells, as outlined in 40 CFR §264 Subpart F.

3.1 SAMPLE LOCATIONS AND FREQUENCY

Groundwater monitoring at the CAMU wells will be conducted at eleven monitoring locations (Figure 1-2) on a quarterly basis. These eleven monitoring wells will serve as compliance points (40 CFR §264.95). Sampling will be conducted once per calendar quarter, in order to provide groundwater elevation and quality data for contrasting points on the seasonal groundwater hydrograph.

Four monitoring wells are located around the perimeter of each of the two CAMU cells, covering each potential flow direction. The CAMU Phase 1 Cell is bordered by monitoring wells MW-1, MW-2, MW-3, and MW-4. The CAMU Phase 2 Cell is bordered by monitoring wells MW-5, MW-8, MW-9, and MW-10. Two additional monitoring wells, MW-6 and MW-7, are located in the area of the CAMU cells. Monitoring well MW-11 was installed west of the CAMU Phase 2 Cell location in 2007. Wells MW-1 through MW-11 were or will be installed for the specific purpose of monitoring water quality in the vicinity of both CAMU cells. Groundwater monitoring locations are described in Table 3-1 and shown on Figure 1-2. Monitoring well logs are in Attachment A.

3.2 SAMPLING METHODOLOGY

Collection of groundwater samples from the CAMU monitoring wells will generally consist of four steps:

1. Inspection of the monitoring well to verify well integrity;
2. Measurement of static water level;
3. Well purging and monitoring for field parameter stabilization; and
4. Water quality sample collection.

3.3 MONITORING WELL INSPECTION

As part of the detection monitoring program, during each quarterly monitoring event, all CAMU monitoring wells will be inspected to verify the integrity of the installation. A well inspection form (Attachment B) will be completed for each monitoring well site.

3.4 STATIC WATER LEVEL AND TOTAL DEPTH MEASUREMENT

Prior to collection of samples, the static water level will be measured at each well using an electric water level probe to determine the depth to groundwater below a specified measuring point (typically the top of the PVC well casing). Water level measurements will be combined with surveyed measuring point elevations (Table 3-1) to compute groundwater elevations at each monitoring point.

The total depth of each CAMU monitoring well will be measured at least annually, as part of the well inspection procedure. Decreases in total depth can occur due to collapsing or breached well casings, or improperly designed or installed well screens.

3.5 WATER QUALITY SAMPLE COLLECTION

Dedicated tubing installed in each monitoring well and a 12-volt submersible pump will be used to purge and sample monitoring wells. Purging will consist of removing three to five well volumes while routinely monitoring field parameters (pH, dissolved oxygen, temperature, specific conductance) at least twice during removal of each well volume. Field parameters will be measured using a flow-through device to minimize potential effects from atmospheric exposure. Purge water will be containerized and dispensed into the Asarco plant water treatment system.

Samples for laboratory analysis will be collected only after one of the following purge conditions is met:

- A minimum of three well volumes have been removed and successive field parameter measurements agree to within the stability criteria given below;

- At least five well volumes have been removed although field parameter stabilization criteria are not yet met; or
- The well has been pumped dry and allowed to recover sufficiently such that adequate sample volumes for rinsing equipment and collecting samples can be removed.

Criteria for field parameter stabilization are as follows:

Parameter (Units)	**Stability Criteria**
pH (standard units)	± 0.1 s.u.
water temperature (°C)	± 0.2 °C
specific conductance (µmhos/cm)	± 5% (SC ≤ 100 µmhos/cm) ± 3% (SC > 100 µmhos/cm)
dissolved oxygen (mg/L)	± 0.3 mg/L

NOTE: Stability criteria obtained from USGS *National Field Manual for the Collection of Water Quality Data: Chapter A4, Collection of Water Samples* (September 1999).

Following well purging, final field parameter measurements will be collected and recorded, and groundwater quality samples will be obtained. Sample bottles will be filled directly from a sampling port, prior to the pumped water passing through the flow-through cell.

Sample containers will be rinsed three times with sample water prior to sample collection, then preserved as appropriate for the intended analysis (e.g. nitric acid preservation to pH <2 for metals analysis), and stored on ice in coolers at approximately 4°C for transport. Filtered samples (for dissolved metals analyses) will be processed through a single-use 0.45 µm pore-size disposable filter prior to preservation.

3.6 SAMPLE DOCUMENTATION

All groundwater quality sampling information will be documented in waterproof ink in a dedicated project field notebook. Notebook entries will include, at a minimum, the following information:

- Project name;
- Date and time;
- Sample location;

- Sample number;
- Media type;
- Field meter calibration information;
- Sampling personnel present;
- Analyses requested;
- Sample preservation;
- Field observations (field parameter measurements, appearance of sample);
- Weather observations; and
- Other relevant project-specific site or sample information.

Entries will be made in permanent ink, with corrections crossed out with a single line, dated and initialed. Field books will be signed and dated at the bottom of each page by personnel making entries on that page.

Individual samples (including QC samples) will be assigned unique sample numbers according to the following sample numbering scheme:

AAA-YYMM-XXX

where AAA is a three-character code denoting the project, YYMM is a four-digit code denoting the year (i.e., 07 for 2007) and month (i.e., 05 for May) of collection, and XXX is a three-digit code that is incremented sequentially for each successive sample (i.e., if the first sample collected is 100, then subsequent samples are numbered 101, 102, 103, etc.).

Additional information to be included on the sample container label will include the date and time of collection, sample preservation information, and requested analytical parameters for the sample.

3.7 EQUIPMENT DECONTAMINATION

Groundwater sampling equipment reused between monitoring locations (sampling pump and short piece of discharge line used to connect to the dedicated well tubing) will be thoroughly

decontaminated between uses. Equipment decontamination will consist of the following steps:

- Rinse with about 3 gallons of soapy water (Alconox or other non-phosphate detergent);
- Rinse with about 5 gallons of clean tap water; and
- Final rinse with about 3 gallons of distilled or deionized water.

The effectiveness of the decontamination procedure will be evaluated through the periodic collection of equipment rinsate and deionized water blanks, as described below.

3.8 FIELD QUALITY CONTROL SAMPLES

Field quality control (QC) samples will be collected and analyzed as part of the CAMU groundwater monitoring program for evaluation of data quality. The collection of field QC samples is also part of the site-wide post-RI monitoring program. The QC samples specified for collection as part of the CAMU monitoring program will also serve as QC samples for the post-RI monitoring program.

Required groundwater field QC sample types and QC sample frequency for the CAMU groundwater monitoring program will be as follows:

- Equipment rinsate blanks – one per CAMU monitoring event;
- Deionized water blanks – one per CAMU monitoring event; and
- Field duplicate samples – one per CAMU monitoring event.

Blank samples are collected to estimate the potential for sample contamination from any materials contacting sample water (filtration equipment, bottles, preservatives etc.) and from random atmospheric contamination. The deionized water blank sample will be collected by filling sample bottles with reagent-free deionized water in the field, preserving as appropriate, and submitting the sample blind to the laboratory for analysis. The equipment rinsate blank will consist of deionized water processed through decontaminated sample

collection equipment (including pump, discharge lines and filtration equipment as appropriate).

Field duplicate samples will be collected to estimate field and laboratory precision (reproducibility). Field duplicate samples will be collected by sequentially filling two sets of sample bottles at the same monitoring location, assigning unique sample numbers to the two samples, and submitting both samples to the laboratory for analysis.

All field QC samples will be submitted blind to the laboratory (QC samples will be packaged and shipped in such a manner that the laboratory will not be aware of the nature of the samples). Further discussion of QC samples, including required laboratory QC samples and target control limits for both field and laboratory QC samples, is presented in Section 7.0.

3.9 SAMPLE HANDLING AND CHAIN-OF-CUSTODY

Sample containers and preservation methods for CAMU groundwater samples are listed in Table 3-2. Samples will be transferred to the laboratory (hand-delivered) either the day of sample collection or the next day. During field storage, samples will be maintained in coolers, iced to a temperature of approximately 4° C.

Chain-of-custody procedures will be followed throughout the project by utilizing standard chain-of-custody forms to transfer samples from the field to the laboratory. Each cooler of delivered samples will be accompanied by a cover letter, analytical parameter list, and chain-of-custody documentation for recording the transfer of samples from the possession of field personnel to the possession of the laboratory.

3.10 SAMPLE ANALYTICAL PARAMETERS AND METHODS

The primary analytical laboratory for the analysis of water samples collected under this SMP will be Energy Laboratories in Helena, Montana. Groundwater samples will be tested for the parameters listed in Table 3-3, using the appropriate method to achieve the specified quantitation levels. Field-measured parameters include pH, specific conductance, water temperature, and

dissolved oxygen. Laboratory parameters include major ions (calcium, magnesium, sodium, potassium, sulfate, and chloride), total dissolved solids, alkalinity, specific conductance, and an extended suite of dissolved metals (see Table 3-3), including speciation of both arsenic (arsenic (III) and arsenic (V) forms) and selenium (selenium (IV) and selenium (VI) forms). The extended suite of metals includes constituents listed in both Appendix VII of 40 CFR §261 (Hazardous Constituents) and 40 CFR §264 Appendix IX (Ground-Water Monitoring List). Metals (including arsenic and selenium) are considered the constituents of concern for the CAMU wells, based on the history of the Asarco Plant site and the nature of the materials in the CAMU Phase 1 Cell and the materials scheduled for placement in the CAMU Phase 2 Cell.

4.0 DETECTION MONITORING PROGRAM DATA EVALUATION AND REPORTING

This section of the SMP details the data evaluation and reporting requirements for the detection monitoring program, the monitoring components of which are presented above in Section 3.0. The data evaluation will determine whether, based on the most recent groundwater sampling results, an exceedance of the groundwater protection standard for the CAMU has occurred. For the purposes of this Sampling and Monitoring Plan, an exceedance of a groundwater protection standard at a compliance point will be indicated by either of the following:

1. A concentration for a constituent of concern (metals, including arsenic and selenium) from any of the eleven CAMU monitoring wells is greater than a specified concentration limit for that parameter at that well (see Section 4.1); or
2. A statistical evaluation of the data indicates that there is statistically significant evidence of contamination at a compliance point (see Section 4.2).

Currently, the data set for the CAMU wells for constituents of concern includes arsenic, cadmium, copper, iron, lead, manganese, and zinc, for wells MW-1 through MW-7. Therefore, evaluation of data under the detection monitoring program will be limited to these seven wells and seven parameters in 2007. As noted in Section 3.10, an extended suite of metals analytes and a quarterly monitoring frequency is proposed for all CAMU wells (MW-1 through MW-11) beginning with the 2007 groundwater sampling events. Following the first full year of quarterly data collection and establishment of a sufficient database, concentration limit calculations and comparisons, and statistical evaluations will be conducted for the newer CAMU wells, and for additional constituents of concern (other metals) based on the initial year of quarterly results.

4.1 CONCENTRATION LIMIT COMPARISON

Requirements for establishing concentration limits for hazardous constituents in groundwater at solid waste management units are presented in 40 CFR §264.94. As noted in Section 2.0

above, the groundwater chemistry in CAMU monitoring wells is quite variable, and the complexity of the hydrogeologic system makes defining upgradient (background) and downgradient wells difficult. Therefore, in order to determine concentration limits for the CAMU monitoring wells, the following procedure was employed to estimate background levels of constituents of concern for each well:

1. Available metals data was compiled for each well, with averages and standard deviations calculated, along with the total number of samples and the number of samples with data below the reporting limit (Attachment C);
2. Concentration limits were assigned based on one of the following criteria:
   a. If all data were below reporting limits, the practical quantitation limit (PQL) for the parameter (Table 3-3) was established as the concentration limit;
   b. If more than 50% of the data were below reporting limits, 3 x PQL was established as the concentration limit;
   c. If less than 50% of the data were below the reporting limit, the concentration limit was established as the average plus two standard deviations.

The well-specific concentration limits for each parameter for the CAMU wells are shown in Table 3-4. The method described above for determining concentration limits is intended to account for some expected natural variability in reported concentrations (due to fluctuations in true concentrations and to inherent sampling and analytical variability), as well as the observed interwell variability, while remaining sufficiently low to allow detection of potential groundwater impacts from the CAMU Phase 1 and/or Phase 2 Cells.

4.2 STATISTICAL EVALUATION

The purpose of the statistical evaluation of CAMU groundwater monitoring data is to "detect and characterize" potential groundwater quality impacts from materials within the CAMU (see Section 1.2), to allow for appropriate responses to protect human health and the environment. EPA guidance on the statistical evaluation of groundwater monitoring data at RCRA facilities (EPA, 1989 and 1992) discusses various data assessment techniques that may be used depending on the particular characteristics of the dataset for individual wells

and as a whole. At the same time, the EPA documents recognize that the suggested methods are guidance rather than regulation, and that a flexible, site-specific approach to acceptable statistical methods of evaluation is necessary. This section presents the statistical evaluation proposed for the CAMU monitoring well network, based on a consideration of groundwater flow patterns and groundwater quality observed to date, applicable RCRA and other statistical guidance, and on the requirements of 40 CFR §264.97(h).

Statistical guidance for RCRA facilities (EPA, 1989 and 1992) is primarily based on comparisons of parameter concentrations in background wells with concentrations in downgradient wells. Various methods (prediction or tolerance intervals, analysis of variance (ANOVA), control charts) are suggested to test for statistically significant differences in background versus compliance well concentrations, which may indicate groundwater impacts if compliance well concentrations are higher than background concentrations in a statistically significant sense. These tests are "inter-well" methods, comparing datasets from different monitoring locations.

Inter-well procedures are not considered appropriate for the Asarco CAMU groundwater monitoring program, for the following reasons:

- As noted in Section 2.0, measured groundwater elevations in the CAMU area are not readily interpreted to yield a consistent groundwater flow direction, with well-defined upgradient and downgradient wells;
- The data collected prior to placement of materials in the CAMU Phase 1 Cell is limited to two sampling events (November 2000 and May 2001), and does not include all of the current monitoring well sites. Thus, the background dataset for individual wells is less than ideal for determining representative background concentrations; and
- Groundwater quality data collected to date show considerable inter-well variability (see Section 2.0 and Table 2-1) both before and after placement of materials in the CAMU Phase 1 Cell.

Therefore, an intrawell approach to statistical evaluation is proposed for the Asarco CAMU groundwater monitoring program, where data from each individual well is compared with previous data collected at that well, to assess changes over time. In essence, this method considers all of the CAMU monitoring wells as "downgradient" wells potentially affected by any impact from the CAMU.

The intrawell statistical test that will be used by Asarco to evaluate CAMU groundwater monitoring data is the Mann-Kendall test for trend, described by Helsel and Hirsch (2002) and Helsel et al. (2005). The Mann-Kendall trend test is a nonparametric test that evaluates whether a particular variable at a particular well shows a tendency to increase over time. The Mann-Kendall test may be conducted using software available from the USGS (Helsel et al., 2005), or by any number of commercially available statistics programs. The significance level (Type I error level) for the Mann-Kendall test will be set at $\alpha = 0.01$, such that the probability of the test resulting in a false positive (incorrectly identifying an increasing trend when none is present) is 1% or less. Groundwater data will be tested using both the general Mann-Kendall test and the Seasonal Mann-Kendall test. The Seasonal Mann-Kendall test accounts for any seasonal effects in the dataset, such as variable groundwater elevations, and removes these effects from the computation of the test result, so that seasonality in the dataset has a minimal influence on the statistical significance of the trend test (Helsel and Hirsch, 2002).

Mann-Kendall trend testing will be conducted on metals data (including arsenic and selenium) for each of the eleven CAMU monitoring wells. If continued data collection shows that certain parameters are routinely at or below reporting limits, statistical testing may be discontinued in consultation with the agencies. As noted in EPA (1992), "By limiting the number of tested constituents to the most useful indicators, the overall number of statistical comparisons that must be made can be reduced, lowering the facility-wide false-alarm rate."

Another intrawell comparison procedure for groundwater data is the control chart (EPA, 1992). Control charts have the benefit of allowing data to be viewed graphically over time.

A reasonable number of background data points are required in order to establish reliable estimates of mean concentrations and parameter variability (a minimum of eight points are recommended). If the Mann-Kendall trend test conducted on the CAMU groundwater data indicates that there is no long-term trend in the data over a considerable period of time (8-10 years), a control chart approach for monitoring the CAMU wells could be implemented to complement the Mann-Kendall trend test statistics. The Shewhart-cumulative sum (CUSUM) Control Chart described in EPA (1992), using the initial 8-10 groundwater data points as a baseline for each well, would be an appropriate method for the CAMU wells. While this procedure is not proposed as a routine statistical test at this time, Asarco and the agencies may wish to consider including analysis of the groundwater data using a control chart as the data set expands.

The statistical tests proposed for the evaluation of CAMU monitoring well data have been selected based on the properties of the existing data set and the hydrogeologic conditions observed at the site. As additional data (new wells and an expanded set of parameters) are collected under the detection monitoring program outlined in Section 3.0, alternative methods of statistical analysis may be recognized as appropriate techniques for detecting potential releases to groundwater from the CAMU. Therefore, statistical procedures other than those suggested above may be used to evaluate site data. Any statistical method used to evaluate CAMU groundwater data will comply with 40 CFR §264.97(h) and (i).

4.3 DATA REPORTING

Following quarterly groundwater monitoring events, a Data Submittal will be prepared for EPA within thirty days of the receipt of analytical results from the laboratory. The semiannual Data Submittal will include the following:

- Copies of field notes and laboratory analytical results for the most recent monitoring events;
- Tabulated unique sample numbers (Section 3.6) and corresponding sample locations;

- Results of the statistical testing for each well for each of the parameters described above, including a summary of any statistically significant trends or exceedances identified;
- Concentration contour maps for any detected constituents of concern (arsenic and metals);
- Updated time-concentration plots for each well for all analyzed parameters; and
- A tabulated summary of the groundwater data for the most recent monitoring events.

The quarterly Data Submittals may be provided in hard copy, digital electronic format, or both at the discretion of the agency.

In addition to the quarterly Data Submittals, an Annual Groundwater Monitoring Report (GMR) will be prepared for EPA and submitted no later than March 31st of each year. The GMR will contain, at a minimum, the following information:

- Updated groundwater elevation and potentiometric contour maps for each of the previous year's monitoring events, along with updated hydrographs for each of the wells (temporal plots of changes in water elevation over time);
- A summary of results of the statistical testing completed during the previous year; and
- A discussion of statistical results, observed trends, data quality (see Section 7.0), deviations from the SMP, and any other issues pertinent to the CAMU groundwater monitoring program.

4.4 GROUNDWATER PROTECTION STANDARD EXCEEDANCES

4.4.1 Notification Requirement

If an exceedance of the groundwater protection standard is observed for any CAMU monitoring well (either an exceedance of a concentration limit, or a finding of statistical evidence of contamination), Asarco will notify EPA within seven days of the finding, specifying the nature and location of the exceedance (40 CFR §264.98(g)(1)).

4.4.2 Verification Sampling

For any well where one or more parameters is found to exceed a groundwater protection standard, the well will be resampled within 30 days of notification to EPA, unless Asarco and EPA in consultation determine that resampling is not necessary, or that resampling may occur on an alternate schedule. This verification sampling will only be required for those parameters and at those wells where groundwater protection standard exceedances were indicated during the most recent monitoring event.

If the verification sample also indicates an exceedance of the groundwater protection standard, a compliance monitoring program will be initiated (Section 5.0), and Asarco will determine whether or not the exceedances are attributable to the CAMU cells (Section 4.4.3).

4.4.3 Determination Of Source

If a verification sample indicates an exceedance of a groundwater protection standard, Asarco may make a demonstration that the groundwater protection standard was exceeded due to sources other than the CAMU, or to errors in sampling, analysis, or evaluation. Asarco shall notify EPA within seven days of receiving the verification sample results if this demonstration will be made. The report demonstrating that non-compliance with the groundwater protection standard is attributable to a factor other than a release from the CAMU will be submitted to EPA within 90 days of the notification. Compliance monitoring (Section 5.0) will continue during this period, until EPA provides written notice to Asarco that the detection monitoring program may resume.

4.5 MONITORING PROGRAM REVIEW

Following the receipt of semiannual monitoring data and preparation of Data Submittals and/or the Annual GMR, Asarco, EPA, and MDEQ should re-evaluate the CAMU groundwater monitoring program to determine if changes are warranted (e.g. modifications to the analytical parameter list, changes in sampling frequency, installation of additional wells) based on the most recent analytical and statistical results. Any changes to the detection monitoring program for the CAMU will be subject to Asarco and agency approval.

5.0 COMPLIANCE MONITORING

A compliance monitoring program will be implemented for the Asarco CAMU groundwater monitoring wells, if the sampling and data evaluation under the detection monitoring program determines that a groundwater protection standard has been exceeded, and that the exceedance is attributable to a release to groundwater from the CAMU (Section 4.4). If a compliance monitoring program is required, Asarco will submit a plan for compliance monitoring to EPA within 90 days of determining this requirement. The compliance monitoring program may be based on the detection monitoring program, but will also include any additional information necessary to comply with 40 CFR §264.99, such as the following:

- Any proposed changes to the groundwater monitoring network;
- Any proposed changes to monitoring frequency, parameters, or analytical methods; and
- Any proposed changes to groundwater protection standards (concentration limits and/or statistical evaluation methods).

If the statistical evaluation of groundwater data collected under the compliance monitoring program indicates exceedance of a groundwater protection standard, Asarco will notify EPA of this finding within seven days. Verification sampling and determination of sources under the compliance monitoring program may proceed as described in Sections 4.42 and 4.4.3 above for the detection monitoring program. If compliance monitoring data indicate exceedance of a groundwater protection standard, and that the exceedance is due to a release from the CAMU, Asarco will be required to establish a corrective action program (Section 6.0). As noted previously, compliance monitoring will continue until written notification from EPA that detection monitoring may resume.

6.0 CORRECTIVE ACTION

If a corrective action program is required based on an exceedance of a groundwater protection standard observed during implementation of a compliance monitoring program, Asarco will propose a corrective action to ensure that prevents hazardous constituents from exceeding applicable limits at the compliance point(s) by removing the hazardous constituents or treating them in place. Within 180 days of determining a corrective action program is necessary, Asarco will submit a plan detailing the corrective action program that complies with 40 CFR §264.100, and includes the following:

- A description of the specific measures to be taken to prevent hazardous constituents from exceeding applicable limits at the compliance point(s);
- A groundwater monitoring program to demonstrate the effectiveness of the corrective action program; and
- Provisions for annual reporting to EPA of the effectiveness of the corrective action program.

Asarco will continue corrective action measures for as long as necessary to achieve compliance with the groundwater protection standard. Corrective measures may be terminated based on a period of demonstrated compliance with the groundwater protection standard, to be determined on a case-specific basis by EPA.

7.0 QUALITY ASSURANCE PLAN

This section of the Asarco CAMU SMP provides guidance on quality assurance requirements for monitoring plan implementation. The Quality Assurance Plan (QAP) has been prepared in general accordance with applicable U.S. Environmental Protection Agency (EPA) guidance (EPA 1998a, 1998b). In general, the QAP outlines field and laboratory methodologies that will be required for completion of specific project activities, with the goal of generating a data set of sufficient quality to support future regulatory and/or remedial decisions concerning the CAMU. The content and level of detail in the QAP have been structured to be appropriate to the scope of work outlined above. The QAP is organized as follows, corresponding to the four standardized groups of required elements for quality assurance plans (EPA, 1998b):

- Section 7.1 -- Project Management;
- Section 7.2 -- Measurement/Data Acquisition;
- Section 7.3 -- Assessment/Oversight; and
- Section 7.4 -- Data Validation and Usability.

7.1 PROJECT MANAGEMENT

Overall project management for groundwater monitoring at the Asarco East Helena CAMU will be coordinated by Asarco and EPA. Designated project managers from Asarco and EPA will be the primary data users and decision-makers for the Asarco CAMU.

Asarco or a contractor selected by Asarco will implement the CAMU SMP, and will be responsible for providing staff to fill the following positions:

- Project Management;
- Health and Safety Officer;
- QA/QC Officer;

- Field Team Leader; and
- Field crews and/or subcontractors for environmental sampling and any additional field activities.

As noted previously, Asarco has entered into a Consent Decree with EPA (Section 1.0). This SMP represents a plan for ongoing evaluation of potential impacts to groundwater from the existing CAMU Phase 1 and proposed CAMU Phase 2 Cells at the Asarco East Helena site. The scope of work for the groundwater monitoring project is described in detail in Sections 2.0 through 6.0 of this document.

7.1.1 Quality Objectives and Criteria for Measurement Data

Quality objectives and criteria for measurement data have been developed for the Asarco CAMU groundwater monitoring program in general accordance with the Data Quality Objectives (DQO) process (EPA, 1994). The purpose of the DQO process is to ensure that data of the appropriate type, quality, and quantity are collected to support decisions to be made at the site.

The overall objective of the CAMU SMP is to detect and characterize any releases to groundwater from the CAMU through a program of data collection and statistical analysis. The decision to be made with respect to the CAMU groundwater monitoring data can be stated as follows: "Does the cumulative CAMU groundwater data indicate that impacts to groundwater from the CAMU are occurring?" The statistical procedures outlined in Section 6.0 describe the methods that will be used to address this question. In addition, the following analytical data quality objectives and measurement criteria have been incorporated into the Asarco CAMU SMP:

1. The sampling design, field methods, and analytical requirements have been specifically identified to ensure that representative samples are collected and analyzed;

2. Field and laboratory quality control samples and target control limits are stipulated in Section 7.2, to provide estimates of data precision, accuracy, and completeness; and
3. Provisions for required field and analytical documentation, project oversight, and data review procedures are also presented in Sections 3.0 through 6.0 above, and in Sections 7.3 and 7.4.

Adherence to the procedures and requirements set forth in this SMP will generate a defensible data set, minimizing the likelihood of potential decision errors at the Asarco CAMU for both false positive errors (i.e., deciding that a release from the CAMU is occurring, when in fact it is not) and false negative errors (i.e., deciding that a potential source is not occurring, when in fact it is).

7.2 MEASUREMENT/DATA ACQUISITION

The measurement/data acquisition section of the QAP ensures that appropriate methods for sampling and analysis, quality control sampling, and data handling are employed through specifying methodologies for the collection, handling, and analysis of samples, as well as management of generated data (EPA, 1998b). Sampling locations, methodology, handling procedures, and analytical procedures for the CAMU groundwater monitoring are detailed above in Section 3.0. Quality control sampling, control limits, analytical considerations, and data management procedures are outlined below.

7.2.1 Quality Control Samples and Control Limits

Field quality control (QC) samples will be collected as outlined in Section 3.8, including one equipment rinsate blank, one deionized water blank, and one field duplicate sample per CAMU monitoring event.

Target control limits for field blanks (both deionized water and equipment rinsate blanks) are no contaminants present above laboratory detection limits. Target duplicate sample control limits for inorganic water constituents will be as follows (EPA, 2002): control limit of ±20% relative percent difference (RPD) for original and duplicate samples with concentrations

greater than five times the laboratory detection limit (DL); or control limit of ± DL if the original or duplicate/split concentration is less than 5 times the DL. Relative percent difference is calculated as follows:

$$RPD = \frac{|S - D|}{\frac{(S+D)}{2}} \times 100$$

where RPD = relative percent difference (%)
S = original sample result; and
D = duplicate sample result.

Laboratory quality assurance and quality control will be maintained through adherence to the laboratory's internal quality assurance protocol during analysis. Lab QC sample frequency guidelines are specified in laboratory quality assurance (QA) plans.

Laboratory analysis for groundwater samples will include (at a minimum) the following types of QC samples:

- Laboratory preparation blanks;
- Matrix spike duplicates;
- Laboratory duplicates; and
- Laboratory control standards.

Target control limits for laboratory preparation blanks are no contaminants present above laboratory detection limits. Target laboratory duplicate sample control limits for inorganic constituents will be the same as those described above for field duplicates. Target control limits for matrix (pre-digestion) spike duplicates will be recovery in the range of 75 to 125%. Target control limits for laboratory control standards (LCSs) will be recovery in the range of 80 to 120%.

7.2.2 Instrument Maintenance and Calibration

Routine maintenance and calibration of field instruments (SC meter, dissolved oxygen meter, pH meter, etc.) will be accomplished through following manufacturer's recommendations and accepted field practice. Field instruments will be checked for proper performance prior to the initiation of field work. Backup instruments or provisions to obtain backup instruments at short notice should be in place prior to the initiation of field work to prevent loss of information due to instrument malfunction.

Calibration of laboratory instruments will be guided by the selected laboratory's internal quality assurance QA plan. Instrument calibration information will be retained by the laboratory and may be examined as necessary during the data review process.

Maintenance of laboratory instruments will be the responsibility of laboratory personnel, and will be conducted in such a manner as to minimize instrument downtime and interruption of analytical work. Trained staff will be responsible for routine maintenance; if major repairs become necessary, authorized technicians will be responsible for repairing instruments. The laboratory will archive maintenance records for all analytical instruments and will provide such information upon request.

In the event that analytical problems arise (e.g. matrix interferences or other problems), the laboratory will be responsible for notifying the project manager and QA/QC Officer. The resolution of analytical problems will be determined cooperatively by the project managers in consultation with the analytical laboratory.

7.2.3 Data Management and Documentation

Field data (including copies of field notebooks) will be reviewed for completeness and archived in the project file following completion of the field sampling event. Sample collection information will be checked to ensure that appropriate field parameter data have been collected for all sampling locations and that all samples have been collected as specified in the SMP and assigned appropriate sample numbers.

The laboratory will provide analytical data for samples in both hard copy and electronic format for transfer to a project-specific database. The laboratory will review data prior to submission to check for transcription errors, and to ensure that all required documentation is included in the submittal package. Documentation for analytical results will include, at a minimum:

- Chains-of-custody;
- Cover sheet indicating analysis;
- Tabulated analytical results;
- Tabulated reporting limits; and
- QC sample results.

The project database will be maintained in a format amenable to queries and reporting of data in common electronic or hard copy format (i.e., the database will be capable of generating spreadsheet tables, summary data reports, etc. as requested by project personnel).

7.3 ASSESSMENT/OVERSIGHT

Regulatory personnel may provide oversight during implementation of the CAMU SMP. Agency approval of this SMP (following an initial review and comment period) will serve as the first step in ensuring the project is implemented in a manner consistent with the monitoring objectives. During the field sampling and analysis phase of the project, oversight personnel may conduct audits or assessments of field crews, equipment, record-keeping procedures, laboratory personnel or procedures, or other project team members at their discretion. Oversight personnel may also require the analysis of performance evaluation (PE) samples, and may request splits of any samples collected during the field efforts to verify the reliability of analytical data generated by the laboratory.

As data collected under the guidance of this SMP is received and reviewed, data summary and statistical reports will be prepared as described in Section 6.0 to advise project personnel of results, including QC results. Nonconformance with established quality assurance and/or quality control procedures for the project may result in corrective actions in the field or

laboratory. The scope of any corrective actions will depend on the particular violation of QA/QC protocols and the potential effects on the end use of the data. Examples of corrective actions are resampling of critical sites or reanalysis of particular parameters. Any corrective actions will be fully documented by field or laboratory personnel, and documentation will be retained in the project file.

7.4 DATA VERIFICATION AND USABILITY

A review of field and analytical data will be conducted following receipt of the laboratory data package. The data review will focus on the following QA/QC parameters:

- Completeness of sampling and analysis (correct number and types of samples collected, analyzed for the correct parameters);
- Completeness of field and laboratory documentation (information in field notebooks and on laboratory reports is complete and correct relative to project requirements);
- Holding times;
- Field QC sample results; and
- Laboratory QC sample results.

Data review procedures and application of data qualifiers will follow the general guidance given in *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2002), consistent with procedures currently used for review and qualification of the post-RI groundwater data. Data qualifiers will be assigned to data outside of target quality control criteria. A summary of the data qualifier codes is shown in Table 7-1.

Results of the data quality review will be included as part of the annual GMR submittal (Section 4.3). The primary focus of the data quality review will be an estimate of the effects any deviations from approved procedures may have on the project objectives or data uses.

8.0 REFERENCES

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Hydrometrics, 2007b. Technical Inspection Report, Corrective Action Management Unit (CAMU) Phase I Cell, Asarco East Helena. Prepared for Asarco, LLC. Revised January 2007.

FIGURES

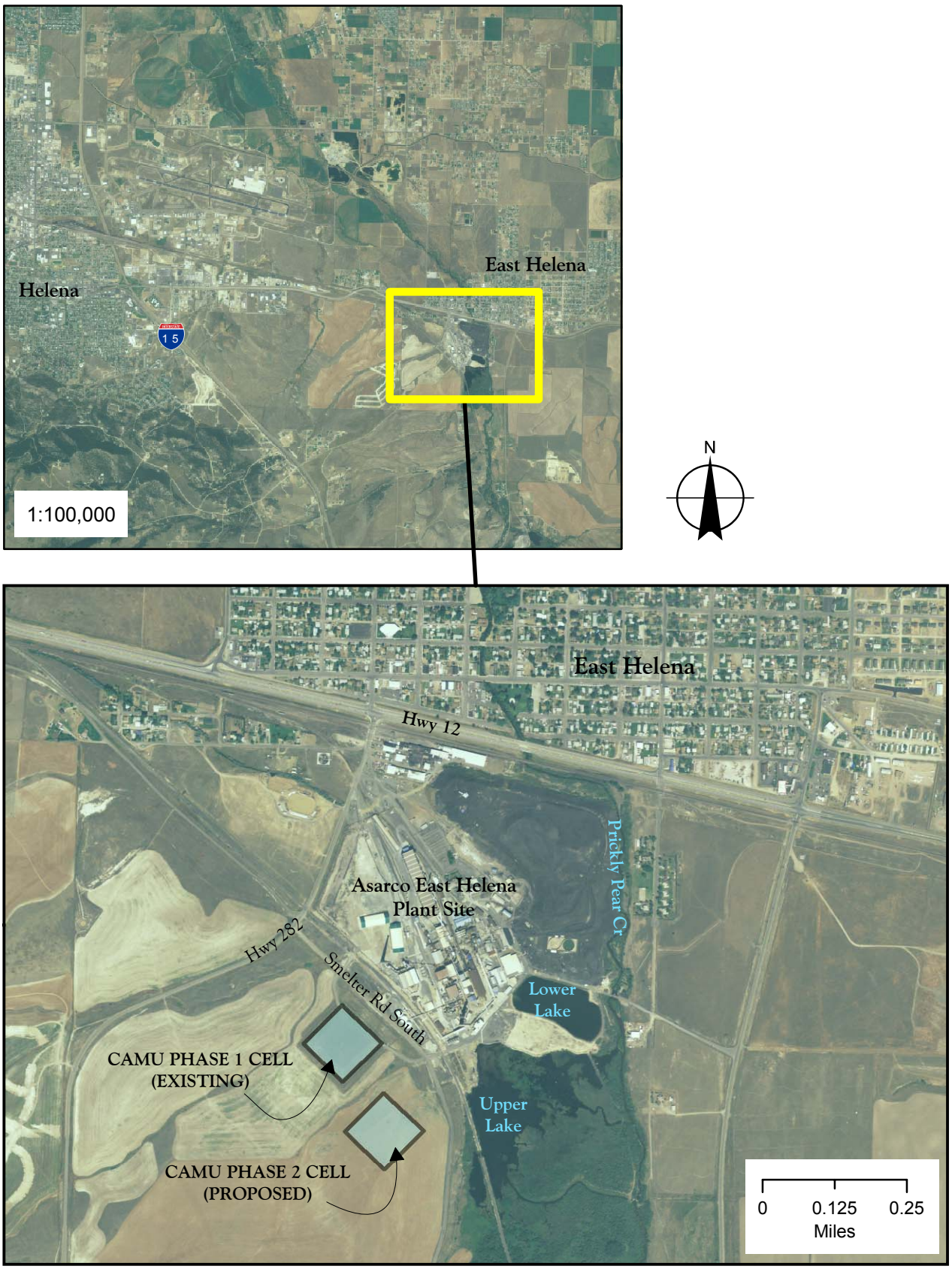

Figure 1-1
Asarco East Helena
General Location Map

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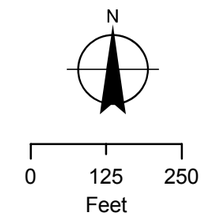

NOTE: Elevations shown are November 2006 water level elevations. NM = not measured.

Potentiometric surface based on contours and interpretation presented in CAMU Phase 1 Cell Technical Inspection Report (Hydrometrics, 2007b).

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Figure 1-2
Asarco East Helena
CAMU Area Monitoring Wells and November 2006 Water Levels

TABLES

TABLE 2-1. GROUNDWATER QUALITY OF ASARCO EAST HELENA CAMU MONITORING WELLS

Parameter/ Statistic		Monitoring Location						
		MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7
Number of Samples		12	12	12	12	11	8	7
pH	average	7.15	6.92	6.90	7.21	7.45	6.96	7.46
	standard deviation	0.61	0.44	0.38	0.59	0.59	0.57	0.86
SC	average	425	524	615	485	337	665	223
	standard deviation	22	26	26	29	22	53	17
arsenic	average	0.005	0.012	0.011	0.004	0.007	0.159	0.017
	standard deviation	0.001	0.004	0.001	0.001	0.001	0.050	0.005
cadmium	average	0.0010	0.0010	0.0010	0.0011	0.0010	0.0010	0.0010
	standard deviation	0	0	0	0.0003	0	0	0
copper	average	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	standard deviation	0	0	0	0	0	0	0
lead	average	0.0052	0.0050	0.0050	0.0050	0.0050	0.0055	0.0050
	standard deviation	0.0006	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000
iron	average	0.055	0.055	0.027	0.030	0.025	0.219	0.037
	standard deviation	0.088	0.082	0.016	0.024	0.010	0.037	0.021
manganese	average	0.020	0.289	0.028	0.019	0.019	4.990	0.022
	standard deviation	0.004	0.021	0.004	0.003	0.003	0.302	0.010
zinc	average	0.019	0.019	0.019	0.019	0.019	0.019	0.018
	standard deviation	0.003	0.003	0.003	0.003	0.003	0.004	0.004
calcium	average	48.0	72.8	84.6	58.2	38.4	93.6	18.7
	standard deviation	3.1	4.4	4.9	3.6	3.4	6.5	1.2
magnesium	average	10.2	16.2	19.3	12.4	7.8	20.3	5.5
	standard deviation	0.6	0.8	1.1	0.8	0.7	1.6	0.5
sodium	average	25.1	20.6	23.2	29.6	24.1	25.3	19.5
	standard deviation	1.2	1.0	1.3	1.7	1.4	1.8	1.5
potassium	average	5.1	5.3	6.0	6.4	4.7	5.2	5.1
	standard deviation	0.2	0.5	0.6	0.7	0.5	0.4	0.2
sulfate	average	72.3	22.7	53.5	68.8	35.3	60.0	21.8
	standard deviation	8.2	7.6	9.4	10.9	9.0	26.4	5.4
chloride	average	13.2	6.4	10.3	9.8	6.9	9.4	2.5
	standard deviation	2.4	1.1	1.3	1.4	1.7	2.1	1.4
bicarbonate	average	150	298	311	206	166	351	109
	standard deviation	21.7	6.8	8.1	12.0	10.3	6.7	5.4

NOTES: Concentrations are mg/L, except pH (s.u.) and SC (µmhos/cm).
Statistics based on Fall 2000 through Spring 2006 monitoring period.
Below laboratory detection limit values replaced with the laboratory detection limit for calculation of statistics.
Metals concentrations expressed as dissolved.

TABLE 3-1. CAMU GROUNDWATER MONITORING WELL COMPLETION DETAILS

SITE	LOCATION	TOTAL DEPTH (ft bgs)	SCREENED INTERVAL (ft bgs)	TARGET AQUIFER	MEASURING POINT ELEVATION (ft amsl)
MW-1	Southwest of CAMU Cell 1	68	58-68	Volcanic Ash	3949.43
MW-2	Northwest of CAMU Cell 1	66	56-66	Volcanic Ash	3942.36
MW-3	Northeast of CAMU Cell 1	50	38.5-50	Volcanic Ash	3937.38
MW-4	Southeast of CAMU Cell 1	72	54-64	Volcanic Ash	3943.52
MW-5	Northwest of CAMU Cell 2	71	55-65	Volcanic Ash	3952.52
MW-6	East of CAMU Cell 1	40	30-40	Shallow Alluvium	3934.54
MW-7	West of CAMU Cell 1	60	44-59	Volcanic Ash	3959.99
MW-8	Southeast of CAMU Cell 2	70	44.5-64.5	Volcanic Ash	3954.97
MW-9	Southwest of CAMU Cell 2	70	50-70	Volcanic Ash	3961.72
MW-10	Northeast of CAMU Cell 2	70	42-62	Volcanic Ash	3942.60
MW-11	West of CAMU Cell 2	70	50-70	Volcanic Ash	Survey Pending

ft bgs = feet below ground surface
ft amsl = feet above mean sea level

TABLE 3-2. CAMU GROUNDWATER MONITORING SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Matrix	Parameter(s)	Filtration	Container	Preservation
Water	Dissolved Metals	Yes (0.45-µm filter)	500 mL polyethylene	HNO_3 to pH <2; cool to 4°C
	Major Cations/Anions and Physical Parameters	No	1000 mL polyethylene	Cool to 4°C

TABLE 3-3. CAMU GROUNDWATER ANALYTICAL PARAMETER LIST

Parameter	Analytical Method[1]	Practical Quantitation Limit (mg/L)
Field Parameters		
pH	Field SOP	None
Specific conductance	Field SOP	None
Dissolved oxygen	Field SOP	None
Water temperature	Field SOP	None
Water level	Field SOP	None
Laboratory Parameters		
Major Cations/Anions and Physical Parameters		
Calcium (Ca)	215.1/200.7	5
Magnesium (Mg)	242.1/200.7	5
Sodium (Na)	273.1/200.7	5
Potassium (K)	258.1/200.7	5
Sulfate (SO4)	300.0	1
Chloride (Cl)	300.0	1
Total alkalinity as $CaCO_3$	310.1	5
Total dissolved solids	160.1	10
Specific Conductance	120.1	None
Metals (Dissolved)		
Aluminum (Al)	200.7/200.8	0.1
Antimony (Sb)	200.7/200.8	0.005
Arsenic (As)	200.7/200.8	0.005
Arsenic III/V	E 1632A M	0.005
Barium (Ba)	200.7/200.8	0.1
Beryllium (Be)	200.7/200.8	0.001
Cadmium (Cd)	200.7/200.8	0.001
Chromium (Cr)	200.7/200.8	0.001
Cobalt (Co)	200.7/200.8	0.01
Copper (Cu)	200.7/200.8	0.004
Iron (Fe)	200.7/200.8	0.02
Lead (Pb)	200.7/200.8	0.005
Manganese (Mn)	200.7/200.8	0.015
Mercury (Hg)	200.8/245.1	0.006
Nickel (Ni)	200.7/200.8	0.01
Selenium (Se)	200.7/200.8	0.005
Selenium IV/VI	SM 3114B M	0.005
Silver (Ag)	200.7/200.8	0.005
Thallium (Tl)	200.7/200.8	0.002
Tin (Sn)	200.7/200.8	0.1
Vanadium (V)	200.7/200.8	0.01
Zinc (Zn)	200.7/200.8	0.02

NOTES: (1) Field Standard Operating Procedures (SOPs) approved for previous work at the Asarco East Helena Site will be used as guidance for collection of field water quality parameters. Laboratory analytical methods are from EPA's *Methods for Chemical Analysis of Water and Wastes* (1983); supplemental EPA methods (E), or *Standard Methods for the Examination of Water and Wastewater* (SM). M = modified.

TABLE 3-4. CONCENTRATION LIMITS FOR CONSTITUENTS OF CONCERN

	Well-Specific Concentration Limits (mg/L)						
Parameter	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7
Arsenic (As)	0.008	0.019	0.013	*0.015*	0.009	0.254	0.027
Cadmium (Cd)	**0.001**	**0.001**	**0.001**	*0.003*	**0.001**	**0.001**	**0.001**
Copper (Cu)	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**	*0.012*	**0.004**
Iron (Fe)	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*	0.29	0.08
Lead (Pb)	*0.015*	**0.005**	**0.005**	*0.015*	**0.005**	*0.015*	**0.005**
Manganese (Mn)	*0.045*	0.336	0.036	**0.015**	*0.045*	5.55	*0.045*
Zinc (Zn)	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**

NOTE: Concentration limits derived from existing metals data set for each well as follows:

[1] If all data below reporting limits, concentration limit set at the PQL (Table 3-3). These parameters denoted in **bold type**.

[2] If >50% of data below reporting limits, concentration limit set at 3x the PQL (Table 3-3). These parameters denoted in *italic type*.

[3] If <=50% of data below reporting limits, concentration limit set at the average plus two standard deviations. These data denoted in normal font.

TABLE 7-1. DATA VALIDATION CODES AND DEFINITIONS

CODE	DEFINITION
J -	The associated numerical value is an estimated quantity because quality control criteria were not met. Subscripts for the "J" qualifier: 2- Deviation from required calibration procedures, calibration range exceeded, or poor recovery on a known standard. Possible bias. 3- Holding time not met. Indicates possible low bias. 4- Other quality control outside control limits.
UJ -	The "U" indicates that the material was analyzed for, but was not detected. The "J" indicates that the associated value is an estimate. Subscripts for the "UJ" qualifier are applied as follows: 1- Blank contamination. Indicates possible high bias and/or false positive 2- Deviation from required calibration procedures, calibration range exceeded, or poor recovery on a known standard. Possible bias. 3- Holding time not met. Indicates possible low bias. 4 - Other quality control outside control limits.
R -	Quality control indicates that the data are unusable (compound may or may not be present). Resampling and/or reanalysis is necessary for verification.

ATTACHMENT A

MONITORING WELL LOGS

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Well Log and Construction Diagram

Hole Name: MW-1

Date Hole Started: 6/25/97 Date Hole Finished: 6/26/97

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NE, SW Section 36, T10N, R3W
Location Description:

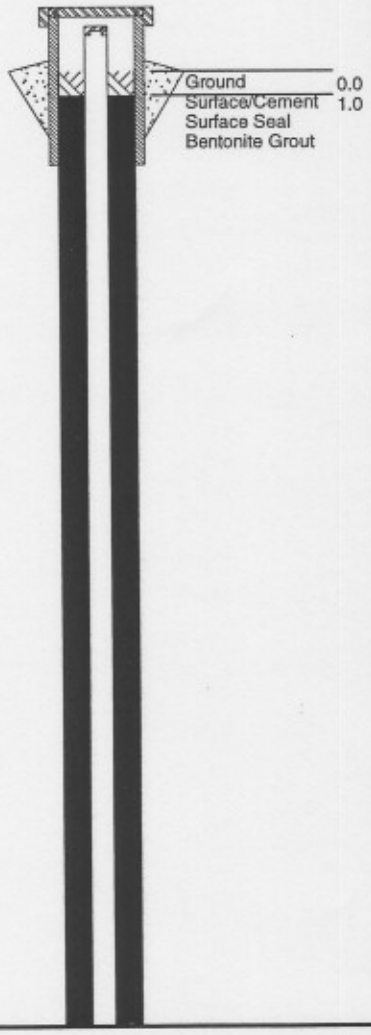
Recorded By: John Ruth
Drilling Company: O'Keefe Drilling
Driller: Dan Duran
Drilling Method: Air Rotary with casing drive
Drilling Fluids Used: None
Purpose of Hole: Groundwater monitoring well
Target Aquifer: First Water
Hole Diameter (in): 7
Total Depth Drilled (ft): 68

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch PVC casing	+1.9-68.0
Surface Casing Used?	Y	6-inch steel	+2.0 - 3.0
Screen/Perforations?	Y	0.010 slot PVC screen	58.0 - 68.0
Sand Pack?	Y	10-20 silica sand	55.0 - 68.0
Annular Seal?	Y	Bentonite grout, bentonite chips	1.0 - 51.0, 51.0 - 55.0
Surface Seal?	Y	Cement pad	0.0 - 1.0
DEVELOPMENT/SAMPLING			
Well Developed?	N		
Water Samples Taken?	N		
Boring Samples Taken?	Y	lithologic identification	

Northing: 9145.74 Easting: 7019.35
Static Water Level Below MP: 50.21
Date: 7/21/00
MP Description: Top of PVC
MP Height Above or Below Ground (ft): 1.65
Surface Casing Height (ft): 2.0
Riser Height (ft): 1.88
Ground Surface Elevation (ft): 3947.78
MP Elevation (ft): 3949.43

Remarks: Drilling performed with a Drilltech DH40 air rotary with casing drive drilling rig.

WELL CONSTRUCTION



SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Silty Clay**
Light brown, tan, soft, trace coarse grained sand, dry, loose, trace rounded fine gravel

5.0 - 10.0' **Silty Clay**
As above, grading to clayey silt (ML) in part, very slightly moist, trace coarse grain sand, very soft, low plasticity.

10.0 - 15.0' **Silty Clay**
As above, grading to clayey silt (ML), trace coarse sand and fine gravel.

15.0 - 20.0' **Silty Clay**
As above, grading to clayey silt (ML), slightly darker brown, very slightly moist to dry.

20.0 - 25.0' **Silty Clay**
Rust brown becoming gravelly with 1/4 - 1/2" size gravel.

25.0 - 30.0' **Sandy Gravel**
1/4 - 3/4" size gravel, angular, trace subrounded, basalt, quartzite, fine to coarse sand, unconsolidated, dry.

30.0 - 36.0' **Sandy Gravel**
As above, angular fine gravel, tough drilling.

36.0 - 40.0' **Gravelly Silty Clay**
Orange brown, 8% fine angular gravel, 10% fine to coarse grain sand, very slightly moist, unconsolidated, low plasticity.

Continued Next Page

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

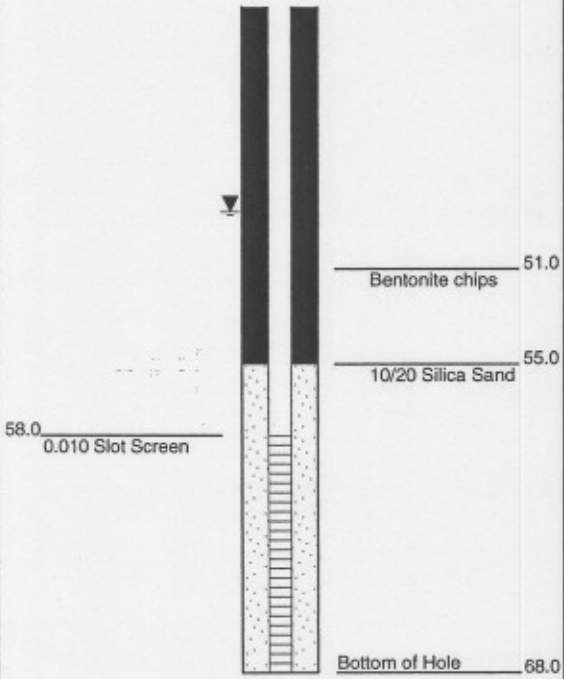
Consulting Scientists and Engineers
Helena, Montana

Well Log and Construction Diagram

Hole Name: MW-1

Date Hole Started: 6/25/97 Date Hole Finished: 6/26/97

WELL CONSTRUCTION



SAMPLE NOTES	GRAPHICS	GEOLOGICAL DESCRIPTION
		40.0 - 45.0' **Sandy Clay** Light tan, fine to medium grain sand, moderately sorted, damp to very damp, very soft, low plasticity. [Ash]
		45.0 - 50.0' **Sandy Clay** As above, damp, soft, sticky, 20% fine to coarse sand, trace fine angular gravel, damp. [Ash]
		50.0 - 55.0' **Sandy Clay** As above, 10% fine to medium grain sand, soft, very damp. [Ash]
		55.0 - 60.0' **Clayey Sand** Light tan, fine to medium grain, 5% coarse grain, loose, wet. [Ash]
		60.0 - 68.0' **Clayey Sand** Coarser than above, medium to coarse grain, trace fine gravel, wet. [Ash]

STANDARD_REV4 1064.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Well log and construction diagram

Hole Name: MW-2

Date Hole Started: 6/26/97 Date Hole Finished: 6/27/97

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NE, SW Section 36, T10N, R3W
Location Description:

Recorded By: John Ruth/John Ballantyne
Drilling Company: O'Keefe Drilling
Driller: Dan Duran
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Water quality monitoring
Target Aquifer: First Water
Hole Diameter (in): 7
Total Depth Drilled (ft): 66

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+1.9-66.0
Surface Casing Used?	Y	6-inch steel	+2.0 - 3.0
Screen/Perforations?	Y	0.010 slot PVC screen	56.0 - 66.0
Sand Pack?	Y	10-20 silica sand	53.0 - 66.0
Annular Seal?	Y	Bentonite grout, bentonite chips	1.0 - 49.0, 49.0 - 53.0
Surface Seal?	Y	Cement pad	0.0-1.0
DEVELOPMENT/SAMPLING			
Well Developed?	N		
Water Samples Taken?	N		
Boring Samples Taken?	Y	lithologic identification	

Northing: 9564.62 Easting: 6981.24
Static Water Level Below MP: 35.01
Date: 7/21/00
MP Description: Top of PVC
MP Height Above or Below Ground (ft): 1.79
Surface Casing Height (ft): 2
Riser Height (ft): 1.87
Ground Surface Elevation (ft): 3940.57
MP Elevation (ft): 3942.36

Remarks:

WELL CONSTRUCTION

SAMPLE NOTES	GRAPHICS	GEOLOGICAL DESCRIPTION
		0.0 - 5.0' **Clayey Gravelly Sand** Light brown, fine to coarse sand, loose, slightly moist, 5% fine gravel, subrounded.
		5.0 - 10.0' **Sandy Silty Clay** Orange, brown, soft, slightly moist, 35% fine to medium grained sand, trace coarse grained, trace fine gravel.
		10.0 - 15.0' **Silty Clay** Orange brown, low plasticity, grading to clayey silt, very slightly moist, trace sand and fine gravel.
		15.0 - 20.0' **Silty Clay** As above.
		20.0 - 25.0' **Silty Clay** Orange, brown, 5% fine to coarse sand, trace fine gravel, low plasticity, slightly moist.
		25.0 - 30.0' **Sandy Gravel** Gray, black, red brown, 1/4 - 3/4", angular to subrounded, 15% fine to coarse grain sand, dry, unconsolidated.
		30.0 - 34.0' **Sandy Gravel** Fine gravel as above, subangular, predominantly basalt, limestone and quartzite, loose, dry, hard drilling.
		34.0 - 40.0' **Silty Clay** Tannish white, changing to orange brown, low plasticity, soft, trace fine to medium grain sand, very moist to damp. [Ash]

Continued Next Page

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Well log and construction diagram

Hole Name: MW-2

Date Hole Started: 6/26/97 Date Hole Finished: 6/27/97

WELL CONSTRUCTION

SAMPLE NOTES	GRAPHICS	GEOLOGICAL DESCRIPTION
		40.0 - 45.0' **Silty Clay** As above, tan, 10% angular fine to coarse sand, drilling with water so unsure of water contact, sample material moderately sticky. [Ash]
		45.0 - 50.0' **Silty Clay** As above, trace angular fine to coarse sand, difficult to drive casing to sticky clays. [Ash]
		50.0 - 55.0' **Silty Clay** With fine to coarse sand and gravel size fragments of weathered ash ??, tan color, can break with fingers, but casing driving very hard, casing TD at 52.5'. [Ash]
		55.0 - 65.0' **Ash/Tuff** Sand size material, assume to be weathered ash/tuff, siliceous, subrounded to angular fragments, making 10+ gpm, very minor silt and clay, fragments are tan to white to pink in color, some chert present. [Ash]

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Well log and construction diagram

Hole Name: MW-3

Date Hole Started: 6/27/97 Date Hole Finished: 6/30/97

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NW, Sw, Section 36, T10N, R3W
Location Description:

Recorded By: JB/GH
Drilling Company: O'Keefe Drilling
Driller: Dan Duran
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Water quality monitoring
Target Aquifer: First Water
Hole Diameter (in): 7
Total Depth Drilled (ft): 50

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+2.3 - 48.0
Surface Casing Used?	Y	6-inch steel	+2.5 - 2.5
Screen/Perforations?	Y	0.010-inch slot, Sch 40, PVC	38.5 - 48.0
Sand Pack?	Y	10-20 silica sand	37.0 - 48.0
Annular Seal?	Y	Bentonite Grout, 3/8" bentonite chips	1.0-33.0, 33.0-37.0
Surface Seal?	Y	Cement pad	0.0-1.0
DEVELOPMENT/SAMPLING			
Well Developed?	N		
Water Samples Taken?	N		
Boring Samples Taken?	Y	lithologic identification	

Northing: 9585.79 Easting: 7367.42
Static Water Level Below MP: 30.49 Surface Casing Height (ft): 2.50
Date: 7/21/00 Riser Height (ft): 2.31
MP Description: Top of PVC Ground Surface Elevation (ft): 3935.84
MP Height Above or Below Ground (ft): 1.54 MP Elevation (ft): 3937.38

Remarks:

WELL CONSTRUCTION

SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Silty Clay**
Grading to clayey silt, tan to light brown, very minor sand and gravel (angular) slightly moist, slightly sticky, plastic.

5.0 - 10.0' **Clayey Silty Sand**
Tan to light brown,minor angular gravel, loose, dry to slightly moist, 15-20% gravel.

10.0 - 15.0' **Silty Sand**
Red, brown, fine grain, 15% silt, minor clay and very minor coarse sand and gravel, loose, dry to slightly moist.

15.0 - 19.0' **Silty Sand**
As above, with increase in gravel at 18-19'

19.0 - 25.0' **Sandy Gravel**
Dry, loose, subangular to subrounded, generally <1" diameter, multi-colored, 20% fine to coarse sand, hard drilling from 19-25'

25.0 - 30.0' **Sandy Gravel**
Dry, loose, subangular to subrounded, but not as large material as above, generally <1/2", some fragments very angular, very minor silt and clay, 40% sand, 60% fine gravel.

30.0 - 35.0' **Silty Clay**
Tan to brown, with coarse sand and minor angular gravel, damp, slightly plastic and sticky, gravel fragments are limestone and basalt.
[Ash]

35.0 - 40.0' **Silty Clay**
Tan color, moderately sticky and plastic, trace coarse sand and gravel, damp, orange brown to tan at 40', casing driving hard at 40', lithified ash or bedrock?
[Ash]

Continued Next Page

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Well log and construction diagram

Hole Name: MW-3

Date Hole Started: 6/27/97 Date Hole Finished: 6/30/97

WELL CONSTRUCTION	SAMPLE NOTES	GRAPHICS	GEOLOGICAL DESCRIPTION
Bottom of Hole 50.0			40.0 - 45.0' **Clayey Sand** Fine to coarse sand, subangular to subrounded, wet. [Ash]
			45.0 - 50.0' **Clayey Sand** As above, water free in hole, 15% gravel, coarse, subrounded. [Ash]

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-4

Date Hole Started: 5/8/2000 Date Hole Finished: 5/10/00

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NW, NW, SE, Sec. 36 T10N, R3W
Location Description:

Recorded By: JR
Drilling Company: Hydrometrics, Inc.
Driller: Ron Meinstma
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Water(approximately 200 gallons)
Purpose of Hole: CAMU Monitoring Well
Target Aquifer: First Water
Hole Diameter (in): 6
Total Depth Drilled (ft): 72

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+2.6-72
Surface Casing Used?	Y	5-inch steel	+3 to -2
Screen/Perforations?	Y	0.010-inch slot, Sch 40, PVC	54-64
Sand Pack?	Y	10-20 silica sand	50-70
Annular Seal?	Y	Bentonite Pellets/Bentonite Grout	48-50 pellets, 1-48 grout
Surface Seal?	Y	Cement	0-1
DEVELOPMENT/SAMPLING			
Well Developed?	Y	pumping	
Water Samples Taken?	Y	common ions, metals	
Boring Samples Taken?	Y	lithologic identification	

Northing: 9179.4484 Easting: 7414.9809
Static Water Level Below MP: 45.26
Date: 7/21/00
MP Description: Top of PVC
MP Height Above or Below Ground (ft): 2.44

Surface Casing Height (ft): 2.6
Riser Height (ft): 2.4
Ground Surface Elevation (ft): 3941.08
MP Elevation (ft): 3943.52

Remarks: Depth water encountered: 52'

WELL CONSTRUCTION

SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Silt**
Tan, whitish tan, dense.

5.0 - 7.0' **Silt**
Whitish tan, trace clayey, no plasticity, dense, trace fine gravel, formation is dry, driller adding some water.

7.0 - 10.0' **Silt**
Whitish tan, trace clayey, no plasticity, dense, trace fine gravel, formationis dry, driller adding some water.

10.0 - 12.0' **Silt**
Whitish tan, trace clayey, no plasticity, dense, trace fine gravel, formation is dry, driller adding some water. Clayey silt from 10-10.5'

12.0 - 15.0' **Silt**
Whitish tan, trace clayey, no plasticity, dense, trace fine gravel, formation is dry, driller adding some water.

15.0 - 17.0' **Silt/Gravelly Silt**
Silt as above, tan, lightish brown, slightly clayey, changing to gravelly sand at 16', dry, unconsolidated, abundant cobbles.

17.0 - 20.0' **Gravelly Sand**
Light brown, fine grain - 10%, medium grain, moderately sorted, 35% fine gravel, unconsolidated, abundant 3-4" gravels and cobbles.

20.0 - 22.0' **Gravels**
Gray, medium sized 1/2 to 1" in size, abundant cobbles 3-5", difficult drilling, 20% fine grain sand, dry.

22.0 - 31.0' **Sandy Gravels**
As above, gravels and cobbles dry.

31.0 - 40.0' **Ash-Silty**
Tan, black flecks, biotite(?), basalt fragments (?), loose to medium dense, moderately cemented in part dry, becoming moist at 39'.
[Ash]

40.0 - 42.0' **Ash-Silty**
Tan, speckled black, moderately to well cemented, dense to hard, dry to moist.
[Ash]

42.0 - 50.0' **Ash-Silty**
As above, tan, speckled black, dense to hard, driller adds water.
[Ash]

50.0 - 52.0' **Ash-Silty Sandy**
Tan, very fine to fine grain. 10% medium to coarse grain, poorly sorted, firm, 30% silt, appears to be weathered ash, making 6 gpm.
[Ash]

52.0 - 60.0' **Ash w/Gravel**
Black, brown, fine to coarse grain, difficult drilling, driller adding water.
[Ash]

60.0 - 62.0' **Ash-Clayey Sandy**
Brown, tan, mottled yellow and white, very fine to fine grain, 5% clayey, non-plastic, 5% medium grain, moderately to well sorted, firm, moist, driller adding water. Coarse sand at top of spoon, may be washed slough.

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STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-4

Date Hole Started: 5/8/2000 Date Hole Finished: 5/10/00

WELL CONSTRUCTION	SAMPLE NOTES	GRAPHICS	GEOLOGICAL DESCRIPTION
			[Ash] 62.0 - 70.0' **Ash-Sandy Silt** Tan, yellow, white, 20% very fine to fine sand, 3% medium to coarse sand, sorted firm, no plasticity, moist, driller adding water, abundant mica. [Ash] 70.0 - 72.0' **Ash-Sandy Silt** As above. [Ash]

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-5

Date Hole Started: 5/11/2000 Date Hole Finished: 5/12/2000

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NE, NE, SW, Sec. 36 T10N, R3W
Location Description:

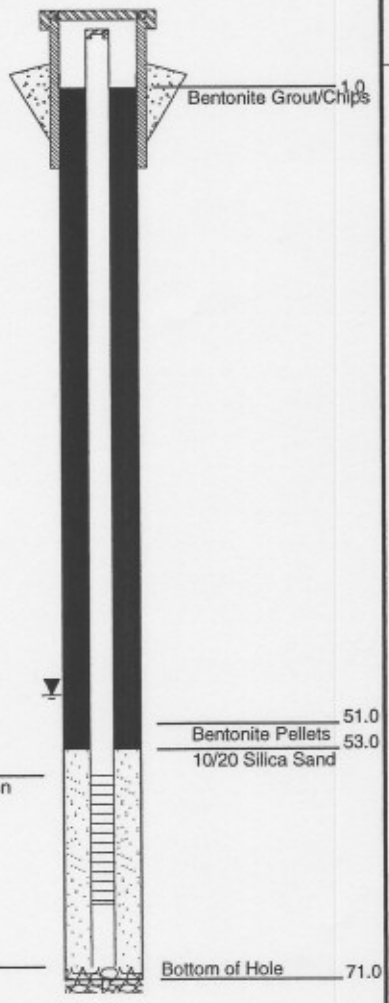
Recorded By: JR
Drilling Company: Hydrometrics, Inc.
Driller: Ron Meinstma
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Water(approximately 80 gallons)
Purpose of Hole: CAMU Monitoring Well
Target Aquifer: First Water
Hole Diameter (in): 6
Total Depth Drilled (ft): 71

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+2.9-65
Surface Casing Used?	Y	5-inch steel	+3 to -2
Screen/Perforations?	Y	0.010-inch slot, Sch 40, PVC	55-65
Sand Pack?	Y	10-20 silica sand	53-70
Annular Seal?	Y	Bentonite Pellets	6-51 grout, 51-53 chips
Surface Seal?	Y	Cement	0-1
DEVELOPMENT/SAMPLING			
Well Developed?	Y	pumping	
Water Samples Taken?	Y	common ions, metals	
Boring Samples Taken?	Y	lithologic identification	

Northing: 8841.6307 Easting: 7219.2612
Static Water Level Below MP: 51.64
Date: 7/21/00
MP Description: Top of PVC
MP Height Above or Below Ground (ft): 2.90
Surface Casing Height (ft): 3.0
Riser Height (ft): 2.9
Ground Surface Elevation (ft): 3949.62
MP Elevation (ft): 3952.52

Remarks: Samples collected with 3-inch diameter spoons on 2 7/8-inch rods, driven by a 300 lb/30-inch drop auto hammer.

WELL CONSTRUCTION



SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Gravelly Silt**
Tan, brown, 1-2" size angular gravel, loose, dry.

5.0 - 7.0' **Silt**
Tan, trace, very fine grain sand, loose, dry.

7.0 - 10.0' **Gravelly Silt**
Silt as above, 3% fine to medium gravels, dry.

10.0 - 12.0' **Gravelly Silt**
Tan, dark brown, 10% fine to coarse gravel, abundant basalt gravel, gravel up to 3 inches in size.

12.0 - 15.0' **Silt**
Brown, dry, loose.

15.0 - 17.0' **Silt**
Brown, semi-loose to loose, trace fine to medium sand.

17.0 - 19.5' **Silt**
As above, encounter fine to large gravel at 14.5'. Driller adding water.

20.0 - 22.0' **Silt**
Brown, trace clayey, low to no plasticity, moist, driller adding water, coarse gravels at 22'.

22.0 - 30.0' **Gravels**
Black, white, coarse size gravels, difficult drilling, dry, driller adding water.

30.0 - 31.0' **Sandy Gravel**
Sand changing to sandy gravel. 6" of brown, fine to medium grain sand, moderately sorted, changing to coarse gravels and cobbles, subrounded gravels to 3"in size, abundant basalt gravel and cobbles. Driller adding water.

31.0 - 40.0' **Silty Sand**
Tan, fine grained, 5% coarse grain, poorly sorted, 30% silt, tan, damp, no plasticity. 1" yellow-white clay at top of sample, high plasticity, damp.

50.0 - 52.0' **Silty Sand**
Tan, fine grained as above with 25% yellow-white clay as above, layered deposits for 1 foot. Then 10% fine gravels, subrounded.

60.0 - 62.0' **Clayey Sand**
Brown, tan, yellow, white, very fine to fine grained, poorly sorted, 20% yellow-white clay, fine to medium grained, plastic, weathered, wet, 5% fine to medium grained gravels, subrounded to subangular.
[Ash]

70.0 - 72.0' **Sandy Silt**
Yellow-white silt (tuff?), 10% fine sand, 3% coarse sand, moderate plasticity, micaceous.

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-6

Date Hole Started: 5/13/2000 Date Hole Finished: 5/14/2000

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NW, NW, SE, Sec. 36 T10N, R3W
Location Description:

Recorded By: JR
Drilling Company: Hydrometrics, Inc.
Driller: Ron Meinstma
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Water(approximately 40 gallons)
Purpose of Hole: CAMU Monitoring Well
Target Aquifer: First Water
Hole Diameter (in): 6
Total Depth Drilled (ft): 40

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+2.6-40
Surface Casing Used?	Y	5-inch steel	+3 tp -2
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	30-40
Sand Pack?	Y	10-20 silica sand	22-40
Annular Seal?	Y	Bentonite Pellets/Bentonite Grout	24-27 pellets, 1-24 grout
Surface Seal?	Y	Cement	0-1
DEVELOPMENT/SAMPLING			
Well Developed?	Y	pumping	
Water Samples Taken?	Y	common ions, metals	
Boring Samples Taken?	Y	lithologic identification	

Northing: 9236.7837 Easting: 7920.5073
Static Water Level Below MP: 26..68 Surface Casing Height (ft): 2.8
Date: 7/21/00 Riser Height (ft): 2.6
MP Description: Top of PVC Ground Surface Elevation (ft): 3931.92
MP Height Above or Below Ground (ft): 2.62 MP Elevation (ft): 3934.54

Remarks: Samples collected with 3-inch diameter spoons on 2 7/8-inch rods, driven by a 300 lb/30-inch drop auto hammer.

WELL CONSTRUCTION

SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Gravelly Silty Sand**
Brown, tan, very fine to fine grained, 15-20% silt, 15% fine angular gravel, dry. Driller adding water.

5.0 - 7.0' **Clayey Silt**
White, black speckles, resembles weathered volcanic ash, 2" of brown, gravelly silt, moist, poor split spoon recovery.

7.0 - 10.0' **Sandy Gravelly Silt**
Brown, tan, 15% very fine grain sand, 10% fine to medium sized gravel, dry.

10.0 - 12.0' **Gravelly Silt**
Brown, gray, orange brown, 10% fine grain sand, fine to coarse gravel, trace cobbles, gravel to 3" in size, dry.

12.0 - 15.0' **Gravelly Sand**
Brown, tan, fine to coarse sand, poorly sorted, fine to medium size gravel, loose, unconsolidated, driller adding water.

15.0 - 17.0' **Gravelly Sand**
Brown, orange brown in part, fine to medium grain, moderately sorted, 25% coarse to medium size gravel, subrounded, unconsolidated, dry.

17.0 - 20.0' **Gravelly Sand**
As above, slightly coarse, fine to coarse grain, 10% coarse grain, poorly sorted, unconsolidated, dry.

20.0 - 22.0' **Clayey Silt**
Light tan, mottled green, black speckled, orange brown from 21-22'. Appears to be weathered, volcanic ash, no plasticity, moist, dense, driller adding water. [ASH]

30.0 - 32.0' **Silt**
Brown, speckled, black, very moist, dense, crumbly, no plasticity, borehole making approx. 1 gpm.

38.0 - 40.0' **Sandy Gravels**
Brown, black, 1/4 - 1/2" size gravels in cuttings, borehole making 30-40 gpm.

40.0 - 42.0' **Silty Sand**
Brown, fine grain, 8% coarse grain, weakly cemented, 35% silt, borehole making approx. 40 gpm.
[ASH]

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-7

Date Hole Started: 5/16/2000 Date Hole Finished: 5/18/2000

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: NW, NE, SW, Sec 36 T10, R3W
Location Description:

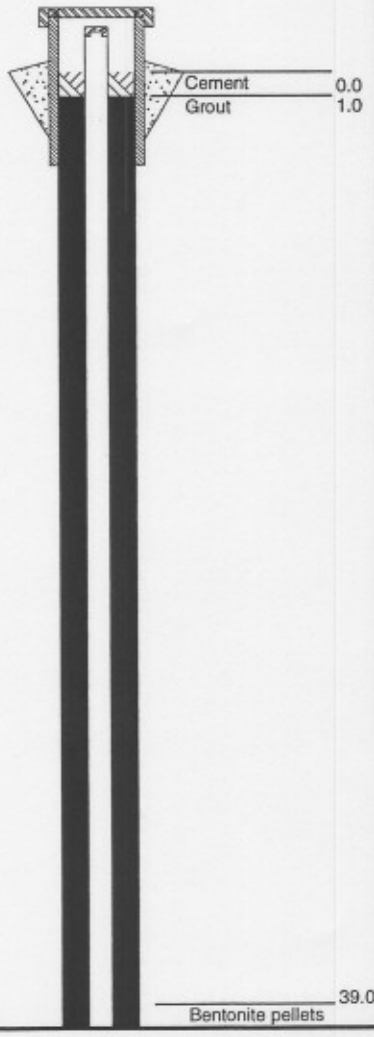
Recorded By: JR
Drilling Company: Hydrometrics, Inc.
Driller: Ron Meintsma
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Water(approximately 100 gallons)
Purpose of Hole: CAMU Monitoring Well
Target Aquifer: First Water
Hole Diameter (in): 6
Total Depth Drilled (ft): 60

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+2.3-59
Surface Casing Used?	Y	5-inch steel	+3 to -2
Screen/Perforations?	Y	0.010-inch slot, Sch 40, PVC	44-57
Sand Pack?	Y	10-20 silica sand	42-59
Annular Seal?	Y	Bentonite Pellets/Bentonite Grout	39-42 pellets, 1-39 grout
Surface Seal?	Y	Cement	0-1
DEVELOPMENT/SAMPLING			
Well Developed?	Y	pumping	
Water Samples Taken?	Y	common ions, metals	
Boring Samples Taken?	Y	lithologic identification	

Northing: 9235.2585 Easting: 6565.4048
Static Water Level Below MP: 54.88
Date: 7/21/00
MP Description: Top of PVC
MP Height Above or Below Ground (ft): 2.3
Surface Casing Height (ft): 2.5
Riser Height (ft): 2.3
Ground Surface Elevation (ft): 3957.69
MP Elevation (ft): 3959.99

Remarks: Samples collected with 3-inch diameter spoons on 2 7/8-inch rods, driven by a 300 lb/30-inch drop auto hammer.

WELL CONSTRUCTION



SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Gravelly Sand**
Brown, fine to coarse grain, poorly sorted, loose, dry, 15-20% fine to medium size gravel, angular.

5.0 - 7.0' **Gravelly Sand**
As above, fine to coarse grain, poorly sorted, 15-20% fine to medium size angular gravel; driller adding water.

7.0 - 10.0' **Gravelly Sand**
As above.

10.0 - 12.0' **Gravelly Sand**
As above, brown, fine to coarse grain, poorly sorted, 15% fine to medium size gravel, subangular, 5% coarse gravel and cobbles.

12.0 - 14.0' **Gravelly Sand**
As above, 20% fine to coarse size gravel. Brown clay from 14-15'.

15.0 - 17.0' **Silt**
Olive tan, v. fine sandy to clayey texture, medium dense, trace black speckles, appears to be weathered ash, moderately sorted from 15-15.5'; driller adding water.
[Top of Ash at 14']

17.0 - 20.0' **Silt**
As above, appears to be weathered volcanic ash.

20.0 - 22.0' **Silt**
Olive tan, orange brown, speckled black in part, hard and brittle in part, appears to be volcanic ash, changing to dense and firm, borehole, making trace water at 20', approx. 1 pint/min.

22.0 - 30.0' **Silt**
Olive tan, white and tan, speckled black, clayey in part, brittle to soft, low plasticity.

30.0 - 32.0' **Silt**
Olive brown, 5% fine grain sand, dense, firm-soft, trace brittle, appears to be weathered volcanic ash.

32.0 - 40.0' **Silt**
As above, soft to brittle, difficult drilling, driller adding water, trace sand and clay.

Continued Next Page

STANDARD_REV4 1054.GPJ HYDHLN1.GDT 9/26/06

Hydrometrics, Inc.

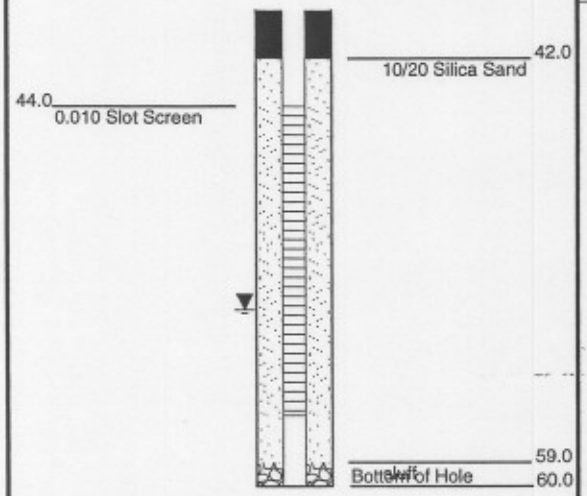
Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-7

Date Hole Started: 5/16/2000 Date Hole Finished: 5/18/2000

WELL CONSTRUCTION



SAMPLE NOTES	GRAPHICS	GEOLOGICAL DESCRIPTION
		40.0 - 42.0' **Sandy Silt** Olive brown, orange brown, dark gray, 10% fine to coarse sand, 50% fine grain sand from 41 to 41.5', sample appears to be weathered volcanic ash, moist.
		42.0 - 50.0' **Sandy Silt/Silty Sand** Olive brown, silt with 15% fine grain sand size material, clayey in part, changing to silty sand, predominantly fine grain ash?, very difficult drilling, seems well cemented.
		50.0 - 52.0' **Sandy Silt** Orange brown, tan, lime green, 10% fine to coarse sand, firm, dense to very dense, borehole making less than 1 gpm, dense from 50-50.5'.
		52.0 - 60.0' **Sandy Silt** Tan, light brown, 10% very fine grain sand, weakly cemented, firm, trace clayey, wet.
		60.0 - 62.0' **Silty Sand/Sandy Silt** Silty, very fine to medium grained sand sized material in silt, 20-30% moist, grading to sandy silt with clay and pea gravel at 61'. Sample more heterogeneous below 61' and stratified, some minor orange layers 4 mm thick, overall color light brown-cream. [Volcanic Ash]

STANDARD 9/26/06

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-8

Date Hole Started: 9/25/06 Date Hole Finished: 9/26/06

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: Sec 36 T10N, R3W
Location Description:

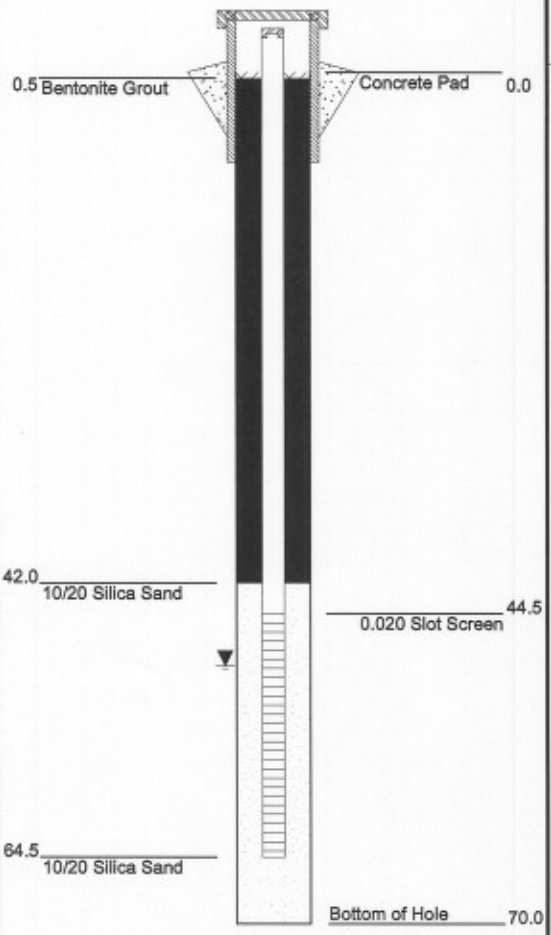
Recorded By: John Bergin
Drilling Company: Boland Drilling
Driller: Rick & Chuck
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Air/water
Purpose of Hole: Groundwater Monitoring Well
Target Aquifer: First Water
Hole Diameter (in): 4
Total Depth Drilled (ft): 70

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+2.12 - 64.5
Surface Casing Used?	Y	4" Steel	+2.41 - 2.59
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	44.5 - 64.5
Sand Pack?	Y	10-20 silica sand	42-70
Annular Seal?	Y	Bentonite Chips	0.5-42
Surface Seal?	Y	Cement	0-0.5
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailer/pump	
Water Samples Taken?	N		
Boring Samples Taken?	Y	lithologic identification	

Northing: 8376.8943 Easting: 7685.1041
Static Water Level Below MP: 50.91
Date: 11/2/06
MP Description: Top of PVC
MP Height Above or Below Ground (ft): 2.12
Surface Casing Height (ft): 2.41
Riser Height (ft): 2.12
Ground Surface Elevation (ft): 3952.82
MP Elevation (ft): 3954.97

Remarks:

WELL CONSTRUCTION



SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.5' **Silty Sand**
Top Soil, light brown, dry, loamy silt with sand and gravel (1/2"). Ash (white) layer approximately 0.5' thick at 15' bgs. Veins of ash @ 1.5'

1.5 - 21.0' **Silty Clayey Sand**
Light brown, moist (@5') clayey silt with sand to coarse sand. Some gravels (1/2")

21.0 - 23.0' **Sand**
Brown, moist silty sand - coarse sand (5%). Well graded / fine grained sand at approximately 21.5' bgs.

23.0 - 33.0' **Silty Gravel**
Gravel (1"), light brown moist silty sand (10%) (auger cuttings)

33.0 - 70.0' **Silty Sand**
Volcanic Ash - Some gravel. Light Yellow, moist silty sand. Increasing sand with depth, moderate cohesion.

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Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-9

Date Hole Started: 9/26/06 Date Hole Finished: 9/27/06

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: Sec 36 T10N, R3W
Location Description:

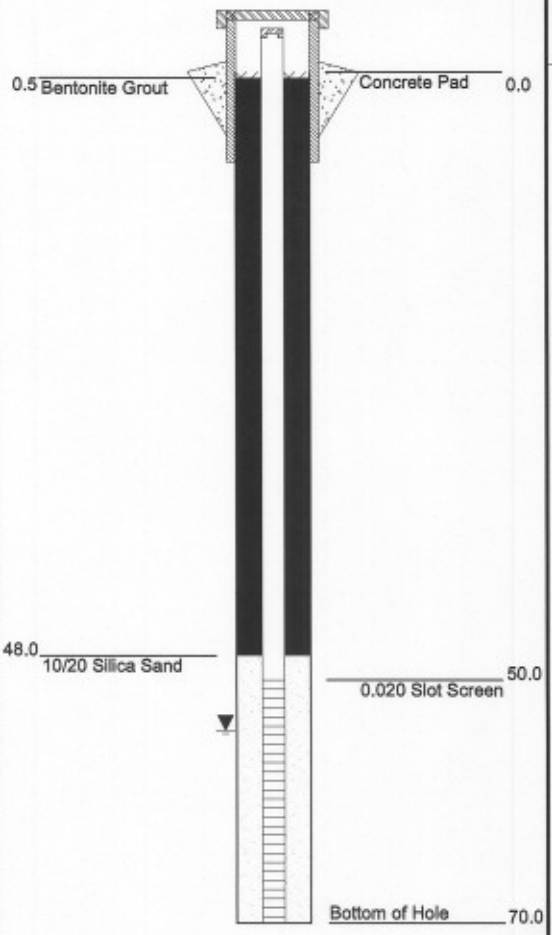
Recorded By: John Bergin
Drilling Company: Boland Drilling
Driller: Rick & Chuck
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Air/water
Purpose of Hole: GGroundwater Monitoring Well
Target Aquifer: First Water
Hole Diameter (in): 4
Total Depth Drilled (ft): 70

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+1.83-70
Surface Casing Used?	Y	4" Steel	+2.77 - 2.33
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	50-70
Sand Pack?	Y	10-20 silica sand	48-70
Annular Seal?	Y	Bentonite Chips	0.5-48
Surface Seal?	Y	Cement	0-0.5
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailer/pump	
Water Samples Taken?	N		
Boring Samples Taken?	Y	lithologic identification	

Northing: 8376.8165 Easting: 7262.8426
Static Water Level Below MP: 56.90
Date: 11/2/06
MP Description: Top of Steel Casing
MP Height Above or Below Ground (ft): 2.77
Surface Casing Height (ft): 2.77
Riser Height (ft): 1.83
Ground Surface Elevation (ft): 3958.95
MP Elevation (ft): 3961.72

Remarks:

WELL CONSTRUCTION



SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Silty Sand**
Brown with slight plasticity and slightly moist. Silty Sand (SM-SC)

5.0 - 10.0' **Silty Clay**
Light brown, very slightly moist, little plasticity, silty

10.0 - 23.0' **Silty Clay**
Light Brownish Red, Dry, Little plasticity, silty

23.0 - 25.0' **Silty Gravel**
Dark Brown, dry with slight plasticity

25.0 - 30.0' **Silty Gravel**
Gravel with some silt. Little plasticity.

30.0 - 34.0' **Silty Gravel**
Gravel with silt, Dry.

34.0 - 50.0' **Sandy Clay**
Light Yellow, moderate plasticity, slightly moist. Clay with sand; increasing sand and moisture with depth.

50.0 - 65.0' **Sandy Clay**
As above w/ trace of gravels, Injected water

65.0 - 70.0' **Sandy Clay**
As Above, some reddish color in cuttings

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Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Monitoring well

Hole Name: MW-10

Date Hole Started: 9/27/06 Date Hole Finished: 9/28/06

Client: ASARCO, INC.
Project: Interim Measures East Helena Facility
County: Lewis and Clark State: Montana
Property Owner: Asarco Inc.
Legal Description: Sec 36 T10N, R3W
Location Description:

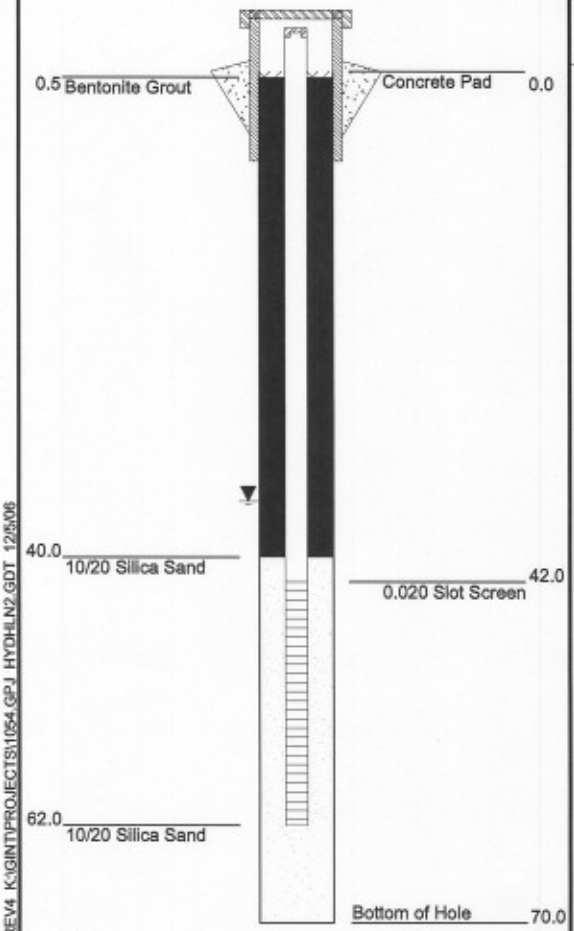
Recorded By: John Bergin
Drilling Company: Boland Drilling
Driller: Rick & Chuck
Drilling Method: Air Rotary/ODEX
Drilling Fluids Used: Air/water
Purpose of Hole: Groundwater monitoring well
Target Aquifer: First Water
Hole Diameter (in): 4
Total Depth Drilled (ft): 70

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	2-inch, flush threaded, Sch 40, PVC	+1.86-62
Surface Casing Used?	Y	4" Steel	+2.86-2.14
Screen/Perforations?	Y	0.020-inch slot, Sch 40 PVC	42-62
Sand Pack?	Y	10-20 silica sand	40 - 70
Annular Seal?	Y	Bentonite Chips	0.5-40
Surface Seal?	Y	Cement	0-0.5
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailer/pump	
Water Samples Taken?	N		
Boring Samples Taken?	Y	lithologic identification	

Northing: 8974.659 Easting: 7811.757
Static Water Level Below MP: 38.24 Surface Casing Height (ft): 2.86
Date: 11/3/06 Riser Height (ft): 1.86
MP Description: Top of Steel Casing Ground Surface Elevation (ft): 3939.74
MP Height Above or Below Ground (ft): 2.86 MP Elevation (ft): 3942.6

Remarks:

WELL CONSTRUCTION



SAMPLE NOTES

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Gravelly Silt**
Light brown silt with some gravels, dry, little plasticity.

5.0 - 10.0' **Gravelly Silt**
Dark brown, silt and gravel / broken rock. Very slight moisture, very little plasticity.

10.0 - 24.0' **Cobbles and Gravels**
Rock with some silt, little plasticity.

24.0 - 30.0' **Clayey Silt w/ gravels**
White silt with gravel mixed in. Volcanic Ash.

30.0 - 35.0' **Clayey Silt w/ gravels**
Light brown silt with some rocks, moderate plasticity, slightly moist. Volcanic Ash.

35.0 - 70.0' **Clayey Silt w/ gravels**
Light Yellow silt with some rocks, moderate plasticity, slightly moist. Volcanic Ash

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ATTACHMENT B

MONITORING WELL INSPECTION FORM

Asarco East Helena CAMU Groundwater Monitoring
Well Inspection Form

Well ID: _____ Personnel: _____

Date: _____

Time: _____ Signature: _____

Inspection Checklist

		Yes	No
[1]	Protective surface casing intact with locking lid secure? *Comments*	☐	☐
[2]	Surface seal around outer casing intact? *Comments*	☐	☐
[3]	Positive drainage away from outer casing? *Comments*	☐	☐
[4]	PVC well casing and seal intact and cap installed? (e.g., no cracks in PVC, measuring point visible, surface seal OK) *Comments*	☐	☐
[5]	Evidence of leakage through lid/protective casing? (e.g., pooled water between protective casing and well casing) *Comments*	☐	☐
[6]	Total depth measured, consistent with previous results? *Comments*	☐	☐

NOTE: Total depth measurements are required at a minimum frequency of once per year.

Additional Comments:

ATTACHMENT C

DATA SUMMARY FOR DETERMINATION OF CONCENTRATION LIMITS

		Parameter						
StationName	Data	Arsenic (As)	Cadmium (Cd)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Zinc (Zn)
MW-1	Average (M)	0.005	0.001	0.004	0.052	0.005	0.019	0.019
	Standard Deviation (S)	0.001	0	0	0.085	0.001	0.005	0.003
	M + 2S	0.008	0.001	0.004	0.223	0.006	0.029	0.025
	# Non-Detects	5	13	13	10	12	12	13
	# Samples	13	13	13	13	13	13	13
	% Non-Detects	38%	100%	100%	77%	92%	92%	100%
MW-2	Average (M)	0.012	0.001	0.004	0.050	0.005	0.286	0.019
	Standard Deviation (S)	0.003	0	0	0.077	0	0.025	0.003
	M + 2S	0.019	0.001	0.004	0.204	0.005	0.336	0.025
	# Non-Detects	0	14	14	12	14	0	14
	# Samples	14	14	14	14	14	14	14
	% Non-Detects	0%	100%	100%	86%	100%	0%	100%
MW-3	Average (M)	0.011	0.001	0.004	0.027	0.005	0.028	0.019
	Standard Deviation (S)	0.001	0	0	0.015	0.000	0.004	0.003
	M + 2S	0.013	0.001	0.004	0.058	0.005	0.036	0.025
	# Non-Detects	0	13	13	12	13	0	13
	# Samples	13	13	13	13	13	13	13
	% Non-Detects	0%	100%	100%	92%	100%	0%	100%
MW-4	Average (M)	0.004	0.001	0.004	0.029	0.016	0.018	0.019
	Standard Deviation (S)	0.001	0	0	0.023	0.038	0.004	0.003
	M + 2S	0.006	0.002	0.004	0.075	0.092	0.026	0.025
	# Non-Detects	9	12	13	11	12	13	13
	# Samples	13	13	13	13	13	13	13
	% Non-Detects	69%	92%	100%	85%	92%	100%	100%
MW-5	Average (M)	0.007	0.001	0.004	0.024	0.005	0.018	0.019
	Standard Deviation (S)	0.001	0	0	0.010	0	0.004	0.003
	M + 2S	0.009	0.001	0.004	0.043	0.005	0.026	0.025
	# Non-Detects	1	13	13	11	13	12	13
	# Samples	13	13	13	13	13	13	13
	% Non-Detects	8%	100%	100%	85%	100%	92%	100%
MW-6	Average (M)	0.152	0.001	0.004	0.217	0.005	4.97	0.019
	Standard Deviation (S)	0.051	0	0	0.035	0.001	0.289	0.003
	M + 2S	0.254	0.001	0.004	0.287	0.008	5.548	0.026
	# Non-Detects	0	9	8	0	8	0	9
	# Samples	9	9	9	9	9	9	9
	% Non-Detects	0%	100%	89%	0%	89%	0%	100%
MW-7	Average (M)	0.017	0.001	0.004	0.037	0.005	0.022	0.018
	Standard Deviation (S)	0.005	0	0	0.021	0	0.010	0.004
	M + 2S	0.027	0.001	0.004	0.078	0.005	0.041	0.026
	# Non-Detects	0	6	6	3	6	5	6
	# Samples	6	6	6	6	6	6	6
	% Non-Detects	0%	100%	100%	50%	100%	83%	100%

APPENDIX E

CORRECTIVE ACTION MANAGEMENT UNIT OPERATING PLAN

APPENDIX E

OPERATING PLAN
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

February 2007
Revised May 2007
Revised June 2007
Revised August 2007
Revised October 2007

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APPENDIX E

OPERATING PLAN
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)

1.0 GENERAL INFORMATION

This plan addresses care, operation, monitoring, and maintenance of the Corrective Action Management Unit (CAMU) and is included as Appendix E of the Design Analysis Report Asarco East Helena Corrective Action Management Unit (CAMU) Phase 2 Cell. The CAMU is located adjacent to the Asarco East Helena Plant, and south of the community of East Helena, Montana. In 2001 a waste containment facility, known as the CAMU Phase 1 Cell, was constructed for the disposal of soils, sediments and demolition debris resulting primarily from smelter site remedial cleanup activities. In 2008, a second waste containment facility, known as the CAMU Phase 2 Cell, will be constructed adjacent to the Phase 1 Cell, and will contain demolition debris and waste soils from current remedial cleanup activities. Although not required by CAMU regulations, the Phase 1 and Phase 2 Cell were designed to comply with the Resource Conservation and Recovery Act (RCRA), Subtitle C regulations and guidelines.

1.1 PURPOSE

The purpose of this Operation Plan is to set forth the enforceable requirements for operation and maintenance of the CAMU Phase 2 Cell prior to permanent closure of the unit. This Operation, Maintenance, and Waste Hauling Plan establishes specific criteria and response timelines for repair for each inspection element, including notification provisions of required repairs to regulatory agencies; as well as, provides insight and guidance into the measures that will be implemented to properly transport hazardous waste materials from the Asarco East Helena Smelter site to the Corrective Action Management Unit (CAMU) Phase II Cell. This

plan complies with all applicable requirements specified in the Code of Federal Regulations, Title 40, Part 264 – Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264). This Operation, Maintenance, and Waste Hauling Plan provides:

1. Basic construction information;
2. A description of all required site inspection and monitoring activities, including the frequency with which each activity will be performed and the corrective actions that will be taken for each problem encountered; and
3. A description of all required site maintenance activities, including the frequency with which each activity will be performed.

In addition, this plan minimizes the need for facility maintenance after the site is closed and controls, minimizes, or eliminates to the extent necessary for protection of human health and the environment, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground, surface waters, or atmosphere. This plan also minimizes the risk to both the environment and human health by addressing the means and methods that will be utilized to implement dust control measures, maintain equipment, and sustain clean work and road surfaces.

1.2 RESPONSIBILITY

Asarco LLC is responsible for implementation of this plan. Asarco LLC is referred to as the owner/operator throughout this plan.

1.3 COMMUNICATIONS

Lines of communication between the contractor, inspectors, and ASARCO will be established before construction of the CAMU cell begins. All communications, inspection logs, and incurred problems shall be documented and copies provided to the owner/operator.

1.4 OPERATING LOG

Asarco LLC will maintain an operating record of all site inspections and maintenance activities as required under 40 CFR 264.73. Communications between the contractor, inspectors, and the owner should be documented and kept as part of the operation log.

1.5 PUBLIC SAFETY AND HEALTH

The CAMU Phase 1 Cell has been closed and is secured by fencing. Like the Phase 1 Cell, the Phase 2 Cell will be fenced and kept secured to control public access to the site. Once the Phase 2 Cell has been closed, the site will pose no special public safety or health hazards. The contractor will be responsible for ensuring that the site is secure and gates and fences will be inspected weekly to keep the site secure.

2.0 CONSTRUCTION INFORMATION

The CAMU Phase 2 Cell consists of the following components listed in order from the bottom to the top of the cap:

1. Secondary Composite Liner
   - 3-foot compacted clay liner (CCL)
   - Reinforced GCL liner
   - 60-mil Double Sided Textured HDPE flexible membrane liner (FML)
2. Leak Detection, Collection, and Removal System
   - Geocomposite Drainage Layer
3. Primary Liner
   - 60-mil Double Sided Textured HDPE flexible membrane liner (FML)
4. Primary Leachate Collection and Removal (PLCR) System
   - Geocomposite Drainage Layer
5. 2-foot Cushion Layer
6. Waste
7. 12-inch Gas Migration Layer
8. Cap Composite Liner
   - Reinforced GCL
   - 40-mil Double Textured HDPE flexible membrane liner
   - Geocomposite
9. Surface Water Collection and Removal (SWCR) System
   - 1-foot thick drainage gravel layer
10. Cover System
    - 2-feet cover soil
    - 6-inches topsoil and
    - Grass cover.

3.0 WASTE HAULING AND DUST CONTROL

Waste Hauling and dust control measures are designed to control the emission of visible fugitive dust. These controls will be accomplished through the use of administrative, engineering, and physical controls. The mitigation of airborne dust generation is considered to be a priority. Throughout the project, the necessary steps will be taken to effectively control dust in the working area during demolition operations. The use of minimum amounts of water will be the main source for dust control. All communications between the contractor, inspectors, and ASARCO should be documented.

3.1 ON-SITE TRANSPORT

Sorting and sizing of demolition debris will occur at the demolition site prior to being loaded in haul trucks. All oversized materials will be reduced at the demolition site and once the debris and material is loaded into haul trucks, no further reduction of materials will be necessary. After demolition debris is loaded into the truck beds, the debris payload will be moistened prior to the vehicle leaving the loading area. The truck beds will utilize sealed tail gates. The use of truck bed covers may be considered if the physical shape of the truck beds accommodate. Transport vehicles will be limited to a maximum of 10 miles per hour while transporting waste across the plant site. Limiting speeds will prevent dust from become airborne during transport and will prevent the kick-up of dust from rolling tire action.

3.2 OFF-SITE PREPARATION AND TRANSPORT

Prior to debris leaving the Asarco Smelter site and being transported to the CAMU, transport vehicles will be run through a scale, sampling station, and moistening station. The haul truck will be weighed on the scale and a sample will be taken from the trucks payload at the interval specified in Attachment C of this Appendix - Sampling and Analysis Plan. The moistening station will consist of a scaffolding platform on which personnel will mist water on the loaded debris as a final step before it travels outside the property fence line and across the County road. The spray will add a final moisture barrier/binder to the debris for the short distance haul to the CAMU. Transport vehicles will be limited to a maximum of 10 miles

per hour during transport. Limiting speeds will prevent dust from become airborne during transport and will prevent the kick-up of from rolling tire action.

3.3 PLACEMENT OF WASTE

Once haul trucks arrive at the CAMU Phase II cell, they will drive into the cell and dump their load in the location specified by the contractor. Asbestos materials are the only materials with a designated location in the CAMU cell and will be placed in this location as directed by the contractor. A water truck will be located close to the CAMU cell to lightly mist debris and knock down any dust during the dumping and spreading phase of the debris in the CAMU. Use of water will be kept to a minimum. Additional water will be applied to locations in the CAMU to eliminate the potential for fugitive dust emissions. Waste will be placed in the CAMU cell in two-foot lifts and compacted according to Project Specifications. Inspections of the CAMU cell will occur at least twice daily to assess the potential for windblown dispersion of fugitive dust. Water will be applied to areas of the cell where fugitive dust could potentially or is found to be a problem.

3.4 CONTINGENCY PLAN

If the CAMU is not immediately available for waste placement, CAMU destine-waste will be transported to and staged inside designated facilities that meet 40 CFR 265 Subpart DD, Containment Building requirements. Waste material will be transported as previously described and will be dumped into bulk stockpiles. The designated facilities will provide protection from weather, specifically wind and rain. Therefore, inside the facilities, materials will not be covered and dust mitigation will not be necessary. Once the CAMU is ready to accept material, stockpiled waste will be transported from the designated facilities to the CAMU as previously described.

3.5 WASTES REQUIRING SPECIAL MANAGEMENT

Wastes requiring special management include; asbestos, flue dust, and acidic waste. Proper procedures for pretreatment and packaging these wastes will be conducted in the demolition areas prior to the materials being loaded on haul trucks. Acidic waste will be neutralized

using lime rock and loaded into haul trucks and hauled to the CAMU cell. Asbestos containing products and flue dust will be handled according to the procedures outlined in Sections 5.0 and 6.0 of the Blast Furnace Flue and Monier Flue Cleaning, Demolition, and Soil Sampling Work Plan (Asarco 2007). These procedures outlined in Sections 5.0 and 6.0 are included as Attachment A. All Friable asbestos that is wrapped and contained, will be loaded, transported, and placed in the southwest corner of the CAMU cell in such a manner that the integrity of the wrapping is not breached. Once the material has been placed in the cell, its location will be surveyed and then covered with soil to maintain the integrity of the wrapping. The location of the asbestos containing material will be shown on the as-built drawings of the CAMU Phase 2 Cell and this drawing will be included in the deed restriction. At no time will friable material be exposed to the environment. Non-friable asbestos waste will be loaded and transported as described above for general demolition debris.

3.6 WORK STOPPAGE

Work shall halt when weather conditions are such that the spread of contaminated dust and debris is likely. These conditions typically exist when there is excessive wind and/or rain. Therefore, if wind with sustained readings of 15 MPH (average hourly rate) or more evolve, the handling and hauling of waste both on-site and off-site will halt to prevent dust and debris from becoming airborne due to the waste management process. Sustained wind speeds will be monitored by management personnel through the use of a calibrated on-site wind sock; as well as, through data provided by the National Oceanic and Atmospheric Administration (NOAA) at www.noaa.gov for wind speeds at the Helena Airport. Furthermore, if a rain event begins, management personnel will evaluate the site conditions. If the rain is such that no run-off is occurring, work activities will proceed uninhibited. In the event that the rain is of such volume that run-off is beginning to occur and the work activities in progress (i.e., waste hauling, placement of waste in CAMU) could create a contaminated run-off, both on-site and off-site work will cease until such time that a run-off potential is not present. The contractor will evaluate these conditions with ASARCO

representatives. In the event that transport is halted, no additional trucks will be loaded and any trucks containing wastes will be covered until conditions improve.

3.7 DECONTAMINATION AND INSPECTION OF EQUIPMENT

Equipment used in the handling and/or transport of demolition debris will be decontaminated prior to the equipment leaving the site, or moving from a demolition zone to an area considered clean. Decontamination pads, a concrete slab suitable for placement of heavy equipment, will be established, in areas agreed upon with and approved by ASARCO representatives. The location of the decontamination pads may change as demolition activities progress. However, all equipment will be decontaminated within close proximity to where it will leave the Asarco Smelter site. Equipment that has been decontaminated will be inspected upon completion to ensure the adequacy of the process and to document the process to ensure quality control prior to the transport vehicle leaving the site.

Decontamination will consist of one or a combination of the following: brushing, vacuuming, or washing methods. The goal of the decontamination is to remove heavy metal laden bearing dust and debris from the areas of the equipment that came into contact with this waste. Upon completion of the decontamination activities, any removed dust and debris residue will be picked up and placed into storage for eventual placement into the CAMU.

Haul trucks leaving the CAMU Phase II cell will be traveling on paved haul roads and will not be decontaminated until they enter the ASARCO smelter facility, where they will be decontaminated on one of the decontamination pads. Any large debris will be knocked off of haul trucks as they leave the CAMU cell. The section of haul road between the CAMU cell and the ASARCO smelter facility will be constantly monitored and swept on a regular basis. This section of haul road will be inspected twice daily.

Transport vehicles will be inspected periodically to ensure that truck beds and gates are properly sealed and that debris is not building up. Full decontamination of vehicles that are leaving the Asarco site should be run periodically.

Equipment used in the CAMU cell for spreading and compacting waste will be decontaminated at the ASARCO smelter facility. This equipment will be placed on trailers and driven via the haul road back to the ASARCO smelter facility, where it will be decontaminated on one of the decontamination pads.

3.7.1 Work and Road Surface Cleaning

Haul roads within the plant site and haul roads used for waste transport will need to be kept clean at all times. A street sweeper designated to cleaning roads and surfaces within the plant site will clean up all loose dust in order to minimize the chances for the off-site migration of dust and debris. This street sweeper will not be used off site of the plant. A second street sweeper designated to keeping CAMU haul roads clean will be run constantly when waste is being hauled. Haul roads will be paved so that waste and debris can easily be cleaned. This will allow for daily visual inspection of haul roads to make sure transport vehicles are being adequately decontaminated and waste is adequately moistened.

3.8 SPILL MITIGATION

Spills of soils or debris being transported to the CAMU will be prevented by constant maintenance of trucks to make sure they are properly sealed and in good working order. In addition, traffic control and slow truck speeds, as previously mentioned will help to prevent accidents from occurring. If waste is spilled in route to the CAMU, the hauling of waste will halt and the spilled waste will be cleaned up using clean decontaminated equipment. If the spill occurs on the haul road, the road will be swept clean. If the spill occurs on soils, follow up soil sampling will be conducted to assure that all the contaminated waste has been cleaned up.

The inspection of the area surrounding the CAMU cell twice daily, will include looking for visible fugitive emissions. If a release from the cell is noticed during an inspection, the waste will be cleaned up using clean decontaminated equipment and placed in the CAMU cell. Excavation of soils where visible waste is noticed will be conducted immediately. Follow up soil sampling will be conducted to assure that all the contaminated waste has been cleaned up.

4.0 SITE MONITORING AND INSPECTION

Inspections will be performed twice daily of areas surrounding the CAMU cell and the haul road between the CAMU and ASARCO smelter facility when the CAMU cell is in operation. Daily inspections of the road used for hauling waste will occur when the haul road is in use. While the CAMU cell is in operation it will be inspected once per week. Quarterly monitoring of groundwater quality and semi-annual site inspections will ensure that public health and safety are maintained at the site. Monitoring and inspection protocol are in accordance with 40 CFR 264.303.

4.1 SITE INSPECTIONS – OPERATION

4.1.1 Daily Inspections

While the landfill is in operation, inspection of the grounds surrounding the CAMU should be inspected twice daily. These inspections should include an assessment of the potential for windblown dispersion of fugitive dust from the CAMU and a visual inspection of the grounds surrounding the CAMU for any visible releases of fugitive dust from the CAMU cell. The haul route used by trucks leaving the CAMU and returning to the ASARCO smelter facility should also be inspected twice daily to ensure that it remains clean and free of dust and debris. The remainder of the haul road should be inspected once per day to ensure that it is free of dust and debris. Daily inspections should be documented and recorded on the Daily Inspection Form included in Attachment B of this Appendix and any problems found will be reported to the project manager and addressed immediately.

4.1.2 Weekly Inspections

While the landfill is in operation, it must be inspected weekly and after significant storms to detect evidence of any deterioration, malfunctions, or improper operation of run-on and runoff control systems, and the proper functioning of or presence of liquids in the leachate collection and leak detection system. When in use, the temporary liner cover that is used between construction seasons prior to permanent closure of the Phase 2 Cell will be examined for signs of damage and seam separation. Anchor trenches around the perimeter of

the cover will be inspected for liner pullout. Sandbags will be inspected for proper spacing and damage. The temporary liner that will cap the CAMU Phase 2 Cell between construction seasons will be fenced and kept secured to help ensure the cap is not disturbed by people or large animals. Inspection of the perimeter fence, gates, condition of haul roads, condition of storm water pond, presence of precipitation run-off or ponded liquids, condition of decontamination pads, and the condition of haul trucks will be included in weekly inspections and any maintenance needed will be recorded on the Weekly Inspection Form included in Attachment B of this Appendix and addressed appropriately.

5.0 SITE MAINTENANCE

5.1 CAMU TEMPORARY CAP

On-site maintenance items are to include repairs to the liner, seams, and sandbags. Cover liner integrity and anchorage are the primary focus of scheduled inspection and preventative maintenance. Periodic inspection of other features, such as above-ground portions of monitoring wells and storm water controls, will also be required.

5.1.1 Housekeeping

Liner Anchorage – Sandbags or tubes that are used to anchor the flexible membrane liner cap over the CAMU cell may need periodic adjustment to ensure they maintain proper spacing.

5.1.2 Corrective Maintenance

The following section covers some problems that may be encountered prior to permanent closure of the cell by construction of a permanent cap. The solutions are by no means all inclusive, but should serve as general guidelines indicating the elements involved for fixing typical case conditions.

1. Subsidence - When an area experiences excessive localized settlement, the cover may no longer drain properly. Even so, there may not be a problem unless the area is large, there is continued ponding, or the flexible membrane liner has been damaged. If it is determined that a repair must be made, the necessary steps involved are:

    a. Determine limits of area to be repaired.
    b. Remove sandbags or tubes from area.
    c. Cut and remove flexible membrane liner.
    d. Fill depression and grade for proper drainage.
    e. Install and seam new flexible membrane liner.
    f. Test seams to ensure integrity of repair.
    g. Replace sandbags or tubes to anchor flexible membrane liner.

2. Rips and tears - Repair of rips and tears in the liner cap is necessary not only to prevent water from leaking through to the underlying cell but also to prevent wind from getting under the liner. If allowed to get under the liner, high winds may inflate the surface of the flexible membrane cap to a point where sand bags will be dislodged.
3. Seam separation – Repair of separating or inadequately sealed seams is necessary for the same reasons as repair of rips and tears in the liner. Seams can be temporarily repaired using seaming tape, but should be permanently repaired by hot-air welding or sewing as soon as a liner installer can be called to the site.
4. Liner anchorage – High winds may cause liner edges to pull out or sandbags or tubes to displace. If this occurs, anchor trenches will be excavated, liner edges reinstalled, and the trench filled and compacted in accordance with the liner installation plans. Sandbags or tubes will be repositioned to provide evenly spaced anchorage on the cap liner.

5.1.3 Groundwater

Pre-closure CAMU monitoring will be accomplished in accordance with Appendix D – Sampling and Monitoring Plan. During quarterly groundwater monitoring events, components of the groundwater monitoring system will be visually inspected to ensure good working order. All inspections will be documented on the Inspection/Repair form included in Attachment B of Appendix D and included in the annual report. If any problems with the groundwater monitoring system are encountered, they will be documented on the Inspection/Repair form and the owner/operator will be notified within 24 hours. The owner/operator is responsible for making sure all repairs are scheduled and completed within 14-calendar days of the inspection. Details of completed repairs will be noted on the Inspection/Repair form. The owner/operator is also responsible for reporting any significant issues to the EPA representative verbally within 7-calendar days and in writing within 14-calendar days.

ATTACHMENT A

ASBESTOS PROCEDURES

5.0 Asbestos and Lead Removal Techniques and Procedures

1) Asbestos-containing materials that will be removed from the site buildings and are judged by a competent person to be friable (i.e., those ACMs that, when dry, can be crushed, crumbled, pulverized, or otherwise rendered to a dust by hand pressure) will be packaged and stored in a manner prescribed herein for disposal as hazardous waste.

1) Lead Dust is present within the interiors of structures schedule to be demolished. These structure will be cleaned of the dust before demolition of the structure.

2) Lead Dust waste that is collected during cleaning of the structures will be packaged and stored in a manner prescribed herein for disposal as hazardous waste.

5.1 Notifications

1) IRSE will make required notifications to the Department of Environmental Quality and submit these notifications to CWC before beginning work.

5.2 Work Area Preparation

5.2.1 Warning Signs – Asbestos Abatement

2) Danger signs meeting the specifications of OSHA Construction Safety Order, Section 1529 and WAC 296-62-077 will be posted at any location and approach where regulated areas are present. Signs will be posted at a distance sufficiently far enough away from the work areas to permit any employee or visitor to read the sign and take the necessary protective measures to avoid exposure. Warning signs shall include the following wording:

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA

2) These warning signs shall be printed in letters of sufficient size to be clearly legible.

5.2.2 Warning Signs- Lead Dust Abatement

3) Entrance by non- trained personnel into the lead paint removal area will be restricted using 3" barrier tape posted at the work area perimeter. Warning tape shall include the following wording:

Danger Lead Removal
Authorized Personnel Only

2) The warning tape shall be printed with letters of sufficient size to be clearly legible.

5.2.3 Electrical Power

1) The contractor will provide adequate power at each of the buildings. IRSE will provide temporary lighting sources and ensure safe installations (including ground faulting) of temporary power sources and equipment by complying with all applicable electrical code requirements and OSHA requirements for temporary electrical systems, within each building, as applies.

5.2.4 Establishing Asbestos Removal Work Areas

1) During indoor Class I removal of thermal system insulation, the wrap and cut method will be utilized. (HEPA) vacuums and wet methods will be utilized.

2) As applicable, IRSE will seal the exterior of the regulated areas. All windows, doors, and any other openings to the outside of the building from the regulated areas, will be sealed with a minimum of one layer of 6-mil poly sheeting with duct tape, until a negative exposure assessment is conducted.

3) During Class I removal of TSI using glovebag and wrap and cut methods with HEPA vacuum method procedures, the work area will be restricted using signs as described in 5.2.1. 6-mil poly will be installed on floors/ground in work area. Negative air machines may be installed in order to provide clean air from outside the work area at sufficient quantities and at strategic locations, so as to provide clean air in the workers' breathing zone, as described in Appendix D IRSE Hazardous Material Contractor Quality Control Plan.

4) During outdoor Class II removal of transite shingles and skirting, a single layer of 6-mil poly will be placed on the ground directly under the material to be removed, extending 10-20' out from the base of the building.

5) During outdoor Class II removal of metal siding, a single layer of 6-mil poly will be placed on the ground directly under the material to be removed, extending 10-20' out from the base of the building.

6) During Class II removal of floor covering, the work area will be restricted using signs as described in 5.2.1. 6-mil poly will be installed critical in the work area. Negative air machines will be installed in order to provide clean air from outside the work area at sufficient quantities and at strategic locations, so as to provide clean air in the workers' breathing zone, as described in Appendix D IRSE Hazardous Material Contractor Quality Control Plan.

7) During Class II removal of asbestos-containing roofing materials a single layer of 6-mil poly will be placed on the ground directly under the material to be removed, extending 10-20' out from the base of the building.

8) During Class II removal of window caulking, a single layer of 6-mil poly will be placed on the ground directly under the material to be removed, extending 5-10' out from the base of the building.

8) During removal of all Class II work, the area will be restricted using signs described in 5.2.1. Specific means and methods will be found in Appendix D.

6) 2" red "DANGER ASBESTOS - DO NOT ENTER" tape will be used to restrict access by untrained personnel.

5.2.5 Establishing Lead Dust Removal Work Areas

1) As applicable, IRSE will seal the exterior of the regulated areas. All windows, doors, and any other openings to the outside of the building from the regulated areas, will be sealed with a minimum of one layer of 6-mil poly sheeting with duct tape, until a negative exposure assessment is conducted.

2) 2" red "DANGER LEAD - DO NOT ENTER" tape will be used to restrict access by untrained personnel.

5.3 Workplace Entry and Exit Procedures – Asbestos and LEAD

1) IRSE will be using mobile trailer designed as a 3-stage worker decontamination unit, and a fixed worker decontamination unit (2- or 3-stage, depending on the scope of work at each individual work site) and locate it next to the entrance of the work area.

2) If the quantity of thermal system insulation exceeds 10 linear feet or 25 square feet, IRSE will construct a three-stage decontamination unit, including clean room, shower and dirty room, contiguous to the "regulated work area". If the quantity of ACM to be abated is less than 10 linear feet or 25 square feet, IRSE will construct a two-stage decontamination unit, including clean room and dirty room, contiguous to the "regulated work area". The procedures that will be used to enter decontamination units are described below.

3) Workers will enter the regulated work areas through the worker decontamination unit. The decontamination unit is a fully enclosed system.

4) These decontamination units will include an equipment or "dirty" room, a functional shower equipped with hot and cold running water (if necessary), and a changing or "clean" room in series. The decontamination units will also be constructed in such a manner as to provide a systematic reduction of contamination for the workers and equipment exiting the regulated work area. Personnel entry into and egress from the regulated work areas will be through the decontamination units. Equipment and material replenishment may also be conducted through the decontamination unit.

5) Wastewater resulting from the operation of the shower units shall be filtered with a 5-micron pore-size filtration system before reuse or discharge. To the extent feasible, filtered wastewater will be reclaimed and used on site for application in wet method work practices. Wastewater to be discharged shall be sufficiently filtered to meet state and local water quality objectives before discharge. Filters shall be changed as necessary to achieve this objective.

6) Before exiting the work area, personnel shall remove outer protective clothing and use a HEPA vacuum to remove ACM debris from protective clothing. Workers shall then proceed to move disposable clothing and dispose of it as hazardous waste. Non-disposable clothing (such as work boots) shall be decontaminated before being removed from the work area.

**Removing asbestos dust from protective clothing or equipment by blowing, shaking, or any other means that disperses asbestos fibers into the air shall likewise be prohibited.

6) If applicable, workers exiting the regulated work areas will wash (shower) all areas of the body that were potentially exposed to asbestos contamination.
Respirators shall continue to be worn by workers until the worker has entered the shower and begun to wash. Once the head has been deluged with water, the respirator may be removed. IRSE will supply workers with soap and shampoo to use in the showers.

7) A secure change room shall be provided outside the decontamination units and shall be equipped with storage for workers' street clothes and personal belongings. Workers are to change from street clothes each day before entering the regulated work area. Workers are to change back into street clothes each day before leaving the work site. Personnel are prohibited from wearing potentially contaminated clothing off the site. Housekeeping within the change room will be maintained by IRSE. Periodic area air monitoring will be conducted to evaluate housekeeping efforts.

8) Waste containers shall also be decontaminated using HEPA vacuums and by wet wiping before being removed from the work areas.

9) In the event an emergency egress from within the regulated work is required, the above-described personnel decontamination procedures will not be required. IRSE will exercise judgment to ensure that worker health and safety is placed above environmental contamination concerns.

10) In those instances when it is not feasible to provide shower facilities contiguous with the work area or where the work is performed outdoors, the Contractor shall ensure that employees remove (1) asbestos contamination from their worksuits in the equipment room utilizing a HEPA vacuum before proceeding to a shower that is not adjacent to the work area, or (2) their contaminated worksuits in the equipment room, don a clean worksuit, and proceed to a shower that is not adjacent to the work area. A second inner disposable/breathable Tyvek whole-body coverall may be utilized by workers for modesty's sake under the primary outer worksuit. The outer suit will be cleaned using a HEPA vacuum and removed within the isolated work area.

11) The containment design and decontamination unit that will be utilized for each work area will be dependent on the DEQ asbestos work classification.

5.4 Personal Protective Equipment

1) Except when more stringent requirements are set forth, the personal protective equipment (PPE) utilized during the conduct of this work must meet or exceed the requirements contained in Title 29 CFR 1926.1101.

5.4.1 Respiratory Protection

1) Half-face negative pressure respirators (equipped with HEPA filters) will be utilized for Class I and II materials being removed on this project. Protective glasses or goggles worn by workers will conform to the specifications of the ANSI Z87.1 standard of Title 29 CFR §1910.133.

2) Half-face negative pressure respirators (equipped with HEPA filters) will be worn by all personnel working within Lead Dust Removal Work Areas.

3) Once a negative pressure enclosure (if applies) has been visually inspected and placed under a negative air pressure differential, full-faced supplied air respirators operated in constant flow or pressure demand mode and equipped with HEPA escape filters, will be worn by workers, supervisors, work monitors, industrial hygienists, and other entering the regulated work area.

3) During outdoor Class II removal of materials, half-face negative pressure respirators equipped with HEPA filters will be used.

4) During indoor Class II removal of all materials identified, half-face negative pressure respirators equipped with HEPA filters will be used.

5) All respirators shall be used in a manner consistent with state-of-the-industry practices. The respirators shall be worn with head straps in direct contact with the head and shall not be worn on the outside of the hoods of disposable whole-body coveralls. An exception to this is allowable in those instances when a remote decontamination unit is being utilized and the worker is double suited. Respirators shall be worn until proper personal decontamination methods, as described herein, are completed.

6) The Contractor will provide respirators in accordance OSHA 1019.133 Respirator Protection

5.4.2 Whole Body Protection

1) Work boots with nonskid soles or impermeable work-boot covers shall be worn by workers. Protective footwear worn by workers shall conform to the specifications of the ASNI Z41.1 standard. Work boots that have come into contact with contaminated material shall be cleaned, decontaminated, and bagged before removal from the work area.

2) Protective head gear (hard hats) shall be worn at all times that work is in progress. Protective head gear worn by workers shall conform to the specifications of the ANSI Z89.1 (Class A) standard. Hard hats shall be thoroughly decontaminated before removing from the work area.

3) In work areas where excessive noise is prevalent, worker shall wear hearing protection sufficient to ensure that the worker's 8-hour time-weighted average (TWA) exposure does not exceed 85 Dba.

4) IRSE will make available extra sets of PPE to be used by the owners authorized representative for use to enter the regulated work areas.

5.5 Asbestos Removal Techniques and Procedures

1) For the purposes of this work plan, the removal of ACM thermal system insulation (TSI) or ACM surfacing materials will be considered "Class I Asbestos Work," as defined by OSHA 1915.1001 and Title 29 CFR 1926.1101 and shall be conducted in accordance with work practices and requirements set forth for Class I work.

2) IRSE will conduct the construction activities described herein in accordance with all currently applicable federal, state, and local laws and regulations including, but not limited to, Title 29 CFR 1926.1101.

3) All asbestos-containing material thermal system insulation will be removed via the glovebag method or glovebag and wrap and cut method, with negative air ventilation procedures.

5.5.1 Removal of ACM Thermal System Insulation from Buildings

5) IRSE will then pre-clean the work area. This will entail cleaning of any visible asbestos debris and dirt which may affect area and clearance air monitoring. Following pre-cleaning, IRSE will begin installing glovebags on the pipes which have been determined to contain asbestos-containing thermal system insulation.

6) The IRSE Competent Person will then conduct visual inspections and smoke testing on the glovebags and ensure that all necessary tools are present, including Hudson sprayers, waste bags, and a HEPA vacuum.

7) Only after satisfactory visual inspections from the IRSE Competent Person will the go ahead to begin asbestos removal be given.

8) All glovebagging will be conducted in two-man crews. One worker will remove the asbestos-containing pipe insulation inside the glovebag while the other worker constantly mists the insulation with amended water.

9) Once the ACM insulation has been removed from the pipe and is on the bottom of the glovebag, the pipe and top inside portion of the glovebag will be wet wiped clean. IRSE will twist the bag several times and tape it to keep the ACM in the bottom during removal of the glovebag from the pipe. A HEPA vacuum should be used to evacuate air out of the glovebag.

10) A 6-mil disposal bag will be slipped over the glovebag (while still attached to the pipe). The tape holding glovebag to pipe will then be removed and the top of glovebag opened then folded down into waste bag.

11) Following an acceptable visual inspection from the CWC Site Safety Officer, IRSE will apply an encapsulant to all surfaces in the work area and clearance sampling can be collected for analysis.

5.5.2 Outdoor Removal of Transite Shingles and Metal Siding

1) The workers will don appropriate PPE as described in Section 5.4.

2) IRSE will perform setup of the work area as described in Section 5.2.3(3).

3) IRSE will notify the on-site Safety Officer prior to beginning removal so that visual inspections can be conducted to insure that all necessary tools are available, including water, HEPA vacuum, lined dumpster.

4) After satisfactory visual inspection by the Safety Officer, IRSE will begin transite removal.

5) Transite removal will be conducted using methods described in the IRSE Hazardous Material Contractor Quality Control Plan.

5.5.3 Removal of all other Class II Materials

1) The workers will don appropriate PPE as described in Section 5.4.

2) IRSE will perform setup of the work area as described in Section 5.2.3(7).

3) IRSE will notify the on-site Safety Officer prior to beginning removal so that visual inspections can be conducted to insure that all necessary tools are available, including water, HEPA vacuum, lined dumpster.

4) After satisfactory visual inspection by the Safety Officer, IRSE will begin removal of specific materials, as identified in Appendix D.

5) Class II removal will be conducted using methods described in the IRSE Hazardous Material Contractor Quality Control Plan.

5.5.4 Final Visual Inspection of Work Area

1) Following an acceptable visual inspection by the CWC Site Safety Officer after asbestos removal from each asbestos removal work area, IRSE will apply an encapsulant to all surfaces in the work area and clearance sampling can be collected for analysis.

2) All abated areas will be inspected by the Contractor, CWC Onsite Supervisor and IRSE supervisor. Upon successful inspection, each will sign the completed form *"Final Inspection Report"* Form. The Form can be found at the end of Attachment C: Forms.

5.6 Removal of Lead Dust from Buildings

1) IRSE will conduct the construction activities described herein in accordance with all currently applicable federal, state, and local laws and regulations including, but not limited to, Title 29 CFR 1019.10025.

5.6.1 Vacuuming Lead dust in Building

1) The workers will don appropriate PPE a stated in Section 5.4 and IRSE Hazardous Material Quality Control Plan.

2) IRSE will then perform setup of the "Lead Removal Work Area" as stated in Section 5.2.4. (1), including installing critical barriers.

3) IRSE will also install a two stage decontamination unit as stated in Section 5.3. The decontamination unit will be placed at the doorway leading into the building or at a central area on site.

4) Once the decontamination unit and all critical seals have been installed, the IRSE Competent Person will perform a visual inspection of the work area to ensure that all critical seals are in place and that adequate negative pressure has been established, if applies.

4) All abated areas will be inspected by the Contractor, CWC Onsite Supervisor and IRSE supervisor. Upon successful inspection, each will sign the completed form *"Final Inspection Report"* Form. The Form can be found at the end of Attachment C: Forms.

6.0 Waste Handling and Disposal

6.1 Packaging and Storage of Waste and Removal from the Work Area

1) The friable ACMs that will be removed from the project site and are judged by a competent person to be friable (i.e., those ACMs that, when dry, can be crushed, crumbled, pulverized, or otherwise rendered to a dust by hand pressure) will be packaged and stored in a manner prescribed herein for disposal as hazardous waste.

2) Friable asbestos waste shall be placed in two layers of 6-mil polyethylene disposal bags.

3) All friable asbestos waste (bagged) will exit the work area through the equipment room of the decontamination unit or from a separate waste load out decontamination unit. These waste loads out units will be contiguous to the work area containment.

4) The personnel loading the asbestos-containing waste will be protected by disposable clothing and, at a minimum, half-facepiece air-purifying dual-cartridge respirators equipped with high efficiency filters.

5) The bagged or wrapped asbestos waste shall be properly labeled and placed in locked storage containers. At a minimum, the outside of each waste bag or package containing asbestos hazardous waste will be labeled as described in 6.2(5).

6.2 Packaging and Storage of Nonfriable Waste and Removal from the Work Area

1) The nonfriable ACMs that will be removed from the project site and are judged by a competent person to be nonfriable (i.e., those ACMs that, when dry, cannot be crushed, crumbled, pulverized, or otherwise rendered to a dust by hand pressure) will be packaged and stored in a manner prescribed herein for disposal as hazardous waste.

2) Nonfriable asbestos waste will be loaded directly into a mega boxes, (Gaylord boxes) place in disposal bags and doubled bagged or double wrapped with 6 mil poly.

3) The personnel loading the asbestos-containing waste will be protected by disposable clothing and, at a minimum, half-facepiece air-purifying dual-cartridge respirators equipped with high efficiency filters.

5) The wrapped asbestos waste shall be properly labeled and placed in locked storage containers. At a minimum, the outside of each package containing asbestos hazardous waste will be labeled as follows:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD
HAZARDOUS WASTE
STATE AND FEDERAL LAW
PROHIBITS IMPROPER DISPOSAL
IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY
AUTHORITY OF THE WASHINGTON DEPARTMENT OF
TOXIC SUBSTANCES CONTROL

Generator's Name_____
Address _____
Manifest _____
RQ, Asbestos, 9, NA2212, III

6) The asbestos disposal containers (e.g., bags, wraps and boxes) and storage areas shall be secured and placarded with appropriate warning signage

6.3 Transportation and Disposal

1) The disposal of waste that contains asbestos waste and lead waste will stay onsite and be placed in a storage area designated by the General Contractor.

ATTACHMENT B

INSPECTION FORM AND SITE MAP

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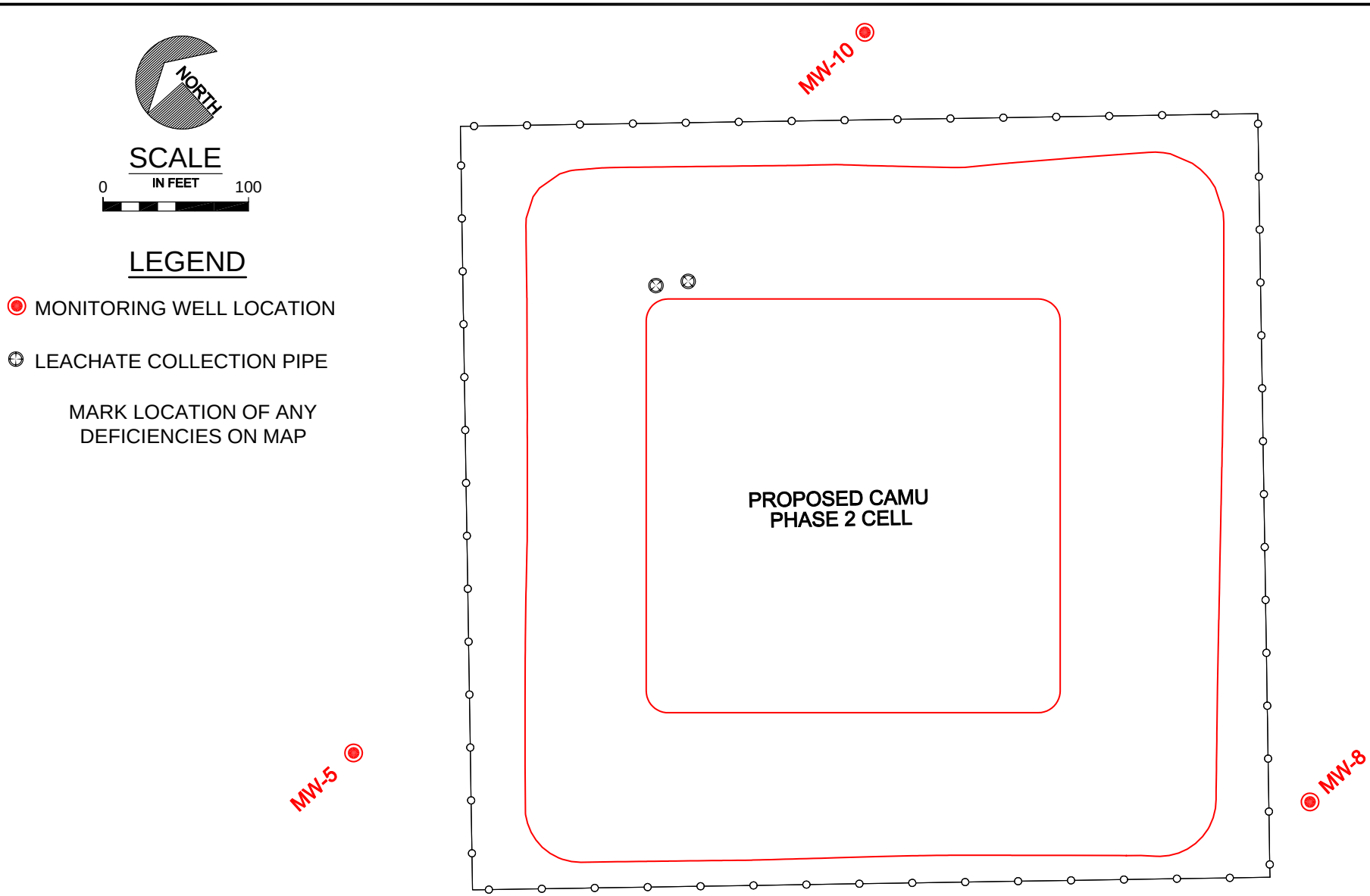

Hydrometrics, Inc.
Consulting Scientists and Engineers

ASARCO EAST HELENA CAMU PHASE 2 CELL OPERATION AND MAINTENANCE PLAN	**CAMU PHASE 2 CELL INSPECTION MAP**	**FIGURE** **A-2**

DAILY INSPECTION FORM

AREA INSPECTED	Cell No. PHASE 2 CELL	DAILY INSPECTION	Inspected by: _____	Date:		
	ITEM NO.	CONDITION	OBSERVATION	ACTION NEEDED		
				MONITOR	INVESTIGATE	REPAIR
SURROUNDING GROUNDS	Visible Dust					
	Potential for Windblown Dispersion					
HAUL ROADS	Visible Dust					
	Visible Debris					
	Run-on					
	Run-off					
	Other:					

Additional Comments:

WEEKLY INSPECTION FORM

AREA INSPECTED	Cell No. PHASE 2 CELL	WEEKLY INSPECTION	Inspected by: _____	Date:		
	ITEM NO.	CONDITION	OBSERVATION	ACTION NEEDED		
				MONITOR	INVESTIGATE	REPAIR
SURROUNDING GROUNDS	Visible Dust					
	Potential for Windblown Dispersion					
HAUL ROADS	Visible Dust					
	Visible Debris					
	Run-on					
	Run-off					
	Condition					
CONDITION OF:	Fences					
	Gates					
	Storm Water Pond					
	Presence of Precipitation run-off or Ponded Liquids					

Additional Comments:

ATTACHMENT C

SAMPLING AND ANALYSIS PLAN

ATTACHMENT C

SAMPLING AND ANALYSIS PLAN

Prepared for:

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ATTACHMENT C

SAMPLING AND ANALYSIS PLAN

1.0 INTRODUCTION

This Sampling and Analysis Plan is designed in order to collect representative samples of waste being hauled and placed in the CAMU Phase 2 Cell. This Plan provides the methodology and procedures for each task presented in the plan. The follow tasks will be conducted to obtain representative samples of waste and to characterize the waste being hauled to the CAMU Phase 2 cell:

- Description of payload inside sampled trucks;
- Grab sampling of wood, dirt, dust, brick, and concrete materials; and
- Laboratory analyses of collected grab samples.

2.0 SAMPLING METHODOLOGY

2.1 SAMPLING FREQUENCY AND PROCEDURES

Demolition waste being hauled to the CAMU Phase 2 Cell from disposal will be sampled from the payload of the haul truck, after the haul truck has been weighed but prior to the haul truck leaving the Smelter facility.

During cleaning and demolition work at the Smelter facility, 13 work areas, will have waste removed and transported to the CAMU Phase 2 Cell. These work areas are presented in Table 1. Work area designations are based on the contractors schedule for demolition, processes that occurred

TABLE 1. WORK AREAS

Work Area	Buildings Included	Stage of Demolition	Material Volume (cubic yards)	Number of Haul Trucks (assume 15 yards/truck)*	Minimum Number of Samples (1/20 trucks)**
1	Contractor's Lunchroom, North End Highline Railroad, Garage, Contractor's Change House, Main Office, Main Natural Gas Valve House.	Stage 1	1,190	80	4
2	Dross Plant Baghouse and 200' Stack, Blast Furnace Building.	Stage 1	270	18	1
3	Thawhouse.	Stage 1	980	66	4
4	Blast Furnace Flue, Monier Flue.	Stage 2	7,900	527	27
5	Acid Plant Cooling Tower, Truck Loading and Spray Dryer Building, Sand Filters, Auto Shop, Acid Plant Shop, Ringling Dust Building.	Stage 2	1,350	90	5
6	400' D&L Stack, 200' Acid Stack, 425' Blast Furnace Stack	Stage 2	6,890	460	23
7	Acid Plant, Pump Tank Building, Main Blower Building.	Stage 2	1,000	67	4
8	Blast Furnace Baghouse.	Stage 2	4,120	275	14
9	Ore Unloading Building, Crushing Mill, Sample Mill.	Stage 2	14,100	940	47
10	Materials Stored in Concentrate Storage and Handling Building, Coverall Buildings, and Direct Smelt Building.	Throughout	14,000	934	47
11	Highline Railroad Remainder, Blast Furnace Office, Power House, Blast Furnace Heat Exchanger, Machine Shop, Direct Smelt Building, Breaking Floor, Locomotive Crane Shed, Blast Furnace Lunchroom, Pump House, Blacksmith Shop, Carpenter Shop, Abandoned Breaking Floor, Sinter Stockpile Building, Charge Building, Cement & Dust Silos.	Alternate A	2,415	161	9
12	Masons Shop, Motor and Paint Shop, Paint Storage Building, Meeting Room, Oil HS, Refractory Storage, Zinc Plant O_2 Building, Zinc Power House, Zinc Pump House, Shop Lunch Room, and Truck Scale.	Alternate B	848	57	3

TABLE 1. WORK AREAS (continued)

13 Misc.	Record Storage, Warehouse Annex, Belly Yard Rail, Slag Handling Pad, Warehouse Oil and Oxygen/Acetyl Storage, Warehouse, Environmental Building, Acid Tanks, Coverall Buildings, Truck Scale & High Grade, Railroad ties and timbers, Slag Dump Cleanup, Remediation of Property for American Chemet, Excavation for Plant Cap, Lake Shore Shed, Asarco On-site Sanitary Treatment, Zinc Plant Locomotive Shop, Bath House, Medical Office and Thornock Tank, HDS Water Treatment, Car Wash, Neutralization Building & Acid Sump, Northwestern Energy Sub Station, and Rodeo Tank & Stormwater Sumps, High Lead Welding Shop.	2009-2012	14,305	954	48
		Totals	**69,368**	**4,629**	**236**

Notes:

* Number of haul trucks assumes a 15 cubic yard capacity. Alternative truck haul capacities may be used by the contractor (typically a range of 10 cubic yards to 20 cubic yards).

** The actual number of samples may vary based on the capacity of the haul trucks used and the number of truck loads. The number of samples will be adjusted to the actual number of truckload transported to the CAMU.

in these areas, and the materials used to construct the buildings. A sample will be collected from one out of every 20 trucks hauling waste from each of the 13 work areas. Therefore, at least one sample will be obtained from each of the 13 areas for every 20 haul trucks that transport waste from that area to the CAMU Phase 2 Cell.

Each haul truck payload to be sampled will be visually divided up into five areas. A grab sample will be collected in accordance with Standard Operating Procedures outlined in Attachment 1 at a random location within each of the five areas. If a location within a sampling area can be visually identified to be potentially the worse case for that area, based on the professional judgment of the sampler, the sample will be obtained from that location to bias the sample as the worst case. If based on the sampler's judgment it is not possible to identify a worst case location, the sample will be obtained from a random location. All five samples will be combined to form a representative composite sample of the waste material being hauled. Large pieces of brick and concrete will be sampled by collecting chip samples according to HM-SOP-37. Large pieces of wood and timber will be sampled according to HM-SOP-47. Broken debris, dirt, and dust will be sampled according to HM-SOP-6. All five samples will be combined into one composite sample, mixed thoroughly, and that one composite sample will be sent to the lab and analyzed.

A sampling notebook will be maintained, and will include the location and work area where waste is being hauled from, a description of the materials in the haul truck payload, the sample identification number, and the date and time the sample is taken.

3.0 LABORATORY PROCEDURES

Laboratory analysis will be performed for total metals using analytical methods shown in Table 2.

TABLE 2. CAMU SOILS ANALYTICAL PARAMETER LIST

Parameter	Analytical Method[1]	Practical Quantitation Limit (mg/Kg)
Total Metals — Digestion by EPA Method 3050 (Method 7471 for Mercury)		
Aluminum (Al)	6010B/6020	5
Antimony (Sb)	6010B/6020	5
Arsenic (As)	6010B/6020	5
Barium (Ba)	6010B/6020	5
Beryllium (Be)	6010B/6020	5
Cadmium (Cd)	6010B/6020	1
Chromium (Cr)	6010B/6020	5
Cobalt (Co)	6010B/6020	5
Copper (Cu)	6010B/6020	5
Iron (Fe)	6010B/6020	5
Lead (Pb)	6010B/6020	5
Manganese (Mn)	6010B/6020	5
Mercury (Hg)	7471	1
Nickel (Ni)	6010B/6020	5
Selenium (Se)	6010B/6020	5
Silver (Ag)	6010B/6020	5
Thallium (Tl)	6010B/6020	5
Tin (Sn)	6010B/6020	5
Vanadium (V)	6010B/6020	5
Zinc (Zn)	6010B/6020	5

NOTES: (1) Laboratory analytical methods are ICP and ICP-MS techniques from EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*.

ATTACHMENT 1

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURES

PACKING AND SHIPPING SAMPLES
HF-SOP-4

1.0 PURPOSE

This procedure is to be followed when packing and shipping water or soil samples to the laboratory by commercial carrier. The Chain-of-Custody standard operating procedure (**HF-SOP-5**) also must be followed if required in the project plan.

2.0 PROCEDURE

2.1 All samples must be labeled and labels filled out in waterproof ink. The label can be Hydrometrics' standard shipping label or may be a project-specific label. Sample labeling procedures are detailed in **HF-SOP-29** (Labeling and Documentation of Samples).

2.2 All samples are placed in the shipping container - normally a metal or plastic cooler.

2.3 Packing:

2.3.1 Sample containers are typically placed in a cooler. Other commercially available insulated containers may be used. The project manager should determine that the containers are appropriate to the type of sample being shipped.

2.3.2 If trip blanks are required, typical for organics sampling, be sure one is present for each and every shipping container.

2.3.3 If an ice pack is used, place the ice pack in the cooler or cooler lid as needed. Fill space with bubble mat wrap or packing material. If necessary, place bubble wrap on top of samples. Sufficient packing material should be used to prevent sample containers from contacting each other during transport.

2.3.4 If custody seals are required, they will be placed on at least two places connecting the cooler container lid to the cooler.

2.3.5 Coolers are then wrapped with nylon strapping tape. Two full rotations of tape will be placed at least two places on the cooler.

2.4 Packing and shipping procedures for Superfund facilities should follow guidelines outlined in the EPA document "A Compendium of Superfund Field Operating Methods."

3.0 SHIPPING

Samples can be sent by commercial air carrier, overnight express, Federal Express or other means. The allowable holding time and often the ability to keep samples cold are important considerations. Copies of all shipment records must be kept in the project files.

Each sample container will be marked with:

- Sampling organization name, address and telephone number;
- Laboratory name, address and telephone number; and
- Ship samples via courier following any applicable DOT requirements. The project manager should determine if there are any special shipping considerations.

3.1 Documents

Each shipping container will contain a description of samples enclosed, date of collection and date of shipment, either a cover letter or a Request for Analytical Services, and/or a Chain-of-Custody form. See Labeling and Documentation of Samples **(HF-SOP-29)**.

For Chain-of-Custody shipments complete a Chain-of-Custody form (see Chain-of-Custody Standard Operating Procedure **HF-SOP-5**).

- Sign the form.
- Place two copies in zip-lock bag in sample container.
- Keep one signed copy in project file.

Signing of the Chain-of-Custody form (record) relinquishes custody of the samples. Relinquishing custody should only occur when directly shipping to the analytical laboratory.

4.0 RELATED REFERENCES

U.S. EPA, 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA-600/4-82-029.

U.S. EPA, 1987. A Compendium of Superfund Field Operations Methods PB88-181557.

STANDARD OPERATING PROCEDURE

CHAIN-OF CUSTODY
HF-SOP-5

1.0 PURPOSE

The purpose of this procedure is to maintain a chain-of-custody for samples. All soil and water samples collected and sent to the laboratory for analysis will be documented using standard chain-of-custody procedures.

2.0 CUSTODY PROCEDURE

Samples will be collected at established project sampling sites using Standard Operating Procedures (SOP). Sampling activities will be recorded in the samplers daily log book and the appropriate collection form(s) completed (see appropriate sampling SOP). Each sample container will be identified by labeling. Labels are attached to sample bottles and are protected with clear label tape to prevent abrasion of labeling information and to guard against failure of label adhesive.

2.1 Sample Identification

Each sample bottle should be labeled with the following information:

- Site;
- Sample Number;
- Person taking the sample;
- Date and time of collection;
- Sample matrix (water, soil, oil, etc.);
- Basis (total or dissolved);
- Preservation; and
- Analyses to be performed.

Labels will be written in waterproof ink.

Use of pre-printed, self-adhesive labels, if available, is preferred.

All samples must be traceable from the time the samples are collected until they are received by the analytical laboratory. The laboratory is then responsible for custody during processing and analysis.

A sample is under custody if:

- It is in your possession;
- It is in your view, after being in your possession;
- It was in your possession and then you locked it up to prevent tampering; or
- It was in your possession and then you placed it in a designated secure area.

2.2 Custody Records

Each sample is identified on a Chain-of-Custody Form(s) by its sample number, date and time of collection, and analysis requested.

Documents will consist of:

- Sample collection records;
- Chain-of-Custody form(s);
- Analytical Parameter List(s) **including analytical methods and detection limits** if not on the Chain-of-Custody form;
- Shipping receipt(s); and
- Purchase Order(s).

3.0 CUSTODY TRANSFER AND SHIPMENT

All samples will be accompanied by **Chain-of-Custody** record. The following procedures will be followed:

- When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date and note the time on the record. This record documents sample custody transfer from the sampler to the laboratory.

- Samples will be packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate custody record accompanying each shipment. Shipping containers will be sealed for shipment to the laboratory. The method of shipment, courier name(s) and other pertinent information are entered in the "Remarks" box.

- All shipments will be accompanied by the **Chain - of - Custody Record** identifying its contents. The original record will accompany the shipment and a copy will be retained in the project file.

- Analytical parameters requested must be noted on the Chain-of-Custody Record, or an attached analytical parameters list accompanying the Chain-of-Custody Record. If not attached to the Chain-of-Custody, an Analytical Parameter List **including analytical**

methods and detection limits must be included with each shipment and should specify methods of analysis required for each parameter.

- All shipping receipts (next day air waybills, freight bills, post office receipts, bills of lading, etc.) purchase orders, and sample collection records will be retained in the project file.

4.0 CUSTODY SEALS

When samples are shipped to the laboratory, they must be placed in containers sealed with custody seals. Some custody seals are serially numbered. Other custody seals are unnumbered seals or evidence tape.

Two seals must be placed on each shipping container (cooler), one at the front and one at the back. Clear tape should be placed over seals to ensure that seals are not accidentally broken during shipment.

STANDARD OPERATING PROCEDURE

DECONTAMINATION OF SAMPLING EQUIPMENT
HF-SOP-7

1.0 PURPOSE

1. Unless entirely disposable sampling equipment is used, cross-contamination can occur and sampling equipment must be decontaminated between sampling locations.

2.0 EQUIPMENT

One or more of the items below is required. Check procedures that follow.

Tap water	Gloves (latex or nitrile)	
Non-phosphate detergent	Distilled or Deionized (DI) Water	Buckets
High Pressure Washer	Organic solvent (preferably hexane or methanol), certified ACS Grade or better	Brushes

3.0 PROCEDURES

Effective decontamination of sampling equipment for sampling inorganics can be achieved by using the following three step process:

1. Wash equipment in warm water and detergent, scrubbing with brushes as necessary to remove visible contaminants;

2. Rinse equipment thoroughly with clean tap water; and

3. Rinse equipment thoroughly with DI (deionized) water.

Deionized or distilled water used during sampling equipment decontamination should be obtained from a source with documented capability to produce contaminant-free water. The source of DI water used (both production source and individual carboy) and any available measurements such as specific conductivity should be recorded in the field notebook. At least 50 mL of DI water should be run through the DI carboy spout prior to using DI water for decontamination or blank sample purposes.

Specific decontamination procedures used should be recorded in field notebooks. Special procedures (i.e., dilute acid rinses, alternate solvent rinses) may be required for some projects.

Any departures from the basic protocol given above for inorganics or organics should also be noted.

The subsections below suggest specific procedures relevant to equipment which may require frequent decontamination.

3.1 Containers

Containers may be used to composite or hold water or soil samples. Between samples, these containers must be decontaminated. Water sample containers also should be rinsed a minimum of three times with water to be sampled.

3.2 Soil Piston Sampler

The soil piston sampler will be decontaminated between sample sites by washing in warm water and detergent followed by rinses in tap water and DI water.

3.3 Soil Coring Devices

Soil samples may be obtained from drill holes by use of coring devices. Split spoons or Shelby tubes can be used. These devices will be decontaminated by thoroughly washing between each sampling depth and sampling sites. Washing will include warm water and detergent followed by a rinse with tap water and DI water.

STANDARD OPERATING PROCEDURE

PROCEDURE FOR COLLECTING SOIL, DUST, AND SMALL DEBRIS SAMPLES©
HS-SOP-6

1.0 PURPOSE

This SOP describes the procedure for collecting a soil, dust, and/or small debris samples for subsequent chemical analysis.

Sample types and sample characteristics can vary considerably within and between sampling sites. It is important, therefore, that detailed records be taken; particularly of the sampling location, depth, and characteristics such as material and color.

2.0 EQUIPMENT

- Stainless steel spoon or plastic spoon;
- 1 gallon size Zip-lock plastic bags (metals);
- Surgical gloves; and
- Field notebook.

When sampling for metals, a stainless steel or plastic spoon should be used for collecting the sample. Sampling tools which are plated with chrome or other materials are to be avoided.

3.0 PROCEDURE

1. Determine the truck/load number to be sampled and record it in the field notebook. The notes and drawings should outline the location of sample units and sample sites, sample site names, sample depths and sample numbers, as appropriate.

2. The truck payload should be divided up into five equal areas and a sample should be collected from each area where soil, dust, or small debris is present. A stainless steel or plastic spoon should be used to collect the sample. Generally, between 100 and 500 grams of soil is required. If more sample is required the sampling area should be expanded.

3. For grab samples, soil collected using a stainless steel or plastic spoon (at the surface or at depth) should be placed directly into the sample container. For metals samples a plastic zip-lock bag is an appropriate container. Generally, coarse material should be excluded from the sample (greater than approximately 1/4 inch where feasible).

4. For composite samples or field split samples, the soil grab sample should be transferred from the stainless steel or plastic spoon to a stainless steel mixing bowl, Teflon tray, or similar device free of potential sample contaminants. Once all grab samples are collected, the sample should be thoroughly mixed prior to transferring the sample to the sample container. Alternately, composite samples may be obtained by transferring each grab sample directly to the plastic sample bag, provided there is sufficient room in the sample to ensure thorough mixing of the sample within the bag. (Since the laboratory may only use a small portion of the total sample, it is important that the sample be thoroughly mixed so that the analysis is representative of all sample grab locations.)

5. Sample containers should be labeled, at a minimum, with sample date and sample number to permit cross referencing with the field notebook. If the sample is not to be submitted as a completely blind sample, other information may also be appropriate including sample depth, station identification, soil type. Refer to **HF-SOP-29**, Labeling and Documentation of Samples.

6. Refer to **HF-SOP-5**, Chain-of-Custody, and **HF-SOP-4**, Packing and Shipping Samples for sample handling procedures.

7. All equipment which contact the soil should be decontaminated after collecting the sample. Refer to **HF-SOP-7**, Decontamination of Sampling Equipment.

STANDARD OPERATING PROCEDURE

LABELING AND DOCUMENTATION OF SAMPLES
HF-SOP-29

1.0 PURPOSE

Documentation of all samples is an important aspect of the project quality assurance program. This SOP specifically describes sample labeling procedure, but also addresses related aspects of sample documentation, all or some of which may be required by the project Quality Assurance Project Plan (QAPP).

2.0 EQUIPMENT

Sample documentation will involve use of some or all of the following:

1. Sample Identification Tag or Labels;
2. Chain-of-Custody Records;
3. Custody Seals;
4. Sample Analysis Form, or cover letter and parameter list; and
5. Field Notebooks.

These documents are sequentially numbered or sequentially paged.

All forms are completed using waterproof ink. Where necessary, the sample labels are protected with label protection tape.

3.0 SAMPLE IDENTIFICATION TAGS OR LABELS

Projects which may be the subject of litigation or are mandated by the EPA typically require serially numbered Sample Identification Tags. Sample labels (generally self-adhesive) are used in lieu of Sample Identification Tags for many projects and provide the same information, but are not serially numbered. The following discussion pertains specifically to use of Sample Identification Tags but, except for the next two paragraphs, is applicable to sample labeling in general.

Sample Identification Tags are distributed to field investigators and the serial numbers are recorded in project files and the field notebook. Individuals are accountable for each tag assigned to them. A tag is considered in their possession until it has been filled out, attached to a sample and transferred to another individual with the corresponding Chain-of-Custody Record.

At no time are any Sample Identification Tags to be discarded. If any tags are lost, voided or damaged, the circumstances are noted in the appropriate field notebook immediately upon discovery and the Quality Assurance officer notified. At the completion of the field investigation activities, all unused Sample Identification Tags are returned and are checked against the list of assigned serial numbers.

Samples are removed from the sample location and transferred to a laboratory or other location for analysis. Before removal, however, a sample is often separated into fractions depending on the analysis to be performed. Each portion is preserved in accordance with prescribed procedures and each is identified with a separate Sample Identification Tag. In this case, each tag should indicate in the "Remarks" section that it is a split sample.

The information recorded on the tag or label includes:

- **Project Code**. An assigned Hydrometrics number (optional);
- **Station Number**. A code assigned by the Field Team Leader (optional), which identifies the station location;
- **Date**. A six-digit number indicating the year, month and day of collection;
- **Time**. A four-digit number indicating the 24-hour clock time of collection (for example, 1345 for 1:45 p.m.);
- **Sample Number**. The sample code number assigned to that sample and recorded in the field notebook;
- **Samplers**. Each sampler's name;
- **Preservative**. The tag should indicate whether a preservative is used, the type of preservative, and whether the sample has been field filtered;
- **Analysis**. The general type of analysis requested;
- **Tag Number**. A unique serial number, stamped on each tag (optional); and
- **Remarks**. The sampler's record of pertinent information (sample matrix, dissolved vs. total, highly contaminated, etc.).

The tag used for water, soil, and sediment samples contain an appropriate place for designating the sample as a grab or a composite, identifying the type of sample collected for analysis, and indicating preservation, if any. The Sample Identification Tags are attached to or folded around each sample and are taped in place.

After collection, separation, identification and preservation, the sample is handled using chain-of-custody procedures as discussed in the **Chain-of-Custody Standard Operating Procedure (HF-SOP-5**).

If the composite or grab sample is to be split, aliquoted portions are placed into similar sample containers. Sample Identification Tags are completed and attached to each container. Tags on quality control samples (e.g. blank, duplicate, blind field standards) are NOT marked to identify samples as such.

3.1 Sample Code Numbering of Duplicate Samples for XRF Analyses

When collecting duplicate soil samples to be analyzed by XRF techniques, the duplicate sample number is the same as the original sample number with the exception of a suffix "D" designation.

For example:	XYZ-9710-100	Original Sample Number
	XYZ-9710-100D	Duplicate Sample Number

4.0 CHAIN-OF-CUSTODY

Samples collected during any investigation may be used as evidence and their possession must be traceable from the time the samples are collected until they are introduced as evidence in legal proceedings. To document sample possession, Chain-of-Custody procedures are followed. These procedures are described in the **Chain-of-Custody Standard Operating Procedure (HF-SOP-5**).

5.0 SAMPLE SHIPMENT

Samples are packaged properly for shipment as described in the **Packing and Shipping Samples Standard Operating Procedure** (**HF-SOP-4**) and dispatched to the appropriate laboratory for analysis.

If sent by mail, the package is registered with return receipt requested. If sent by overnight express courier or common carrier, a Bill of Lading is used. Air freight shipments are sent collect. Freight bills, Postal Service receipts and Bills of Lading are retained as part of the permanent documentation.

When Chain-of-Custody is required, a separate custody record must accompany each shipment. When transferring samples, the individuals relinquishing and receiving samples will sign, date and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the analyst at the laboratory.

6.0 SAMPLE ANALYSIS REQUEST

Samples sent to a laboratory for testing will be accompanied by a Request for Analytical Services or cover letter that describe the samples, specifies the testing required, and who is to receive the analytical report. Commonly, a standard analytical schedule is used for a project and this schedule should be attached to the Request for Analytical Services or cover letter.

7.0 FIELD NOTEBOOKS

A bound field notebook must be maintained by the Field Team Leader to provide a daily record of significant events, observations and measurements during field investigations. All entries should be signed and dated. All members of the field investigation should use this notebook. It should be kept as a permanent record.

These notebooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings. In a legal proceeding, notes, if referred to, are subject to cross-examination and are admissible as evidence.

8.0 CORRECTIONS TO DOCUMENTATION

Unless prohibited by weather conditions, all original data should be recorded in field notebooks, Sample Identification Tags and Chain-of-Custody Records are written with waterproof ink. None of these accountable serialized documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on an accountable document assigned to one individual, that individual may make corrections simply by crossing a single line through the error and entering the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. <u>All subsequent corrections must be initialed and dated</u>.

9.0 SAMPLE NUMBERING

All samples of water and earth materials will be assigned a number by Hydrometrics. The numbers assigned for water samples will all use the project prefix and will be followed by a sequential number. The first sequential number will be 1 and a total of 5000 numbers are available for project water samples. A water sample may consist of several bottles if the sample is to be analyzed for several parameters, each requiring a different preservation technique. All bottles for a sample will have the same sample number. Sampling data including site identification and sample numbers will be recorded in the field sampler's notebook to allow positive identification of the sample.

All samples of earth materials such as drilling cores from test wells and stream bottom sediment will be assigned a number by Hydrometrics. The numbers assigned for earth material samples will use the project prefix and will be followed by a sequential number. The first sequential number will be 5001 and a total of 4999 numbers are available for these samples. Sampling data and sample numbers for earth materials will be recorded and handled in the same manner as for water samples.

The laboratory will not be aware of the specific sample source. All quality control samples will use the same sample numbering method.

10.0 ASSOCIATED REFERENCES

National Water Well Association, 1986. RCRA Groundwater Monitoring Technical Enforcement Document. September.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Vol. II: Field Manual Physical/Chemical Methods. November.

STANDARD OPERATING PROCEDURE

FIELD NOTEBOOKS
HF-SOP-31

1.0 PURPOSE

Field notebooks are intended to provide sufficient data and observations to enable project participants to reconstruct events that occurred during the project and to refresh the memories of field personnel if called upon to give testimony during legal proceedings. In a legal proceeding, notes, if referred to, are subject to cross-examination and are admissible as evidence.

2.0 EQUIPMENT

Bound notebook with water resistant pages
Pen with indelible ink

3.0 PROCEDURE

A bound field notebook must be maintained by the Field Team Leader to provide a daily record of significant events, observations and measurements during field investigations. All members of the field investigation should use this notebook and initial their entries. It should be kept as a permanent record. All information called for in the Work Plan must be recorded, and any other data pertinent to the investigation at hand.

General information recorded in the field notebooks **must** include:

- Date and time;
- Weather conditions;
- Site name and description (if the first visit);
- Names of individuals participating in and/or observing sampling; and
- Unusual circumstances (unlocked well lid, missing staff gage, flood stage, etc.).

In addition, sampling personnel must record descriptions of sampling activities and parameters determined at each sampling station, appropriate to the type of media being sampled. This should include (but is not limited to) the following:

1) For water sampling (surface water and/or groundwater):

Water level measurement
Flow measurement
Sample collection:
- Site number
- Sample code number
- Date and time
- Bottle size(s)
- Sample tag number (for Superfund investigations)
- Bottle quality control number (for Superfund)

Dissolved Oxygen
Water Temperature
Specific conductivity
Calibration of Field Equipment

Preservative(s)
pH
Filtration

2) For soil sampling and/or sediment sampling:

Soil moisture conditions
Soil type (textural classification)
Sample collection

- Site number
- Sample code number
- Date and time
- Sample tag number (for Superfund investigations)

Sketch map of property, designated sample units and sample locations (for soil samples), or cross-section of stream sampled and approximate grab sample locations (for sediment samples).

Site descriptions should be adequate for someone unfamiliar with the site to relocate sampling point, and should be particularly detailed if this is the first sampling.

Other information deemed pertinent to sampling procedures and field conditions should be entered in field notebooks. This should include (at a minimum):

1. Notes confirming that calibration of field instruments (pH, SC, DO, etc.) was performed prior to sampling;

2. Notes detailing decontamination procedures performed (methods, any reagents used);

3. Notes describing the source of DI water used for decontamination or for collection of blanks; and

4. Notes describing shipment of samples to the laboratory and any enclosures included as part of such shipments (chain-of-custody, parameter lists, etc.).

All field notes should be entered into bound notebooks with indelible ink. Corrections should be made by deleting incorrect information with a single line and initialing the deletion in the field notebook. Each page should be numbered consecutively and signed by field personnel. All field records should be kept under custody of the Field Team Leader. Copies of the field records should be available for distribution to all team members for data reduction and report preparation.

STANDARD OPERATING PROCEDURE

CROSS-SECTIONAL DRILL CUTTING SAMPLE COLLECTION FOR WOOD AND SIMILAR MATERIAL ©
(HM-SOP-47)

1.0 PURPOSE

The purpose of drill cutting sampling is to determine residual metals and arsenic concentrations on the surface and internal portions of such materials as wood, timbers, and other similar items with potentially porous surfaces.

2.0 EQUIPMENT

Heavy duty electric drill or brace
1-inch drill bit
Stainless steel knife
Plastic ziplock bags
Waterproof ink marker
Clean plastic sheeting
Cutting catchment basket (18 inches x 18 inches)

3.0 PROCEDURE

1. Underlay the sampled timber (or other to-be-cored material) with clean plastic sheeting. In high locations such as in-place rafter timbers or other wood support structure, a cutting catchment basket lined with clean plastic sheeting may be used. The basket would be suspended below the sample core area by inserting a standard screw eyelet.

2. Drill a cross-sectional sample through the entire thickness of a sample beam, post, or other building timber material using an electric drill equipped with a 1-inch diameter drill bit. Cuttings during the drilling process will be collected using underlaying plastic sheeting which will prevent contamination from the ground or floor surface, and allow easy collection of cuttings.

3. Collect the wood shavings and place in a sample collection ziplock bag. Double bag all samples.

4. Label ziplock bag with waterproof ink marker. In addition prepare EPA tag labels in accordance with **HF-SOP-4**, and insert label between inner and outer ziplock bag.

5. Decontaminate the drill bit, knife, and other sampling implements using deionized (DI) water in accordance with procedures described in **HF-SOP-7**.

6. Collect additional cutting samples following Steps 1 through 4 and composite sample as designed in accordance with Field Sampling Protocol. In general, the sample program

would consist of three cutting samples composited for one analysis per 1,000 cubic feet of wood or a minimum of 3 sample analyses per structure (9 sample points, composited into 3 analytical samples).

7. Package and ship samples in accordance with **HF-SOP-4**.

NOTE: Samples collected for TCLP analyses should be a minimum of 200 grams.

STANDARD OPERATING PROCEDURE

CHIP SAMPLE COLLECTION©
(HM-SOP-37)

1.0 PURPOSE

The following procedure may be used for collection of chip samples. Chip samples may be collected from concrete, brick or other difficult to sample debris.

2.0 EQUIPMENT

Steel Chisel	Magic Marker
Hammer	Ziplock Plastic Bags or Clear Glass Jars

3.0 PROCEDURE

1. Select a representative sampling location.

2. Using a clean steel chisel, obtain sample chips from the items being sampled. A sample of about 200 grams is sufficient.

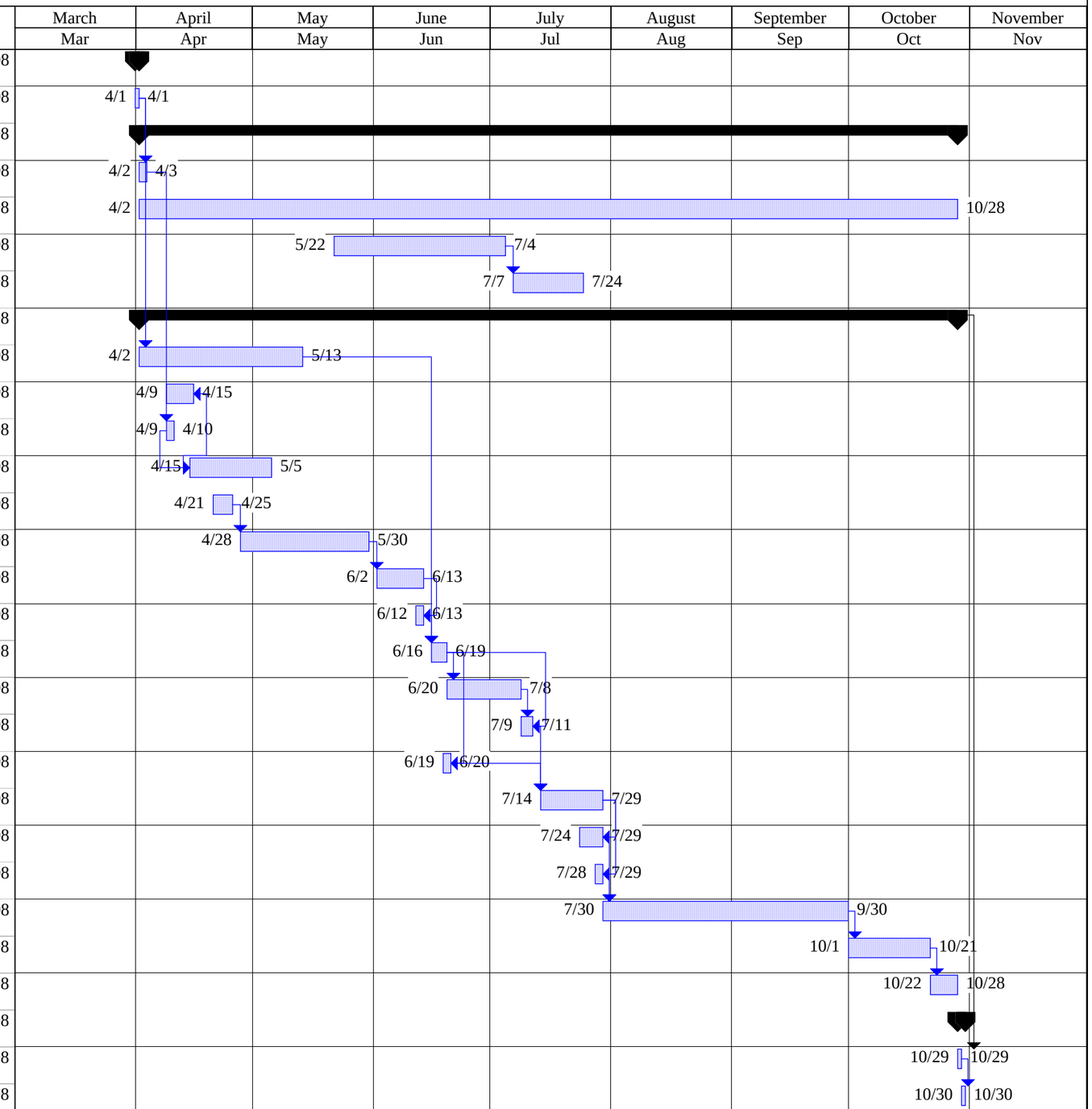
3. Transfer the sample into a clean glass jar or a double ziplock bag. Label using procedures described in **HF-SOP-4** and **HF-SOP-5**.

4. Decontaminate using procedures described in **HF-SOP-7**.

APPENDIX F

CONSTRUCTION SCHEDULE

Task Name	Duration	Start	Finish
Contractor Selection	1 day	Tue 4/1/08	Tue 4/1/08
EPA Approval	1 day	Tue 4/1/08	Tue 4/1/08
Construction Oversight	150 days	Wed 4/2/08	Tue 10/28/08
Preconstruction Conference	2 days	Wed 4/2/08	Thu 4/3/08
Construction Oversight	150 days	Wed 4/2/08	Tue 10/28/08
Liner Cell QC	32 days	Thu 5/22/08	Fri 7/4/08
QC Testing	14 days	Mon 7/7/08	Thu 7/24/08
Construction	150 days	Wed 4/2/08	Tue 10/28/08
Order Liner	30 days	Wed 4/2/08	Tue 5/13/08
Mobilization	5 days	Wed 4/9/08	Tue 4/15/08
Site Layout	2 days	Wed 4/9/08	Thu 4/10/08
Construct Access Roads	15 days	Tue 4/15/08	Mon 5/5/08
Strip Topsoil/ Subsoil	5 days	Mon 4/21/08	Fri 4/25/08
Excavate Soils	25 days	Mon 4/28/08	Fri 5/30/08
Place/compact CCL	10 days	Mon 6/2/08	Fri 6/13/08
Grade/roll Surface for GCL	2 days	Thu 6/12/08	Fri 6/13/08
Install GCL	4 days	Mon 6/16/08	Thu 6/19/08
Install FML	13 days	Fri 6/20/08	Tue 7/8/08
Install Geocomposite	3 days	Wed 7/9/08	Fri 7/11/08
Install Stand Pipe	2 days	Thu 6/19/08	Fri 6/20/08
Install FML	12 days	Mon 7/14/08	Tue 7/29/08
Install Stand Pipe	4 days	Thu 7/24/08	Tue 7/29/08
Install Geocomposite	2 days	Mon 7/28/08	Tue 7/29/08
Haul Waste	45 days	Wed 7/30/08	Tue 9/30/08
Place Temporary Cap	15 days	Wed 10/1/08	Tue 10/21/08
Demobilze	5 days	Wed 10/22/08	Tue 10/28/08
Project Close Out	2 days	Wed 10/29/08	Thu 10/30/08
Notice of Completion	1 day	Wed 10/29/08	Wed 10/29/08
Reporting	1 day	Thu 10/30/08	Thu 10/30/08



Project: CAMU PHASE 2 CELL
Date: Tue 10/2/07

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary

APPENDIX G

CONSTRUCTION QUALITY ASSURANCE PLAN

APPENDIX G

CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN FOR THE ASARCO EAST HELENA CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) PHASE 2 CELL

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

May 2007
Revised June 2007
Revised August 2007

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CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN FOR THE ASARCO EAST HELENA CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) PHASE 2 CELL

1.0 INTRODUCTION

1.1 PURPOSE

This Construction Quality/Quality Control Assurance Plan (CQA/QCP) provides guidance in attaining and maintaining high quality in the construction of liners and leachate detection and collection systems for the Corrective Action Management Unit (CAMU) Phase 2 Cell. Execution of this plan will provide confidence that the facility is constructed in accordance with the Plans and Specifications. This CQA/QCP is intended for use in conjunction with Project Plans and Specifications.

Specific Performance Standards for CAMU Phase 2 cell design are addressed in the Design Analysis Report (Hydrometrics, 2007). One of the Performance Standards for the CAMU Phase 2 cell design requires establishment of a Construction Quality Assurance (CQA) program to ensure that the constructed cover meets or exceeds all design criteria and specifications in accordance with 40 CFR 264.19. This CQA/QCP along with the Plans and Specifications for the CAMU Phase 2 cell constitutes the Construction Quality Assurance Program.

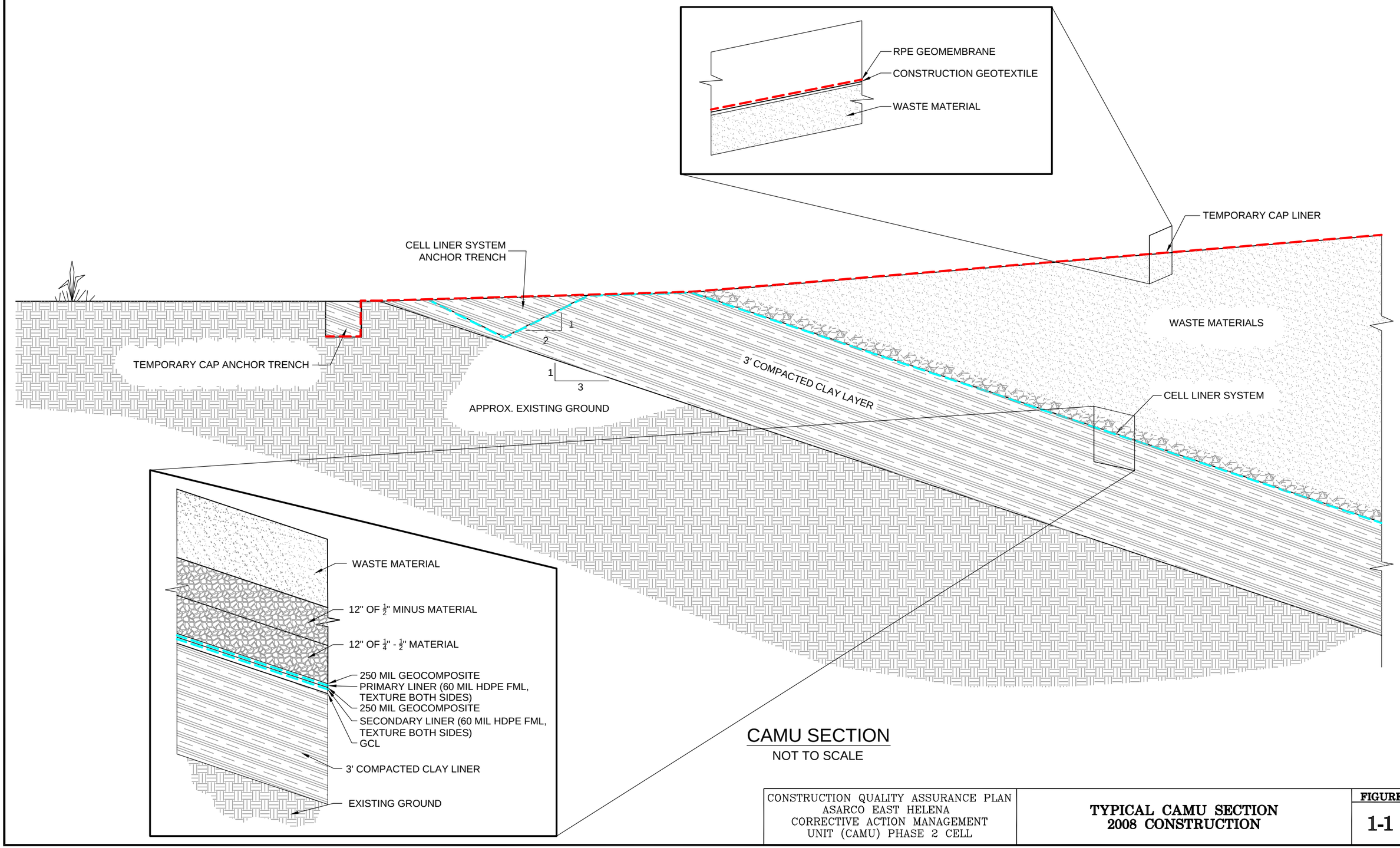
1.2 SCOPE

This plan has been written to include both Quality Assurance (QA) and Quality Control (QC) elements that will be applicable during construction of the CAMU Phase 2 cell including methods of observations, test procedures, and testing frequency. The overall requirements for

inspection and quality assurance of the CAMU Phase 2 cell components, as addressed in this CQA/QCP and in the Plans and Specifications for the Phase 2 cell, are the responsibility of the Engineer. Construction QC requirements are the responsibility of the Contractor as addressed in Section 2.

1.3 LIMITATIONS

This plan focuses on the most critical elements to the success of the CAMU Phase 2 cell, including compacted clay liner, flexible membrane, geotextiles, and geocomposites. Figure 1-1 shows a typical cross-section through the CAMU Phase 2 cell and its components. All elements of the project will be inspected for compliance with Specifications by the Engineering Inspectors. Some elements represent routine types of civil engineering construction (roads, drainage ditches, etc.) and require no special QA or QC provisions other than those described in the Project Plans and Specifications.



CAMU SECTION

NOT TO SCALE

CONSTRUCTION QUALITY ASSURANCE PLAN ASARCO EAST HELENA CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) PHASE 2 CELL	**TYPICAL CAMU SECTION** **2008 CONSTRUCTION**	**FIGURE** **1-1**

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Hydrometrics, Inc.
Consulting Scientists and Engineers

2.0 CONSTRUCTION QUALITY ASSURANCE PLAN ELEMENTS

The following sections address CQA/QCP responsibilities and authorities; project records; and data management and control.

2.1 CQA/QCP RESPONSIBILITY AND AUTHORITY

During construction of the CAMU Phase 2 cell, the Contractor will be responsible for construction QC. The Engineering Inspector will be responsible for assuring that construction QC is effectively implemented as part of the QA responsibilities.

A summary of project responsibilities and authorities relative to QA and QC is included in the following sections. Figure 2-1 presents the QA/QC Functional Organization Chart for CAMU Phase 2 Cell Construction.

2.1.1 Regulatory Agencies

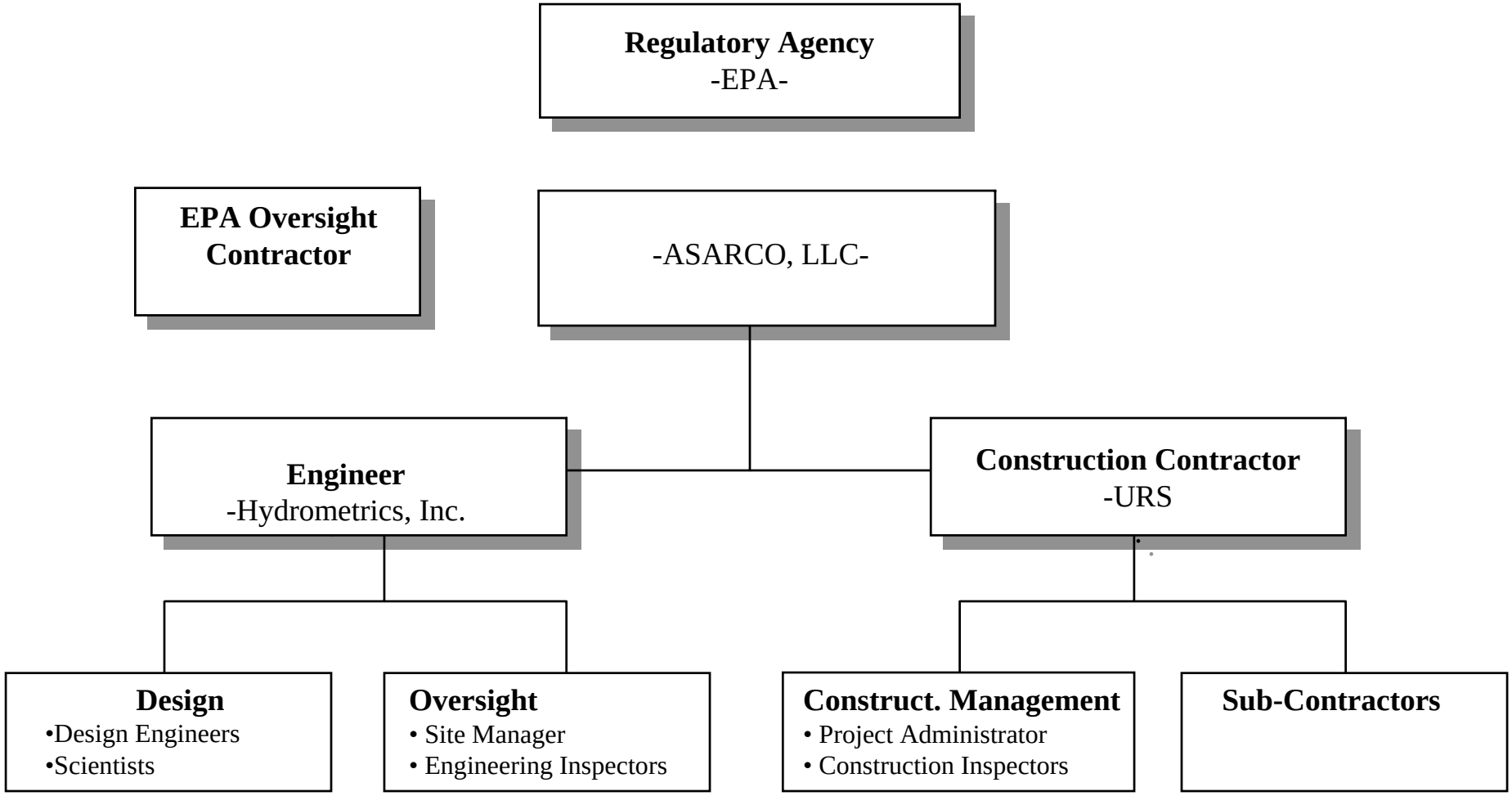
The U.S. Environmental Protection Agency (EPA) is the lead agency responsible for regulatory oversight at the site. EPA is primarily responsible for ensuring public health and the environment are protected. Functional roles of the EPA during CAMU Phase 2 cell implementation are described in Table 2-1.

2.1.2 Project Owner

Asarco, LLC is the Owner for the East Helena Facility and is responsible for the control and implementation of CAMU Phase 2 cell activities. Functional roles of the Owner are further defined in Table 2-1.

2.1.3 Project Engineer

Hydrometrics, Inc. is the Engineer for design and construction oversight of the CAMU Phase 2 cell. During project design, the Engineer is primarily responsible for providing development of designs, plans and specifications which meet project requirements. Functional roles of the Engineer during design are addressed in Table 2-1.



ASARCO,LLC CONSTRUCTION QUALITY ASSURANCE PROJECT PLAN ASARCO EAST HELENA CAMU PHASE 2 CELL	**CONSTRUCTION QUALITY ASSURANCE FUNCTIONAL ORGANIZATION**	**FIGURE** **2-1**

H:\files\007 ASARCO\6043\CAMUCQAP-Org Chart.ppt\HLN\02/27/07

TABLE 2-1. QUALITY ASSURANCE AND QUALITY CONTROL ROLES BY FUNCTIONAL POSITION

Regulatory Agency (EPA)	Owner (ASARCO LLC)	Engineer Design (Hydrometrics)	Engineer Oversight (Hydrometrics)	Engineering Inspectors (Hydrometrics)	Construction Contractor
• Reviews and approves CAMU Phase 2 Cell Work Plans, design documents, and construction plans and specifications. • Monitors the Construction program. • Attends or participates in progress meetings. • Coordinates government agency interaction. • Ensures protection of public health and environment. • Verifies completion of work and approves project closeout.	• Controls and effects CAMU Phase 2 cell activities. • Assigns work to the Engineer and Construction Contractor • Responsible for long term performance of the remedy. • Obtains approvals needed to accomplish project completion (i.e., permits, easements, etc.)	• Prepares construction plans and specifications, and other design documents. • Identifies approvals needed to accomplish project completion. • Provides project engineering and designs. • Performs any necessary design changes during construction to include updates to plans and specifications and construction changes.	• Assesses compliance with construction permits and approvals. • Maintains project records. • Implements portions of CQA/QCP including testing and construction inspection.	• Performs independent, on-site inspections, may include implementation or oversight of performance and certification testing. • Implements CQA/QCP including testing, reporting, and construction inspection. • Performs on-site inspections, including oversight of performance and certification testing.	• Implements CQA/QCP for specific construction activities. • Provides required submittals including progress schedules, reports, and QC documentation. • Submits lists of equipment, material, and proposed methods of work to engineering inspectors. • Submits manufacturers' or suppliers' certification that materials meet specifications

During construction, the Engineer is primarily responsible for assuring that quality standards specified by the design documents and accepted trade practices are met. The functional roles of the Contractor are further addressed in Table 2-1. A Project Manager will be employed by the Engineer to maintain project records as defined in Section 2.3. Project Inspectors will be employed to implement and assure adherence to the CQA/QCP.

2.2 PROJECT RECORDS

Project records will be maintained by the Engineer's Project Manager. Section XI of the RCRA Consent Decree for the East Helena Plant addresses reporting requirements for this project. Submittals by the subcontractors and their vendors will include pertinent shop drawings, data sheets, material certifications, mix designs, permits, and other pertinent or required submittals. The Project Manager will prepare various reports that describe the remediation construction activities and provide documentation that the construction conforms to approved plans and specifications. The specific reports, their content, distribution and distribution schedule will be developed for each specific CAMU Phase 2 Cell construction activity. As a minimum the following reports will be part of the project records:

1. Inspection Testing Report
2. Daily Inspectors Report
3. Problem Identification and Corrective Measures Report
4. Weekly Summary Report and
5. Monthly Summary Report.

Examples of these project reports are included in Appendix A.

2.3 DATA MANAGEMENT AND DOCUMENT CONTROL

All information relevant to remediation activities will be categorized as either (a) data, or (b) construction project records. Data are results from the measurement of some parameter of media and can include sampling and analytical results, and other tests or measurement (e.g., survey information). Construction project records consist of all documentation pertinent to CAMU Phase 2 Cell construction activities.

The QA methods and procedures outlined in this CQA/QCP will be used to verify and document that the project is completed in accordance with plans and specifications, codes, standards and practices referenced therein.

2.4 MEETINGS

To effectively implement this plan, several meetings will be held to promote communication. The meetings are described below.

2.4.1 Pre-Bid Meeting

The meeting will be held prior to bid opening and will allow construction contractors a chance to discuss questions with the Owner and Engineer and to visit the site.

2.4.2 Pre-Construction Meeting

The meeting will be held before construction commences. The Engineer, Contractor, and Owner will attend this meeting. At this meeting, the Engineer's oversight plans will be discussed as well as the CQA/QCP and any specific CQA/QCP addendum.

2.4.3 Progress Meetings

These meetings will be held during construction and their frequency may vary with the amount of construction activity ongoing. While discussion at these meetings may include a wide variety of topics, it should also include any problems encountered or anticipated that are related to CQA. The Engineer will attend progress meetings to monitor overall project progress and issues particularly those related to QA and QC issues. EPA will be notified of progress meetings, provided an agenda and handouts, and may participate via phone or in person.

2.5 REPORTING

QA/QC Issues will be recorded and reported to interested parties in a number of ways. Engineering Inspectors will prepare general daily, weekly and monthly reports documenting construction progress and issues. QA/QC test failures or non-conformance shall be noted on

daily logs. Additionally, each test failure or non-conformance will be further reported on a special report documenting the issue and its resolution.

Sample reporting forms are contained in Appendix A.

Daily reports and QA/QC issue reports will be distributed to the Engineer, Owner and Regulator (EPA) within 48 hours after the close of business on the day reported. Distribution methods may include hand delivery, fax, mail, e-mail, website or other methods.

3.0 EARTHWORK

This section describes QA and QC measures for all earthwork to be performed except for those related to the compacted clay liner (CCL). QA/QC measures for the CCL are described in Section 4.0.

3.1 QUALITY CONTROL MEASURES

The Contractor shall perform QC measures on excavated on-site soils, imported borrow materials, and other miscellaneous earthen materials.

QC measures for on-site soils to be used for cover soil and subsoil shall include visual inspection. All organic material including roots, sticks, leaves, brush trash, and any other debris shall be removed before placing excavated material in the appropriate stockpile.

QC measures for imported borrow materials to be used for drain material, drain aggregate, or 1/2" minus crushed material shall include visual inspection, gradation, and liquid and plasticity limits (where applicable). Imported materials used for road base shall be subject to the same tests and will also be subject to wear, fractured faces and a standard proctor density tests. Placed road base shall be tested for density and moisture content. Table 3-1 lists the specific tests, frequency of testing and acceptance criteria.

QC measures for asphalt used on haul roads shall be at the discretion of the Contractor.

3.2 QUALITY ASSURANCE MEASURES

Engineering Inspectors will perform QA testing to corroborate QC testing. In general, QA testing will use the same methods, standards and rejection criteria as QC testing. The frequency of QA testing will vary from the QC testing.

Those QA tests that can be characterized as a materials acceptance test (such as gradation, liquid and plastic limits, wear and fractured faces, and proctor density tests for drain material

TABLE 3-1. QC TESTS FOR SELECTED EARTHEN AND ASPHALT MATERIALS

Material	Test Description	Test Method	Test Frequency	Standard	Test Rejection Criteria
Drain Material, Drain Aggregate, 1/2" minus Crushed Cushion Material	Deleterious Materials	Visual	Continuous	--	All foreign material and undersized or oversized particles to be removed.
	Gradation	ASTM D-422	1 per 5,000 cy^2	Special provisions Section 203.07.8 or ½" minus	No deviation from standard.
	Liquid and Plastic and Limits Plasticity Index	ASTM D-4318	1 per 5,000 $cy^{2, 3}$	LL <40 PI <6	No deviation from standard.
Road Base Course (Type A Grade 5)	Deleterious Materials	Visual	Continuous	--	All foreign material and undersized or oversized particles to be removed.
	Gradation	ASTM D-422	1 per 5,000 cy^2	Section 701.025 Table 701-8	No deviation from standard.
	Liquid and Plastic Limits Plasticity Index	ASTM D-4318	1 per 5,000 $cy^{2, 3}$	LL <25 PI <6	No deviation from standard.
	Wear	MT-209	1 per 5,000 cy^2	Wear Factor <50 @ 500 revolutions	No deviation from standard.
	Fractured Faces	MT-217	1 per 5,000 cy^2	At least 25% of material retained on No. 4 sieve must have at least one mechanically fractured face	No deviation from standard.

TABLE 3-1. QC TESTS FOR SELECTED EARTHEN AND ASPHALT MATERIALS (continued)

Material	Test Description	Test Method	Test Frequency	Standard	Test Rejection Criteria
Road Base Course (Type A Grade 5) (continued)	Standard Proctor Density	ASTM D-698 or AASHTO T-99 Method A, B, C or D	1 per 5,000 cy[2]	N/A	N/A
	In-Place Density	ASTM D-2922	1 per 500 cy	95% or maximum dry density	No deviation from standard.[(4)]
	Water Contents	ASTM D-2922	1 per 500 cy	Water content within ±2% of optimum	No deviation from standard.[(4)]
Road Subgrade	Standard Proctor Density	ASTM D-698 or AASHTO T-99 Method A, B, C or D	1 per soil type	N/A	N/A
	In-Place Density	ASTM D-2922	1 per 200' of road	95% or maximum dry density	No deviation from standard.[(4)]
Asphalt	Mix Design	N/A	N/A	N/A	None. Asphalt design, mixing, placement and testing shall be at the Contractor's discretion.
General Waste Materials	Compaction	Visual	Continuous	8 passes (4 cycles) with sheepsfoot or padfoot roller	No deviation from standard.
	Lift Thickness	Visual Measurement	Continuous	Two foot lifts	No deviation from standard.
	Gradation	Visual Measurement	Continuous	2' minus diameter	Long oversized debris will be laid flat and void space minimized. Must have one dimension less than 2 feet.

TABLE 3-1. QC TESTS FOR SELECTED EARTHEN AND ASPHALT MATERIALS (continued)

Material	Test Description	Test Method	Test Frequency	Standard	Test Rejection Criteria
1/2” minus crushed cushion materials	Gradation	ASTM D-422	1 per 5,000 cy^2	Special Provisions Section 209.07.8 All material <1/2”	No deviation from standard.
	Compaction	Visual	Continuous	Lightly rolled	No deviation from standard.
	Lift Thickness	Visual Measurement	Continuous	Minimum one foot Maximum two-foot	No deviation from standard.
Cover soil/subsoil	Soil Quality	Visual	Continuous	No roots, sticks, leaves, brush, trash or other debris	Remove all material not meeting standard

Notes:

(1) Inspection shall be by the Contractor’s QC representatives, equipment operators, laborers or other personnel.
(2) Frequency shown is for each type of material. If there is a change in the material or supplier, the same frequency shall apply to the new material.
(3) Liquid and plastic limit testing not applicable to those materials with less than 1% (by weight) or material passing the No. 40 sieve.
(4) Deviations shall be corrected by reworking material until the standard is met.

and road base) will be performed at least once by Engineering Inspectors for each material. For the remaining QA tests that can be characterized as placement tests (such as in place density and water content), QA tests will be performed at a minimum frequency equal to 10% of the frequency of QC testing. In other words, for every ten QC tests, one QA test will be performed.

For those QC tests whose frequency is listed as continuous in Table 3-1, QA tests will be performed at least once per shift for a minimum of 15 minutes.

The testing frequency listed herein should be considered a minimum. Engineering Inspectors should use their judgment to implement additional testing if they suspect a change in materials or conditions.

4.0 COMPACTED CLAY LINER

A compacted clay liner is a component of the CAMU liner system as shown on Figure 1-1. The Contractor will utilize site soil from site excavation for the bottom liner. The CCL will be constructed from soils excavated onsite. Initial exploratory sampling indicates that on-site soils may be suitable for use in a CCL. However, additional segregation and testing of excavated soils is necessary to confirm this. To this end, the Engineer will observe all excavation and direct the Contractor to stockpile for CCL use only those soils most suitable (meaning clay-like and fine-grained). Soils not designated by the Engineer for CCL use will be stockpiled separately and will eventually be placed as waste within the CAMU. The Engineer will visually assess excavated soils to segregate soils into groups suitable for CCL use and not suitable for CCL use.

Following stockpiling, the Engineer will conduct additional tests to confirm that the stockpile materials are suitable for use in the CCL. These tests will consist of gradation, liquid and plastic limits and re-molded hydraulic conductivity. For purposes of this plan, the tests described above (including the visual inspection during excavation) will be referred to as Stockpile Acceptance Testing. Table 4-1 lists test methods, frequency, standards and rejection criteria for Stockpile Acceptance Testing.

After initial Stockpile Acceptance Testing, the Engineer will evaluate the results. If initial results are unacceptable, the Engineer may direct the Contractor to amend the stockpiles, segregate the stockpiles, or take other measures as deemed necessary. Additional testing for stockpile acceptance may follow.

Eventually, the stockpiles will be accepted for use and the Contractor will begin placing the CCL. A grid pattern will be established across the cell to identify testing locations. The Contractor shall perform QC testing which will consist of visual inspections, in-place moisture and density and an inventory of construction stakes. Table 4-2 lists QC testing methods, frequency, standards and rejection criteria.

TABLE 4-1. STOCKPILE ACCEPTANCE TESTING

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Soil Type and Quality	Visual	Continuous	Maximum particle size <1 inch	Reject any excavated material that has not been screened to 1 inch minus
Liquid and Plastic Limits	ASTM D-4318	1 per 1,000 cy	PI>8	Reject portions of the stockpile not meeting the standard or conduct additional hydraulic conductivity tests with failing soils
Remolded Hydraulic Conductivity	ASTM D-5084	1 per 3,500 cy or minimum of 6 tests	Hydraulic conductivity must not exceed $1x10^{-6}$cm/sec	Reject portions of the stockpile not meeting standard.

TABLE 4-2. QC TESTING FOR CCL PLACEMENT

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Soil Type and Quality	Visual	Continuous	Maximum particle size <1 inch	Reject all material that has not been screened to 1 inch minus
Scarification	Visual/Tape Measure	100%	Surface scarified to a depth of 0.5-2.0 inches and a spacing of 6-12 inches before accepting additional lifts	Recompact and/or scarify any surface not meeting standard
In-Place Density	ASTM D-2922	5 per acre per lift	95% of maximum dry density Less than 3% of all densities may not meet the standard above. Of those not meeting standard, no dry density less than 5 pcf less than 95% of maximum dry density. Sample locations shall be selected by the Engineering Inspector based on grid pattern established at project outset.	Reject and reprocess those areas with dry density less than 5 pcf less than 95% of maximum dry density or if cumulative failures exceed 3% of all tests
In-Place Water Content	ASTM D-3017	1 per 1,000 cy	Less than 3% of all measured water content may have water content wetter than +2% or dryer than –3% of optimum	Reject or reprocess material that exceeds both +2%/-3% criteria
Construction Stakes	Daily Inventory	Daily	Contractor must return all construction stakes used within the CCL boundary at the end of each shift to the Engineering Inspector	Reject and replace day's work if stake or portion of stake is missing
Proctor Moisture Density Curve	ASTM D-698 or AASHTO T-99	1 per 2,500 cy	N/A	N/A
Compactive Effort	Visual	Continuous	Contractor to establish rolling pattern and equipment that produces necessary compaction	Rework all areas not sufficiently compacted
Lift Thickness	Visual/Tape Measure	5 per acre per lift	No loose lift thickness shall exceed 6 inches. Smaller lifts may be necessary to meet compaction requirements	Remove excess lift thickness.
Hole Repair	Visual	100%	Firmly packed	Reject and replace holes not repaired or incompletely repaired.

Concurrent with QC testing, the Engineering Inspector will conduct QA testing. Table 4-3 lists QA testing requirements.

Following completion of the CCL to the lines and grades shown on the drawings, the Engineer will conduct confirmation testing. The test shall consist of an in place hydraulic conductivity test conducted per ASTM D-5084. A full depth sample shall be taken using methods of ASTM D-1587 from a location selected by the Engineer. The sample will be separated into three distinct specimens and each sample tested. The Engineer shall consider the results and, if any of the specimens have a hydraulic conductivity in excess of $1x10^{-6}$cm/sec, will consult with EPA on what actions will be taken to mitigate the overall conductivity of the CCL.

Both the in-place hydraulic conductivity test and a number of other tests as well as stake placement (if necessary) will result in penetrations of the CCL or a portion of the CCL. The Contractor shall patch these penetrations by placing approved CCL material in each penetration in a lift not to exceed two inches and firmly compacting the CCL materials by hand tamping. A tamper with a tamping head roughly the size of the penetration shall be used. QC measures for hole repairs shall consist of continuous oversight and documentation of the repair. QA measures shall consist of oversight of at least 20% of all hole repairs.

TABLE 4-3. QA TESTING FOR CCL PLACEMENT

Parameter	Test Method	Frequency[1]	Test Standard	Rejection Criteria
Soil Type and Quality	Visual	Continuous	Soil must be fine-grained (all particles <1 inch), clay-like and free of debris	Reject all material that does not meet standard
Scarification	Visual/Measuring Tape	100%	Surface scarified to a depth of 0.5-2.0 inches and at a spacing of 6-12 inches	Reject and recompact and/or scarify any surface not meeting standard
Proctor Moisture Density Curve	ASTM D-698 or AASHTO T-99	1 per 2,500[2] cy	N/A	N/A
In-Place Density	Electrical Gauge	1 per acre per lift[2]	95% of maximum dry density Less than 3% of all densities may not meet the standard above. Of those not meeting standard, no dry density less than 5 pcf, less than 95% of maximum dry density Outliers may not be concentrated in one area or lift	Reject and reprocess those areas with dry density less than 5 pcf less than 95% of maximum dry density or if cumulative failures exceed 3% of all tests
In-Place Water Content	Electrical Gauge	1 per acre per lift[2]	Less than 3% of all measured water content may have water content wetter than +2% or dryer than –3% of optimum Outliers may not be concentrated in one area or lift	Reject or reprocess material that exceeds both +2%/-3% criteria
In-Place Density	ASTM D-1556	1 per every 10 tests above	N/A	Use to corroborate electrical gauge testing
In-Place Water Content	ASTM D-2216	1 per every 10 tests above	N/A	Use to corroborate electrical gauge testing
Hole Repair	Visual	1 per every five QC tests of same	Firmly packed	Reject and replace holes not repaired or incompletely repaired

Notes:

(1) Frequency noted is a minimum. Inspectors may perform additional tests if conditions change.

(2) Minimum of one test required.

5.0 FLEXIBLE MEMBRANE LINERS

Flexible Membrane Liners (FMLs) are a component of the CAMU Phase 2 cell. Both HDPE and RPE FMLs are used within the project.

Before shipping any FMLs to the site, the Contractor shall submit the manufacturer's QA testing results to the Engineering Inspectors. At a minimum, the manufacturer's QA tests shall consist of the tests list in Table 5-1. The manufacturer's QA tests will be conducted on the particular lot to be used for this project.

On delivery of FMLs to the project site, the Engineering Inspector shall collect additional samples for confirmation testing. The Engineering Inspector shall select one roll or pallet of each FML and shall remove an appropriate length for conformance testing.

The tests to be performed shall duplicate those specified in Table 5-1.

TABLE 5-1. MANUFACTURER'S QA TESTS FOR FML

Property	Test Method	Test Frequency	Test Standard(1)			Rejection Criteria
			OR RPE	HDPE 60 mil	HDPE 40 mil	
Gauge (mils nominal)	ASTM D-1593	1 per lot	20	60	40	Material must meet all standards <u>before</u> delivery to site
Tear Strength (pounds)	ASTM D-1004		70	42	28	
Tensile Strength 1. Yield Stress (lb/in) 2. Break Stress (lb/in) 3. Yield Elongation (%) 4. Break Elongation (%)	ASTM D-638 Type IV		300	 126 90 12 100	 84 60 12 100	
Puncture Resistance (lb)	ASTM D-4833		150	80	60	
Stress Crack Resistance (Hours)	ASTM D-5397		N/A	300	300	
Specific Gravity	ASTM D-1505			≥0.94	≥0.94	

Notes:
(1) Values shown are minimum average roll values.

The Contractor shall implement QC measures during FML installation. QC measures shall include visual inspection of the receiving surface, anchor trenches, panel placement and seams as well as destructive testing of seams. Destructive testing will be conducted on seam samples that are cut from a completed seam. The samples shall be 24 inches by 11 inches minimum. From

the sample, the Contractor shall deliver to the Engineer an 11 inches by 11 inches piece for archival storage. The remainder will be used by the Contractor for field and laboratory testing. Table 5-2 lists the QC tests, their frequency and rejection criteria.

The Engineering Inspectors shall implement QA procedures during FML installation. In general, Engineering Inspectors will perform the same tests as indicated in Table 5-2 at the same frequency. The only exception to this is Destructive Seam Testing (ASTM D-4437 and ASTM D-3083) will be performed once for every ten QC tests of the same.

TABLE 5-2. QUALITY CONTROL CRITERIA FOR FML

Parameter	Test Method	Frequency	Standard	Test Rejection Criteria
Surface Conditions	Visual Inspection	100%	No holes, ridges, voids, rocks, roots, ruts or other non-conformities	Reject and replace all surfaces with any of the items at left
Anchor Trenches	Visual/Tape Measure	100%	See dimensions on project plans	Reject and repair all non-conforming trenches
FML Placement	Visual	100%		Reject and replace non-conforming panels
Seaming	Visual	100%		
Seam Tensile Strength (HDPE only)	ASTM D-638, type M-1	1 per 500 feet of seam	Base material properties – see Table 5-1	Reject and replace non-conforming seams
Seam Shear & Peel (HDPE only)	ASTM D-4437	1 per 500 feet of seam	Shear strength: 120 lb/in – 60 mil 80 lb/in – 40 mil Peel strength: 91 lb/in(2) – 60 mil 78 lb/in(3) – 60 mil 60 lb/in(2) – 40 mil 52 lb/in(3) – 40 mil	Reject and replace non-conforming seams
Trial Seam	ASTM D-3083	1) Beginning of each shift of seaming and every four hours thereafter 2) At any change in seam operator, equipment or weather	Break must be a ductile film tear with at least 80% of minimum sheet strength	Repeat trial seaming until standard is met
Air lance Vacuum Box or Internal Pressure(3)	ASTM D-4437 ASTM D-4437 or As described in specifications	100%	Ripples or bubbles Bubbles emerging from seams Loss of pressure ≤4 psi in 7 minutes	Identify, repair and replace leaking seams

Notes:

(1) Hot wedge seams only
(2) Extrusion fillet weld only
(3) HDPE only

6.0 GEOCOMPOSITES

Geocomposites are used in the CAMU Phase 2 cell leak detection and leachate collection system. The Contractor will obtain the manufacturer's certification that the material conforms to the Project Specifications and provide copies to the Engineering Inspector. The Engineering Inspector will be present during the delivery and unloading of geocomposites and geofabrics. Confirmation testing requirements are listed in Table 6-1. These will be performed by the manufacturer or Contractor and provided to Engineering Inspectors no later than at delivery of the geocomposite.

The Engineering Inspector will be present during installation of the geocomposite and will visually confirm that overlap and panel fasteners conform to Project Specifications. Copies of manufacturer's certifications and the results of any testing or inspection conducted by the Engineering Inspector will be provided to the Engineer.

Quality control measures to be implemented by the Contractor shall include complete visual inspection of overlaps and seaming procedures. QA measures implemented by the Engineer shall also include complete visual inspection of overlap and seaming procedures.

TABLE 6-1. CONFIRMATION SAMPLING FOR GEOCOMPOSITES

PARAMETER	TEST	MINIMUM TEST FREQUENCY	REJECTION CRITERIA
Crush Strength	ASTM D-1621	1 per lot(1)	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.
Thickness	ASTM D-5199	1 per lot(1)	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.
Transmissivity	ASTM D-4716 Width @ 14.5 psi Normal pressure & 0.1 ft/ft hydraulic	1 per lot(1)	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.

Notes:

(1) A lot is the smaller of 100,000 square feet or one production run.

7.0 GCL

A Geosynthetic Clay Liner (GCL) is a component of the CAMU. The Contractor or manufacturer shall provide acceptance testing of the GCL according to Table 7-1. Test results shall be provided to the Engineering Inspector before any GCL is shipped to the project.

During GCL placement, the Contractor shall perform QC tests according to Table 7-2. The Engineering Inspector shall perform QA tests of the same type and at the same frequency as those tests shown in Table 7-2.

If any holes result in the GCL for any reason, the Contractor shall repair the hole by placing a patch of GCL over the affected area. The patch will have a minimum of 12 inches of overlap on all sides from the affected area. Granular bentonite shall be uniformly scattered over the entire patch area at the same rate as used in panel overlaps. The Contractor and Engineering Inspector shall visually inspect all hole repairs.

TABLE 7-1. ACCEPTANCE TESTING FOR GCL

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Mass per Unit Area	ASTM D-5993	1 per lot(1)	0.75 lb/ft^2 MIN	Materials must pass all acceptance testing before delivery to site
Hydraulic Conductivity	ASTM D-5887		5 x 10^{-9}cm/sec MAX	
Shear Strength	ASTM D-5321		500 psf MIN	
Peel Strength	ASTM D-4632		15 lbs MIN	

Notes:

(1) All material used on the project must be from the sampled lot.

TABLE 7-2. QC MEASURES FOR GCL

Parameter	Test Method	Testing Frequency	Test Standard	Rejection Criteria
Overlap	Visual/Measuring Tape	100%	6-8 inches	Manually move panels to meet specifications
Subgrade Smoothness	Visual		No bridging of GCL≥1 inch	Manually repair area
GCL Rips, Tears, Holes	Visual		No irregularities	Patch all irregularities
Granular Bentonite in Overlaps	Visual			Add granular bentonite to meet specification
Freezing/Unrestrained Hydration	Visual		Visibly uneven	Remove and replace affected GCL
Hole Repair	Visual		12 inches of overlap all around with granular bentonite	Remove and replace patch

8.0 LEACHATE COLLECTION AND DETECTION SUMPS AND PIPING

Perforated piping and smooth solid piping are used in the project's leachate collection and detection systems. QA/QC measures for piping shall include obtaining manufacturer's certifications that the materials meet the project specifications, survey verification of pipe grades, verification that pipe joints were constructed according to the specifications, and verification that the pipe is not damaged during backfilling. QA/QC measures for the concrete sump base include verification of formwork to ensure it is complete and has the specified dimensions, verification of concrete placement, and verification of concrete properties.

During construction of the Leachate Collection and Detection Systems, the Contractor shall perform QC tests according to Table 8-1. The Engineering Inspector shall perform QA tests of the same type and at the same frequency as those tests shown in Table 8-1.

TABLE 8-1. QA/QC MEASURES FOR LEACHATE COLLECTION AND DETECTION SUMPS AND PIPING

Parameter	Test Method	Testing Frequency	Test Standard	Rejection Criteria
Pipe Grade	Visual/Level	100%		Manually move piping to meet grade specifications
Pipe Joints	Visual			Repair joints to meet joint specifications.
Backfilling over Pipe	Visual		No damage	Remove and replace all piping damaged during backfilling.
Sump Formwork	Visual			Repair formwork not meeting the required dimensions
Concrete Strength	ASTM C-78	1 per truck	3000 psi 28-day Strength	Reject concrete not meeting the required 28-day strength

9.0 REFERENCES

AASHTO T-99, "The Moisture Density Relations of Soils Using 2.5 kg (5.5 lb) Rammer and a 305mm (12 inch) Drop."

ASTM C-78, "Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)."

ASTM D-422, "Standard Method for Particle-Size Analysis of Soils."

ASTM D-638, "Type M-1, "Tensile Properties of Plastics."

ASTM D-698, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."

ASTM D-1505, "Standard Test Method for Density of Plastic by the Density-Gradient Technique."

ASTM D-1556, "Test Method for Density of Soil In Place by the Sand-Cone Method."

ASTM D-1587, "Standard Practice for Thin-walled Tube Sampling and Soils."

ASTM D-1603, "Standard Test Method for Carbon Black in Olefin Plastics."

ASTM D-1621, "Compressive Properties of Rapid Cellular Plastics."

ASTM D-2216, "Laboratory Determination of Water (Moisture) Content of Rock and Soil."

ASTM D-2922, "Standard Test Methods for Density of Soil and Soil Aggregate In-Place by Nuclear Methods (Shallow Depth)."

ASTM D-3015, ""Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds."

ASTM D-3017, "Standard Test Methods for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)."

ASTM D-4318, "Liquid Limit, Plastic Limit and Plasticity Index of Soils."

ASTM D-4437, "Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes."

ASTM D-4716, "Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane Flow) of Geotextiles and Geotextile Related Product."

ASTM D-5084, "Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter."

ASTM D-5089, “Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers.”

ASTM D-5199, “Measuring Nominal Thickness of Geotextiles and Geomembranes.”

ASTM D-5994, “Standard Test Method for Measuring Core Thickness of Textured Geomembrane.”

Hydrometrics, 2007. Design Analysis Report, Asarco East Helena, Corrective Action Management Unit (CAMU) Phase 2 Cell, January 2007.

MT-209, “Los Angeles Abrasion (Wear Test).”

MT-217, “Method for Determining Percentage of Mechanically Fractured Particles.”

APPENDIX A

FIELD FORMS

INSPECTOR'S DAILY RECORD OF WORK PROGRESS

For submittal to Resident Project Rep. to compile Daily Construction Report

DAY	S	M	T	W	TH	F	S

Project Title _____ Project No. _____

Feature _____

Contractor _____ Type of Work _____

WEATHER	Brite Sun	Clear	Overcast	Rain	Snow
TEMP.	To 32	32-50	50-70	70-85	85 up
WIND	Still	Moder	High	Report No.	
HUMIDITY	Dry	Moder	Humid		

CONTRACTOR'S WORK FORCE (Indicate classifications, including Subcontractor personnel)

EQUIPMENT IN USE OR IDLED (Identify which)

MATERIALS OR EQUIPMENT DELIVERED

NON-CONFORMING MATERIALS OR WORK (Describe reason for non-conformance)

FIELD PROBLEMS (which could result in delay or claim)

QUANTITIES OF PAY ITEMS PLACED

SUMMARY OF CONSTRUCTION ACTIVITIES

FOLLOWUP INSPECTIONS OF PREVIOUSLY REPORTED DEFICIENCIES

DISTRIBUTION 1. Field Office
2. Inspector

Inspector _____

Wiley-Fisk Form 8-5

DAILY CONSTRUCTION REPORT

(Continuation Sheet)

PROJECT _____ REPORT NO. _____

JOB NO. _____ DATE _____

CONSTRUCTION ACTIVITIES (Continued)

DISTRIBUTION:
1. Proj. Mgr.
2. Field Office
3. File
4. Client

SHEET _____ OF _____

BY _____ TITLE _____

Wiley-Fisk Form 8-2

INSPECTOR'S WEEKLY PROGRESS REPORT

Feature Inspected _____

Item No. _____

Project _____ Date _____

Project No. _____ Contract No. _____

Work Order No. _____ Purchase Order No. _____

Contractor _____ Location _____

Subcontractor _____ Location _____

CONTRACT REQ'D DELIVERY DATE _____ ESTIMATED DELIVERY DATE _____

(EXPLAIN DIFFERENCE) _____

ENGINEERING STATUS:

DESIGN COMPLETE % _____ CONTRACTOR COMPL. % _____

INCOMPLETE _____ INCOMPLETE _____

PRODUCTION STATUS:

CONTRACT NOT YET SCHEDULED _____ WILL BE SCHEDULED _____ SCHEDULED _____

CONTRACT IN PRODUCTION _____

CONTRACT PROGRESSING TO PRESENT SCHEDULE _____ INSPECTOR'S ESTIMATE OF % COMPL. _____

SHIPPING INFORMATION:

TOTAL SHIPPED THIS WEEK _____

TOTAL PREVIOUSLY SHIPPED _____

TOTAL SHIPPED TO DATE _____

REMARKS

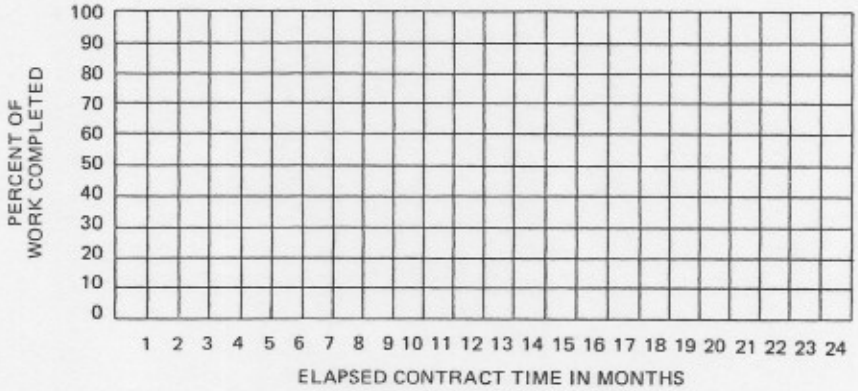
By _____ Title _____

Inspection Agency _____

Wiley-Fisk Form 8-6

MONTHLY REPORT OF CONTRACT PERFORMANCE

		DATE
PROJECT	WORK ORDER NO.	CONTRACT NO.
OWNER	CONTRACTOR	
LOCATION	PROJECT A & E	NO. WKG. DAYS



STARTING DATE:	OFFICIAL	ACTUAL	COMPLETION DATE:	OFFICIAL	ACTUAL
TIME EXTENSIONS RECOMMENDED THIS MONTH:			REASON		
TOTAL EXTENSIONS ACCUMULATED:			NUMBER OF CHANGE ORDERS:	APPROVED	PENDING
PERCENT OF WORK COMPLETED:			PERCENT OF TIME ELAPSED:		

CONTROLLING OPERATIONS AND OTHER REMARKS

DISTRIBUTION:
1. Project Manager
2. Project Accounting
3. Resident Project Representative

SIGNATURE

TITLE

Wiley-Fisk Form 8-8

RECORD OF NONCOMPLYING TESTS

Project Title _____ Project No. _____ Contract No. _____

Contractor _____ Type of Work _____

GENERAL INFORMATION AS TO TYPE OF TEST, RESULTS, AND OTHER AVAILABLE PERTINENT DATA (Cite ASTM, ACI, ANSI, AWS, etc., as applicable)	QUANTITY INVOLVED	ACTION TAKEN

Wiley-Fisk Form 8-12

Hydrometrics, Inc.
Consulting Scientists and Engineers

3020 Bozeman Avenue • Helena, Montana 59601 • (406) 443-4150

SIEVE ANALYSIS WORKSHEET

Client			Date:
Project			Job #:
Lab #:	Sample #:	Sample Depth:	Tare #:

Original Dry Wt. + Pan _____	Dry Washed Wt. + Pan _____	Original Dry Wt. _____
Tare Wt. _____	Tare Wt. _____	Dry Washed Wt. _____
Original Dry Wt. _____	Dry Washed Wt. _____	Washing Loss _____

Sieve Size	Accum. Wt. Retained	Wt. Retained	% Retained	% Passing
Total				

Hydrometrics, Inc.
3020 Bozeman Avenue • Helena, Montana 59601 • (406) 443-4150

Hydrometrics, Inc.
Consulting Scientists and Engineers

Plastic and Liquid Limit Worksheet

Project	Job #
	Lab #
Client	Sample #
	Depth ft
Soil Description	Date

PLASTIC LIMIT Test no.		1	2	3	4	Average
Container no.						
Mass of wet soil+container	g					
Mass of dry soil+container	g					
Mass of container	g					
Mass of moisture	g					
Mass of dry soil	g					
Moisture content	%					

LIQUID LIMIT Test no.		1	2	3	4	
Number of Drops						
Container no.						
Mass of wet soil+container	g					
Mass of dry soil+container	g					
Mass of container	g					
Mass of moisture	g					
Mass of dry soil	g					
Moisture content	%					

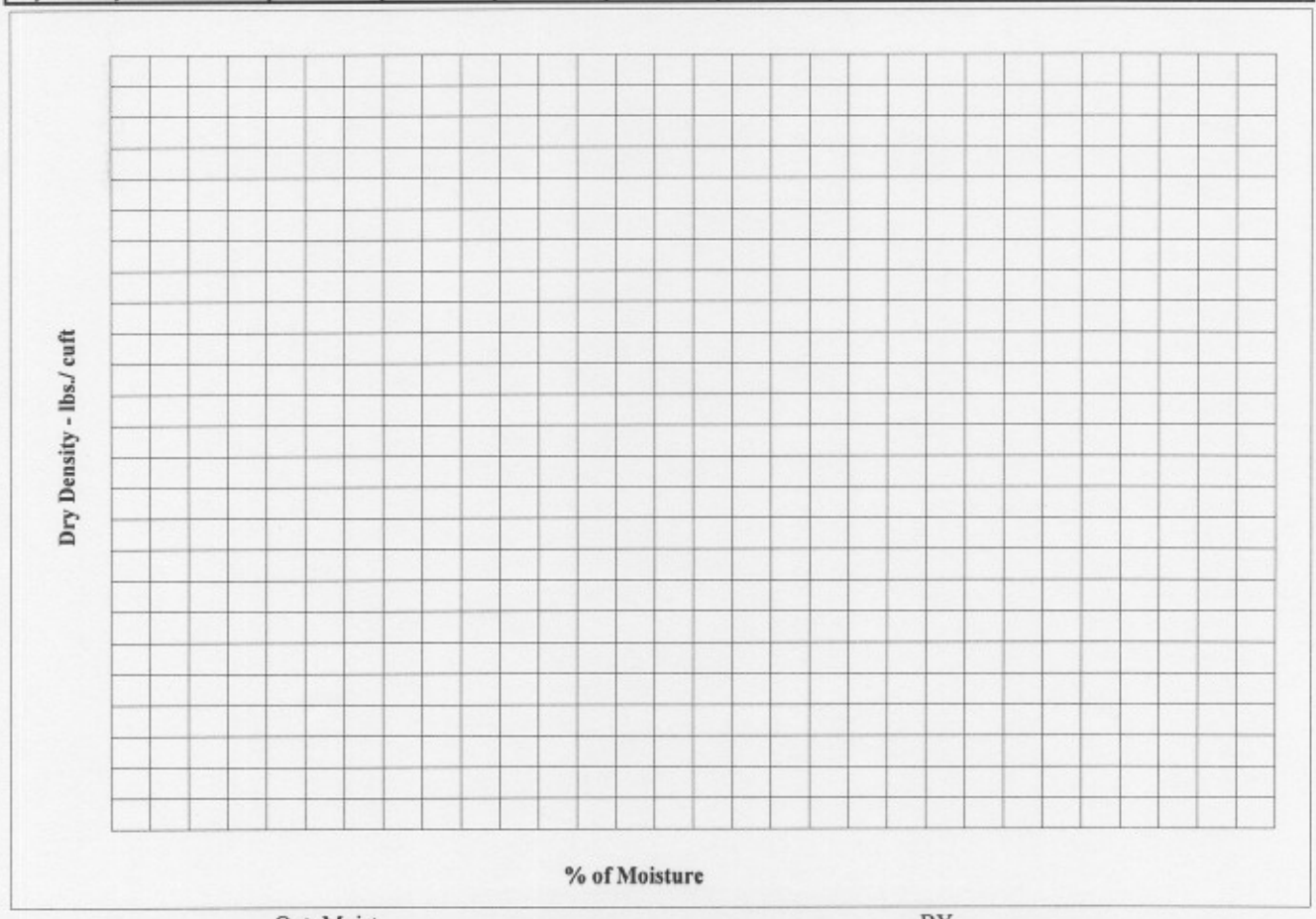
Liquid limit	
Plastic limit	
Plasticity index	

Liquid Limit

Hydrometrics, Inc.
Consulting Scientists and Engineers
3020 Bozeman Ave. · Helena, Montana 59601 · (406) 443-4150

Project:	Date:
Location:	Job # :
Client:	Lab #
Type of Proctor :	Mold Diameter/Hammer Wt. :

Sample No									
Can No									
Sample Wt. + Cyl.									
Cyl. Wt.									
Sample Wt. (Grams)									
Sample Wt. (lbs.)									
Vol. of Cyl									
Wet Density									
Wet Sample + Can									
Dry Sample + Can									
Wt. of moisture									
Wt. of Can									
Wt. of Dry Soil									
% Moisture									
Dry Density									



Opt. Moist. _____
Max. Density _____

BY _____

PROJECT _____ DATE _____
JOB NUMBER _____ TAKEN BY _____

HYDROMETRICS, INC.
3020 Bozeman Ave.
Helena, MT 59601

NUCLEAR COMPACTION TEST DATA

Test Number										
Date Tested										
Location										
Station										
Offset										
Elevation										
Mode & Depth										
% Air Voids										
Void Ratio										
Wet Density										
Moisture										
Dry Density										
Moisture %										
Max Dry Density										
Opt. Moisture										
% Compaction										
Moist. Correct.										

Test Number										
Date Tested										
Location										
Station										
Offset										
Elevation										
Mode & Depth										
% Air Voids										
Void Ratio										
Wet Density										
Moisture										
Dry Density										
Moisture %										
Max Dry Density										
Opt. Moisture										
% Compaction										
Moist. Correct.										

REMARKS: _____

FIELD MOISTURE AND DENSITY TEST RESULT DATA SHEET

Project Name_____ Date_____

Soil Type_____ CQA Engineer_____

Test No.	Date	Test Type Standard/ Nuclear	North/ South Coord	East/ West Coord	Lift No.	Dry Dens	Mois. Cont. (%)	Max. Dry Dens	Opt. Mois. Cont. (%)	Compac tion (%)	Mois. Cont. (+/- of opt).	Pass/ Fail	Remarks

DENSITY IN PLACE SAND CONE - ASTM D 1556

Date: _____ Subcontractor: _____
Location: _____ Job #: _____
Project: _____ Ordered by: _____
Report by: _____ Client: _____

Sample Location					
Sample Location					
Sample Location					
Elevation					
Type of Material					
Sand + Appara. (S_1), lbs.					
After Test (S_2), lbs.					
Sand Used (S_1 -S_2), lbs.					
Sand in Funnel S_3, lbs.					
Sand in Holes (S_1, -S_2, -S_3), lbs.					
Sand Density, lb./c.f. (S_4)					
Volume of Hole (S_5) $\frac{(S_1 - S_2 - S_3)}{S_4}$					
Soil, Wet (W), lbs.					
Wet Density, lb./c.f. (D)					
Moisture % (M)					
Dry Density, lb./c.f. (D)					
Max. Dry Density, lb./c.f.					
Compaction, % (C)					
Specification Requirement					
Optimum Moisture, %					
± From Optimum					
Rel. Min. (B)					
Rel. Max. (A)					
% Rel. A (D-B)/D(A-B) x 100					
Rel. Specification Requirement					
Test Number					

Remarks: If any please see back of sheet
ASTM D 698 & AASHTO T 99 = Standard
ASTM D 1557 & AASHTO T 180 = Modified
ASTM D 2049 = Relative

_____

MOISTURE CONTENT WORKSHEET

Client							Date		
Project							Job #		
Lab #									
Boring #									
Sample #									
Depth - ft.									
Can #									
Wet wt.									
Dry wt.									
Tare wt.									
Water wt.									
Dry Soil wt.									
Moist %									

Lab #									
Boring #									
Sample #									
Depth - ft.									
Can #									
Wet wt.									
Dry wt.									
Tare wt.									
Water wt.									
Dry Soil wt.									
Moist %									

Lab #									
Boring #									
Sample #									
Depth - ft.									
Can #									
Wet wt.									
Dry wt.									
Tare wt.									
Water wt.									
Dry Soil wt.									
Moist %									

TEST REPORT

Project Name_____ Date_____

Material Type Tested_____ CQA Engineer_____

Location/Sheet Number	Test Performed	Reason for Test	Test Results	Pass/ Fail	CQA Engr	Date	Remarks

RECEIVING INSPECTION REPORT
GEOSYNTHETICS

Project Name_____ Date_____

CQA Engineer_____

Arrival Date_____ Unloading Method_____

Invoice No._____ Condition Before

Delivery Vehicle_____ Unloading_____

Geosynthetic Type_____ Number of Rolls_____

Manufacturer's Name_____ Storage Location_____

Product Designation_____

Roll Number	Batch/ Lot No.	Material Dimensions			QA Samples Taken Y/N	QC Certs Recd Y/N	Damage/ Remarks*
		Length	Width	Thickness/ Weight			

* Note any damage found before or after unloading. Include any remedial steps taken or rolls rejected.

CERTIFICATE OF SUBGRADE ACCEPTANCE

Project Name_____ Date_____
Installation Contractor_____ CQA Engineer_____
_____

Material being installed Geomembrane_____
GCL_____
Other_____

The following areas are approved for placement_____
_____
_____
_____
_____
_____
_____

The installer shall be responsible for maintaining the approved areas in accordance with the project specifications from this date to the completion of installation.

INSTALLER'S REPRESENTATIVE

_____	_____	_____
Name	Signature	Date

CQA ENGINEER

_____	_____	_____
Name	Signature	Date

CONTRACTING OFFICER

_____	_____	_____
Name	Signature	Date

NOTES_____
_____
_____
_____
_____
_____
_____

GEOMEMBRANE PANEL DEPLOYMENT LOG

Project Name_____ Date_____
Installation Contractor_____ CQA Engineer_____
Geomembrane Type_____ Placement Equipment_____

Panel No.	Roll No.	Deployed		Time	Amb. Air Temp	Over-lap	Thickness Measurements						
		Length	Width				Side	No. 1	No. 2	No. 3	No. 4	No. 5	Avg
							Lead						
Sketch							Lfside						
							Rtside						
							Trail						
							Notes						

Panel No.	Roll No.	Deployed		Time	Amb. Air Temp	Over-lap	Thickness Measurements						
		Length	Width				Side	No. 1	No. 2	No. 3	No. 4	No. 5	Avg
							Lead						
Sketch							Lfside						
							Rtside						
							Trail						
							Notes						

Panel No.	Roll No.	Deployed		Time	Amb. Air Temp	Over-lap	Thickness Measurements						
		Length	Width				Side	No. 1	No. 2	No. 3	No. 4	No. 5	Avg
							Lead						
Sketch							Lfside						
							Rtside						
							Trail						
							Notes						

PANEL PLACEMENT FORM

PROJECT NAME: _____ **DATE:** _____

PROJECT #: _____

E OF RESPONSIBLE PERSON: _____

MATERIAL DESCRIPTION: _____ **SHEET** _____ OF _____

DATE/TIME	PANEL NUMBER	ROLL NUMBER	PANEL LENGTH	PANEL WIDTH	COMMENTS / PANEL LOCATION
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					
/ /					

GEOMEMBRANE TRIAL SEAM SHEET

Project Name_____
Installation Contractor_____
Geomembrane Type_____

Seam Type_____ Sample Number_____
Welding Machine Number_____ Welding Technician_____
Ambient Air Temp_____ Machine Speed_____
CQA Engineer_____ Wedge Temperature_____
Date/Time_____ Extruder Temperature_____

Test Number	Inside Peel		Outside Peel		Shear	
	Strength	Failure Mode	Strength	Failure Mode	Strength	Failure Mode
1						
2						
3						
4						
5						
Avg						
P/F						

Seam Type_____ Sample Number_____
Welding Machine Number_____ Welding Technician_____
Ambient Air Temp_____ Machine Speed_____
CQA Engineer_____ Wedge Temperature_____
Date/Time_____ Extruder Temperature_____

Test Number	Inside Peel		Outside Peel		Shear	
	Strength	Failure Mode	Strength	Failure Mode	Strength	Failure Mode
1						
2						
3						
4						
5						
Avg						
P/F						

Seam Type_____ Sample Number_____
Welding Machine Number_____ Welding Technician_____
Ambient Air Temp_____ Machine Speed_____
CQA Engineer_____ Wedge Temperature_____
Date/Time_____ Extruder Temperature_____

Test Number	Inside Peel		Outside Peel		Shear	
	Strength	Failure Mode	Strength	Failure Mode	Strength	Failure Mode
1						
2						
3						
4						
5						
Avg						
P/F						

TRIAL WELD FORM

PROJECT NAME: _____ **DATE:** _____

PROJECT #: _____

NAME OF RESPONSIBLE PERSON: _____

MATERIAL DESCRIPTION: _____ **SHEET** _____ OF _____

DATE/TIME	SEAMER INITIALS	MACHINE NUMBER	AMBIENT TEMP	WEATHER	EXTRUSION WELDS			FUSION WELDS			PASS / FAIL	COMMENTS
					BARREL TEMP	PREHEAT TEMP	PEEL / TENSILE	WEDGE TEMP	SET SPEED	PEEL / TENSILE		
/ /												
/ /												
/ /												
/ /												
/ /												
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GEOMEMBRANE SEAM LOG

Project Name_____ Prepared By_____ Date_____
Installation Contractor_____ Reviewed By_____ Date_____
Geomembrane Type_____

Machine Number_____
Destructive Length Carry-Over from Previous Log_____

Passing Trial Seams

Number	Time	Tech ID

Note 1: Reference seam end points from an end of seam (EOS), a repair number, or a point location on the seam.
Note 2: Non-destructive test columns are to be used by the data reviewer only.

Seam Number	Seam Section (Note 1)		Start Time	Amb. Air Temp	Weld Tech	Mach Speed	Machine Temperatures		Weld Length	Length From Last Dest. Test	Dest. Test No.	CQA Insp	Remarks	Non-Destruct Tests	
							Digital Set	Indicator							
	Start Point	Finish Point					Wedge or Barrel Nozzle	Wedge or Barrel Nozzle						Test Date	CQA Insp
								Daily Total							

Destructive Length Carry-Over

GEOMEMBRANE REPAIR LOG

Project Name_____ Prepared By_____Date_____
Installer_____ Reviewed By_____Date_____
Geomembrane Type_____

Machine Number_____

Passing Trial Seams		
Number	Time	Weld Tech

Defect					Repair						
Defect Number	Defect Type	Location	Date	CQA Engr	Time/ Date	Repair Type	Approx Dimension	Weld Tech	Test Date	CQA Engr	Remarks

Defect Code:
AD - Animal Related Damage
B - Undispersed Resin Bead
BO - Fusion Welder Burn
BS - Boot/Skirt for FML
CO - Change of Overlap
CR - Crease
D - Installation Damage
DS# - Destructive Test Number
EE - Earthwork Equipment Damage
EXT - Extension
FM - Fishmouth
FS - Failed Seam Length
FTS - Field Test Strip
HT - Heat Tack Burn
IO - Insufficient Overlap
MD - Manufacturer/Delivery Damage
PT - Pressure Test Cut
SI - Soil Surface Irregularity
SL - Slag on Textured Sheet
T - Three Panel Intersection
VL - Vacuum Test Leak
WR - Wrinkle
WS - Welder Restart
O - Other

Repair Type:
P - Patch
GW - Grind Weld
RS - Reconstructed Seam
C - Cap

NON-DESTRUCTIVE GEOMEMBRANE SEAM TESTING DATA SHEET

Project Name_____ Date_____
Material Description_____ CQA Engineer_____
Geomembrane Type_____

Date/ Time	Seam No.	Seam Length	Air Pressure Testing						Vacuum Box	Notes
			Pressure			Time				
			Start	End	+/-	Start	End	P/F	P/F	

DESTRUCTIVE GEOMEMBRANE SEAM TESTING DATA SHEET

Project Name_____ Date_____
Material Description_____ CQA Engineer_____
Geomembrane Type_____

Test Type CQA or CQC	Date/ Time	Samp. No.	Seam No.	Mach No.	Shear (S) or Peel (P)	Shear/Peel Values Test Number					Pass/ Fail	Date to Lab	Lab Pass/ Fail	Remarks
						1	2	3	4	5				

DESTRUCTIVE SEAM TEST LOG

Project Name_____
Material Description_____
Geomembrane Type_____

Date_____
CQA Engineer_____

Sample Number	Seam Number	Machine Number	Quality Control		Quality Assurance			Remarks
			Date of Test Results	Test Result Pass/Fail	Date Shipped	Test Result Pass/Fail	Date of Notifi-cation	

APPENDIX H

POST-CLOSURE CARE PLAN

APPENDIX H

POST-CLOSURE CARE PLAN
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)

Prepared for:

ASARCO LLC
P.O. Box 1230
East Helena, MT 59635

Prepared by:

Hydrometrics, Inc.
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Helena, MT 59601

And

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February 2007
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APPENDIX H

POST-CLOSURE CARE PLAN
ASARCO EAST HELENA
CORRECTIVE ACTION MANAGEMENT UNIT (CAMU)

1.0 GENERAL INFORMATION

This plan addresses the post closure care, monitoring, and maintenance of the Corrective Action Management Unit (CAMU) and is included as Appendix H of the Design Analysis Report Asarco East Helena Corrective Action Management Unit (CAMU) Phase 2 Cell. This plan will be submitted as required by 40 CFR 270.14(b)(13) as part of the Post Closure permit application.

The CAMU is located adjacent to the Asarco East Helena Plant, and south of the community of East Helena, Montana. In 2001 a waste containment facility, known as the CAMU Phase 1 Cell, was constructed for the disposal of soils, sediments and demolition debris resulting primarily from smelter site remedial cleanup activities. In 2008, a second waste containment facility, known as the CAMU Phase 2 Cell, will be constructed adjacent to the Phase 1 Cell, and will contain demolition debris and waste soils from current remedial cleanup activities. Although not required by CAMU regulations, the Phase 1 and Phase 2 Cell were designed to comply with the Resource Conservation and Recovery Act (RCRA), Subtitle C regulations and guidelines. This Plan complies with the requirements of 40 CFR 264/265 Subparts G and N.

1.1 PURPOSE

The purpose of this Post-Closure Plan is to present guidelines for care, monitoring, and maintenance of the CAMU to fulfill the intent of the remediation activities implemented in response to the implementation of the RCRA Consent Decree (CV98-3-H-CCL). This Post-

Closure Plan establishes specific criteria and response timelines for repair for each inspection element, including notification provisions of required repairs to regulatory agencies. This plan complies with all applicable requirements specified in the Code of Federal Regulations, Title 40, Part 264 – Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264).

This Post-Closure Plan provides:

1. Basic construction information describing how the facility will be constructed and closed;
2. A description of all required site inspection and monitoring activities, including the frequency with which each activity will be performed and the corrective actions that will be taken for each problem encountered;
3. A description of all required site maintenance activities, including the frequency with which each activity will be performed;
4. Contact information during the post-closure period; and
5. A description of the planned land uses during the post-closure care period.

In addition, this plan minimizes the need for facility maintenance after the site is closed and controls, minimizes, or eliminates to the extent necessary protection of human health and the environment, post-closure escape of hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground, surface waters, or atmosphere.

This is the written plan required by 40 CFR 264.118(a).

This plan takes effect upon closure of the CAMU and the notifications required in 40 CFR 264.115 and 40 CFR 264.119. The post closure care period will be for 30 years following the required notifications, unless extended under the requirements of 40 CFR 264.117(a)(2)(ii). Attachment B contains a Post-Closure Cost Estimate as required by CFR 264 Subpart H (Financial Assurance).

1.2 RESPONSIBILITY

Asarco LLC is responsible for implementation of this plan. Asarco LLC is referred to as the owner/operator throughout this plan.

1.3 OPERATING RECORD

Asarco LLC will maintain an operating record of all site inspections and maintenance activities as required under 40 CFR 264.73 and all required activities under 40 CFR Subparts G and N. Communications with the inspectors, regulatory authorities, and the owner/operator will be documented and kept as part of the operation record. The owner/operator will also keep a list of the contents of the cell and the approximate location of each hazardous waste type within the cell. The Operating Record will be maintained at the contact address specified in Section 5.1 of this Plan for the length of the Post Closure Care Period.

1.4 PUBLIC SAFETY AND HEALTH

The CAMU Phase 1 Cell has been closed and is secured by fencing. Like the Phase 1 Cell, the Phase 2 Cell will be fenced and kept secured to control public access to the site. Inspection of the fencing will occur monthly as part of the routine monthly inspections. Once the Phase 2 Cell has been closed, the site will pose no special public safety or health hazards.

2.0 CONSTRUCTION INFORMATION

The CAMU Phase 2 Cell consists of the following components listed in order from the bottom to the top of the cap:

1. Secondary Composite Liner
   - 3-foot compacted clay liner (CCL)
   - Reinforced GCL liner
   - 60-mil Double Sided Textured HDPE flexible membrane liner (FML)
2. Leak Detection, Collection, and Removal System
   - Geocomposite Drainage Layer
3. Primary Liner
   - 60-mil Double Sided Textured HDPE flexible membrane liner (FML)
4. Primary Leachate Collection and Removal (PLCR) System
   - Geocomposite Drainage Layer
5. 2-foot Cushion Layer
6. Waste
7. 12-inch Gas Migration Layer
8. Cap Composite Liner
   - Reinforced GCL
   - 40-mil Double Textured HDPE flexible membrane liner
   - Geocomposite
9. Surface Water Collection and Removal (SWCR) System
   - 1-foot thick drainage gravel layer
10. Cover System
    - 2-feet cover soil
    - 6-inches topsoil and
    - Grass cover.

2.1 CLOSURE ACTIVITIES

Partial closure will be necessary when the placement of materials is halted for the construction season and the temporary cap is placed over the cell. Final closure will be completed when all waste has been placed in the CAMU and the cell is ready for the permanent cover. The CAMU Cell will be closed in accordance with 40 CFR 264.111. The final cell cover has been designed and will be constructed to comply with 40 CFR 264.310. Soils testing will be conducted in soils surrounding the CAMU cell once the final cover has been placed on the cell, to ensure that the closure of the cell meets the closure performance standard.

2.2 CLOSURE SCHEDULE

It may take approximately three construction seasons of cleaning and demolition at the Asarco East Helena Smelter facility before all waste is placed in the CAMU Phase 2 Cell and the cell is ready for closure. Upon final receipt of waste to the cell, it should take approximately 90 days to place the final cover.

2.3 SURVEYING AND RECORDKEEPING

The owner/operator will follow surveying and recordkeeping regulations in accordance with 40 CFR 264.309. The owner/operator will establish a permanent surveyed benchmark, which will be placed on the top of the CAMU Phase 2 Cell once the final cap is complete. The owner/operator will also establish a permanent surveyed benchmark, on the top of the CAMU Phase 1 Cell. After the permanent surveyed benchmark is established, the owner/operator will publish a map to be kept on file in the operating record, which includes the exact location and dimensions, including depth of the cell. The owner/operator will also keep a list of the contents of the cell and the approximate location of each hazardous waste type within the cell. Should the benchmarks be disturbed by post closure care activities, it will be re-established according to recognized practices of public land surveying. The benchmarks will be protected from disturbance by grazing and the public by the fence around the facility as required by 40 CFR 264.310(b)(6).

2.4 NOTIFICATION OF PARTIAL CLOSURE AND FINAL CLOSURE

In accordance with 40 CFR 264.112(d), the owner/operator will notify the EPA regional administrator in writing at least 60 days prior to the date on which the cell is expected to begin closure. The closure date must be no later than 30 days after the date on which the cell receives the known final volume of waste, or if there is a reasonable possibility that the cell will receive additional waste, no later than one year after the date on which the cell received the most recent volume of waste. Within 60 days of completion of final closure, the owner/ operator will submit to the EPA regional administrator, by registered mail, a certification that the CAMU cell has been closed in accordance with all specifications. The certificate must be signed by the owner/operator and by a qualified Professional Engineer.

2.5 SURVEY PLAT

In compliance with 40 CFR 264.116, the owner/operator will submit to the local zoning authority, or authority with jurisdiction over local land use, and to the EPA regional administrator, a survey plat indicating the location and dimensions of the cell with respect to permanently surveyed benchmarks no later than 60 days after completion of final closure. This plat will be prepared by a professional land surveyor. The plat filed will contain a note, prominently displayed, which states the owner's/operator's obligation to restrict disturbance of the cell in accordance with 40 CFR 264 – Subpart G regulations.

3.0 SITE MONITORING AND INSPECTION

Quarterly monitoring of groundwater quality and semi-annual site inspections will ensure that public health and safety are maintained at the site. Monitoring and inspection protocol are in accordance with 40 CFR 264.303.

3.1 GROUNDWATER MONITORING

Groundwater monitoring will be accomplished as described in the Design Analysis Report, ASARCO East Helena Corrective Action Management Unit (CAMU) Phase 2 Cell Appendix D – Sampling and Monitoring Plan. During quarterly groundwater monitoring events, components of the groundwater monitoring system will be visually inspected to ensure good working order. All inspections will be documented on the Inspection/Repair form included in Appendix D and included in the annual report and placed in the operating record. If any problems with the groundwater monitoring system are encountered, they will be documented on the Inspection/Repair form and the owner/operator will be notified within 24 hours. The owner/operator is responsible for making sure all repairs are scheduled and completed within 14-calendar days of the inspection. Details of completed repairs will be noted on the Inspection/Repair form. The owner/operator is also responsible for reporting any significant issues to the EPA representative verbally within 7-calendar days and in writing within 14-calendar days.

3.2 LEACHATE COLLECTION AND LEAK DETECTION SYSTEM MONITORING

The monitoring and maintenance of the CAMU Phase 2 Cell leachate collection and leak detection system will be conducted in compliance with 40 CFR 264.303. The pump used to remove liquids from the sumps will be capable of removing all but the last two feet of liquids from each sump. Therefore, the Pump Operating Level is defined as two feet of liquids in the sumps, which minimizes the head in the sumps and avoids backup into the drainage layer. The owner/operator will record pre- and post-pumping water levels and the amount of liquids removed from the leachate collection and leak detection system sumps once a week and after storms during the active life and closure period. After the post closure care period begins,

pre- and post-pumping water levels will be recorded and liquids will be removed from the leachate collection and leak detection system sumps monthly. The amount of liquids removed will be recorded on the CAMU inspection form (Attachment A). If the liquid level in the sump stays below the pump operating level for two consecutive months, the amount of liquids in the sumps will be recorded quarterly. If the liquid level in the sump stays below the pump operating level for two consecutive quarters, the amount of liquids in the sumps will be recorded semi-annually. If at any time during the post-closure care period the pump operating level is exceeded at units on quarterly or semi-annual recording schedules, the owner/operator must return to monthly water level recording and liquids removal from each sump until the liquid level again stays below the pump operating level for two consecutive months.

Experience with the CAMU Phase I Cell indicates that it is not possible to establish an Action Leakage Rate within the first five years of the post-closure period. This is due to the fact that it is not possible to determine the volume of leachate removed from leakage through the impounded material from the volume of water that entered the drainage system during construction and was not able to be removed. According to EPA guidance (Survey of Technologies for Monitoring Containment Liners and Covers, 2004) leachate levels generally fall to a negligible level in 10 years or less. Therefore, an Action Removal Rate for the CAMU Phase 2 Cell will be established as soon as enough removal data is collected within the first 10 years of the post-closure period. Action Leakage Rate and leachate collection volumes will be presented as an average daily flow rate (40 CFR 264.302) in the annual inspection report. Once the Action Leakage Rate is established, the Response Action Plan, outlined in Section 3.5.1, will be followed if the Action Leakage Rate is exceeded.

Until an action leakage rate is established, the owner/operator will insure that the depth of leachate does not exceed 12-inches over the primary and secondary liners, by keeping the depth of the leachate to less than 5-feet in the 4-foot deep sumps of the leachate collection and leak detection systems. If the water level in either vertical standpipe exceeds 5-feet, the

sump will be pumped immediately and the Response Action Plan, outlined in Section 3.4.1 will be followed.

3.3 SITE INSPECTION – POST-CLOSURE

Periodic inspections are essential to ensure that the cover systems are performing adequately and to identify problems and provide proper maintenance of cover systems. The inspection program will involve three types of inspections: (1) monthly informal inspections, (2) semi-annual technical inspections, and (3) special inspections after extreme events.

3.3.1 Monthly Informal Inspections

The informal inspections will be a continuing effort by on-site personnel, performed in the course of their normal duties but no less than once a month. Education of new personnel will assure the continued effectiveness of these inspections. These inspections will be documented on the CAMU inspection form (Attachment A) and will be concurrent with pumping of the leachate collection and leak detection systems, unless pumping activities are performed on a quarterly or semi-annual basis.

3.3.2 Semi-Annual Technical Inspections

Semi-annual site inspections during the post-closure care period will include in-depth inspections of:

1. Leachate collection and Leak detection system;
2. Final cover system; and
3. Stormwater control systems.

A professional engineer familiar with the design and construction of the cover systems will perform every other semi-annual technical inspection. The semi-annual technical inspections will document settling and subsidence, erosion, membrane liner damage, status of the stormwater control system, and the cap's vegetative state. The inspection will ensure that the site stays in compliance with 40 CFR 264.280. These inspections will be documented and an annual report will be completed and submitted to the EPA and placed in the Operating Record.

3.3.3 Special Inspections after Extreme Events

A professional engineer familiar with the design and construction of the cover systems will also perform Special Inspections after extreme events. The inspection will ensure that the site is in compliance with 40 CFR 264.280. These inspections will be comprehensive and very similar to semi-annual technical inspections and will be performed after extreme events such as rare rain storms exceeding 1.5 inches of precipitation in a 24 hour period at the Helena Regional Airport, winds exceeding 60 miles per hour at the Helena Regional Airport, winter snow-melt events resulting in the loss of 6 inches or more of snow in a 24 hour period at the Helena Regional Airport, a grass fire within the perimeter of the security fencing, or earthquakes producing a lateral acceleration of 0.01 g at the CAMU. These inspections will be documented and a Special Inspections report will be completed and submitted to the EPA separate from the annual inspection report.

3.3.4 Semi-Annual and Special Inspection Procedures

The inspection of the cover systems will typically involve walking the entire site in a systematic fashion that ensures the entire site is inspected. A checklist and site map will be used during inspections to aid in the process and are included as Attachment A. The inspection checklists contained in Attachment A, include the following items to be monitored and recorded:

1. Settlement or subsidence - Inspections will focus on looking for areas of localized settlement, sink holes, ponding water, cracking of cover soils, and any other signs that may indicated cover subsidence. The approximate depth of ponded water or depression, the limits of the affected area, and other pertinent details will be recorded for each inspection. The problem areas will be monitored to determine how the problem develops over time. This will help in evaluating the need for further investigation or repairs and help with planning repair strategies.

2. Erosion - Any evidence of erosion should be a cause of concern. The inspector will be especially observant along steeper slopes, drainage ditches, areas of vegetative stress, and any areas previously troubled by erosion problems.

3. Membrane liner damage - Excessive subsidence or vehicle traffic, such as mowing, on the cover may cause damage to the membrane liner. Unless visibly evident, membrane liner damage may be difficult to detect. Any areas on permanent caps where the synthetic materials are exposed will be noted and a repair plan will be developed without delay.

4. Stormwater Control System - The run-on and runoff stormwater control system needs to be kept clear of all debris. Any evidence of erosion should be noted. The inspector will be especially observant of any subsidence of run-on dikes, the silting or filling in of runoff controls and obstructions that would have the potential to block water flow.

5. Cap's Vegetative State - Grass or plants with shallow root systems will be selected for the vegetated cover on the permanent caps and burrowing animals will be kept off the site. Areas where grasses are poorly established will be examined to determine the cause of the problem. The inspector will look for signs of excessive wetness or dryness, pest infestations, seepage, rodents, weeds, insufficient depth of topsoil, and other conditions that may inhibit healthy growth of the cover vegetation.

6. Perimeter Security - The permanent protective caps overlying the CAMU Phase 2 Cell will be fenced and kept secured to help ensure the cap is not disturbed by people or large animals. Inspection of the perimeter fence will be included in the periodic monthly inspections and any maintenance needed to insure a secure site will be recorded and addressed.

3.4 CORRECTIVE ACTION FOR IDENTIFIED PROBLEMS

If any problem or deficiency is found during any inspection type the following procedures will be followed. The inspector will record the location on a field sketch and will record a complete description of the affected area, including all pertinent data (i.e., size of the area and other descriptive remarks such as exposed synthetic materials, and odors, etc.) on the appropriate reporting forms. An accurate and detailed description of observed conditions will enable a

meaningful comparison of conditions observed at different times. This information has three elements:

1. Location - The location of any questionable area or condition will be accurately described so that the area or condition can be evaluated for changes over time, repaired, or reexamined by experts.
2. Extent or Area - The length, width, and depth or height of any suspected problem area will be measured.
3. Descriptive Detail - A brief, but detailed description of the anomalous condition will be given.

Photographs are helpful in documenting problems. The owner/operator will keep a photographic log of problems, repairs, and general site conditions. This log will provide valuable information when evaluating the long-term performance of the cover system and when planning repair strategies.

If any problems are encountered during routine inspections, they will be documented on the Inspection/Repair form and the owner/operator will be notified within 24 hours. The owner/operator is responsible for making sure all repairs are scheduled and/or completed within 14-calendar days of the inspection. Details of completed repairs will be noted on the Inspection/Repair form. The owner/operator is also responsible for reporting any significant issues to the EPA representative verbally within 7-calendar days and in writing within 14-calendar days. Documentation of problems and repairs will be placed in the Operating Record.

3.4.1 Response Action Plan

The Response Action Plan sets forth the actions to be taken if the action leakage rate has been exceeded or if an action leakage rate has not been established, the depth of leachate

does not exceed 12-inches over the primary and secondary liners. The Response Action Plan is in accordance with 40 CFR 264.304. The actions to be taken include:

- Notifying the EPA regional administrator in writing of the exceedance within 7 days of the determination;
- Submitting a preliminary written assessment to the EPA regional administrator within 14 days of the determination, as to the amount of liquids, likely sources of liquids, possible location, size, and cause of any leaks, and short-term actions taken and planned;
- Determination to the extent practicable the location, size, and cause of any leak;
- Determine whether any waste should be removed from the unit for inspection, repairs, or controls; and
- Determine any short-term and longer-term actions to be taken to mitigate or stop any leaks.

Within 30 days after the notification that the action leakage rate or depth of leachate has been exceeded, the results of the analysis specified above, the results of actions taken, and the actions planned must be submitted to the EPA regional administrator. Monthly thereafter, as long as the action leakage rate or depth of leachate is still exceeded, the owner/operator must submit the EPA regional administrator a report summarizing the results of any remedial actions taken and actions planned. To make the leak and or remediation determinations specified above, the owner/operator must assess the source of liquids and amount of liquids by source or document why such assessments are not needed. Assessing the source of liquids and amount of liquids by source includes conducting a fingerprint, hazardous constituent, or other analyses of the liquids in the leak detection system to identify the source of liquids and possible location of any leaks, the hazard and mobility of the liquid, and assessing the seriousness of any leaks in terms of potential for escaping into the environment. Copies of all notices and the Response Action Plan will be placed in the Operating Record.

4.0 SITE MAINTENANCE

4.1 GENERAL

This section provides guidelines to aid the CAMU operator in instituting and understanding the need for an effective maintenance program. The objectives of such a maintenance program are to:

1. Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;
2. Ensure reliability of operation and limit environmental impacts;
3. Protect and extend the useful life of the CAMU Cell structure; and
4. Ensure public health and safety.

4.1.1 Importance of Maintenance

The CAMU Phase 2 Cell structure represents a substantial investment to protect the public health and environment of the areas surrounding the Asarco East Helena Smelter. One of the important factors to minimizing environmental impacts resulting from the site is a sound maintenance program. A sound maintenance program has the added benefit of identifying problems before they become emergencies.

4.1.2 Types of Maintenance

As shown in Table 4-1, there are four types of maintenance listed by priority rather than by frequency. Table 4-1 is provided as a guide to help put the types of maintenance into proper perspective. The different types of maintenance are also discussed in the following subsections.

TABLE 4-1. PRIORITY OF MAINTENANCE TASKS

Priority	Type of Maintenance	Description and Example
1	Emergency	A situation requiring immediate attention (for example, fire, earthquake, or flood).
2	Preventative	Scheduled inspection and minor repairs carried out during inspection (for example, cleaning of gutters and culverts).
3	Corrective	Corrective maintenance required as a direct result of scheduled inspection (for example, repair of torn membrane liner).
4	Housekeeping	Routine housekeeping of buildings and grounds (for example, mowing grass, painting, and general housekeeping).

1. Emergency maintenance - Emergencies are situations arising unexpectedly that require urgent attention. Often, immediate response must be provided to avert potential serious damage. Provisions for emergency repair/damage control activities and an Emergency Contacts list will be prepared and kept current with a list of phone numbers for local emergency response organizations, lining contractors, and agency and owner representatives. Table 4-2 provides a list of Emergency Contacts.

2. Preventative maintenance - Preventative maintenance is work done to extend the life of equipment and structures. With the exception of routine surveillance and inspections, preventative maintenance tasks will be scheduled in accordance with the recommendations of the material and equipment manufacturers. Scheduled inspection and maintenance of all site facilities will help ensure that potential problems are discovered and corrected before they become serious, as well as providing for the performance of periodically required upkeep. During routine inspections, the property managers will be alerted for any abnormal conditions, which could indicate potential problems.

TABLE 4-2. EMERGENCY NOTIFICATION CONTACTS AND PHONE NUMBERS

General Emergency Numbers:

Fire Department	911
Ambulance	911
Police	911

Corporate Resources

Asarco LLC:

Jon Nickel	(East Helena)	(406) 227- 4529
Blaine Cox	(East Helena)	(406) 227-4098

Other Resources:

Hydrometrics, Inc.	(Helena)	(406) 443-4150
U.S. EPA (24-hour emergency)		(206) 553-1263
Superfund/RCRA Hotline		(800) 424-9346

3. Corrective maintenance - Corrective maintenance is the work required for repairs and other non-routine maintenance. The CAMU owner/operator will handle these tasks as the need arises. Corrective maintenance procedures will follow the equipment or material manufacturer's recommendations. In planning for the corrective maintenance, the CAMU owner/operator will arrange for advice or assistance from an engineer or manufacturer's representative.

4. Housekeeping - Maintaining well-kept site indicates pride on the part of the CAMU owner/operator and cultivates good neighbor relations with adjacent property owners. Housekeeping tasks include mowing grass on the CAMU cap and surrounding areas, controlling weeds, sweeping pavement surfaces, and collecting/disposing of litter or debris.

4.1.3 Maintenance Log

A maintenance log will be maintained by the owner/operator as part of the CAMU Operating Record.

4.2 CAMU PERMANENT CAP

On-site maintenance items are generally limited to grounds keeping tasks since no mechanical systems are provided. Drainage courses, structures, and cover liner integrity are the primary focus of scheduled inspection and preventative maintenance. Periodic inspection of other features, such as aboveground portions of monitoring wells and gas extraction vents is required as part of the informal monthly inspections.

4.2.1 Housekeeping

1. Grass cutting - Periodic cutting will help to establish and maintain a healthy, vigorous stand of grass. This will help control weeds and pests, reduce the potential for grass fires, and provide better erosion protection. In most settings, grass is cut to 4 to 6 inches in height and allowed to grow to a maximum height of 10 inches, at which time it will be cut by the owner/operator.

2. Spot Reseeding - It is important to keep a good stand of grasses on all areas of the cap to minimize erosion and to keep weeds and other undesirable plant species from becoming a problem. Spot reseeding should be done in late August and early September for best results, however, seeding in early spring may also be effective. Seeding in the dry summer months will most likely be unsuccessful without supplemental irrigation. Necessary seeding should be carried out at least once per year using a grass mix specified in the Design Analysis Report, ASARCO East Helena Corrective Action Management Unit (CAMU) Phase 2 Cell Appendix J – Project Specifications.

3. Nutrient Application - It may be necessary to periodically apply nutrients or adjust the acidity of the soil. If vegetative stress is evident, the topsoil may be analyzed to determine what nutrient deficiencies exist. This will prevent over-applying fertilizers. Generally, when required, a slow-release type of fertilizer can be applied in late summer to early fall. The local office of the Natural Resource and Conservation Service or Conservation District, or a local consultant may be contacted for additional information.

4.2.2 Preventive Maintenance

1. Weed and Pest Control - The key to minimizing necessary weed and pest control is to establish and maintain a good, healthy, dense grass cover. If weeds or pests become a problem, first identify the type of weed or pest and then develop a management strategy, chemical or manual, with the help of the local Natural Resource and Conservation Service, the Conservation District, or a local consultant. The method chosen will not affect the integrity of the top liner system. Weed control using chemical herbicides may typically require 1 or 2 applications per year.

2. Rodent Control – Ground squirrels, field mice, and other burrowing animals may attempt to make their homes in the cover soils. Mounds of loose soil resulting from tunneling animals will encourage weed growth and promote erosion. The mounds should be raked and reseeded. Some burrowing animals could damage the CAMU Cell Cap liners. Appropriate pesticides may be used to control small rodents and burrowing animals. The method chosen

will not affect the integrity of the top liner system. A significant rodent population may require the advice of a local consultant.

4.2.3 Corrective Maintenance

The following section covers some problems that may be encountered during the post-closure care period. The solutions are by no means all inclusive, but should serve as general guidelines indicating the elements involved for fixing typical case conditions.

1. Subsidence – Areas that exhibit minor subsidence that disturb the drainage flow will be filled with topsoil or a mixture of topsoil and compost and reseeded according to the seeding plan using a grass mix specified in the Design Analysis Report, ASARCO East Helena Corrective Action Management Unit (CAMU) Phase 2 Cell Appendix J – Project Specifications. Areas of minor subsidence will be monitored to verify that they do not become areas of excessive localized settlement during the monthly inspections. When an area experiences excessive localized settlement, the cover may no longer drain properly. Even so, there may not be a problem unless the area is large, there is continued ponding, or the flexible membrane liner is suspected to have been damaged. The problem may require an investigation to determine the extent of the damaged area and the potential for surface water leaking through the CAMU Cell Cap. If it is determined that a repair must be made, the necessary steps involved are:

    a. Determine limits of area to be repaired.
    b. Strip topsoil and stockpile.
    c. Remove gravel layer (drainage layer) and stockpile.
    d. Cut and remove geocomposite.
    e. Cut and remove flexible membrane liner.
    f. Cut and remove GCL.
    g. Fill depression and grade for proper drainage.
    h. Place low permeable soil layer, geosynthetic clay liner, or bentonite.
    i. Install new flexible membrane liner.
    j. Test seams to ensure integrity of repair.

k. Install drainage net (if present).

l. Replace gravel layer (drainage layer).

m. Replace cover soil and topsoil and reseed area.

2. Erosion - Erosion problems should typically involve a relatively minor repair operation unless the condition is left to develop over time. Minor erosion rills in the topsoil may be filled and the area reseeded. An erosion mat of some type, coarse compost, or other recognized best management practices for sediment control may prevent further erosion while the vegetation is being established. Deeper rills may require a more extensive repair, possibly involving silt fencing. Persistent and reoccurring rills can be filled with gravel to allow for a controlled drainage path downslope. Compost may be used as needed for erosion control.

5.0 POST-CLOSURE CONTACTS AND LAND USE

This Post-Closure Plan identifies the activities that will be carried on after closure of the CAMU Phase 2 Cell and the frequency of these activities. Descriptions of planned monitoring and maintenance activities and frequencies for the post-closure period have already been addressed and comply with 40 CFR 264 – Subpart G regulations.

5.1 POST-CLOSURE CONTACT

Environmental Manager
ASARCO East Helena Plant
100 Smelter Road
P.O Box 1230
East Helena, Montana 59635
(406) 227- 4529

The Operating Record will be maintained at this location during the Post Closure Care Period unless the owner/operator designates an alternate location to the Regional Administrator.

5.2 POST-CLOSURE LAND USE

The site of the proposed CAMU Phase 2 Cell will be closed to public access and maintained as grassland after it is closed. The cell will be fenced to keep out unauthorized personnel and large animals. Limiting access to the site will ensure the integrity of the final cover is kept intact.

5.3 POST-CLOSURE COST ESTIMATE AND FINANCIAL ASSURANCE

The owner/operator has prepared a detailed cost estimate for the post-closure period as required by 40 CFR 264 Subpart H. The cost estimate includes the annual cost of post-closure monitoring and maintenance of the facility in accordance with post-closure regulations 40 CFR 264.117-264.120. The cost estimate is included in Attachment B. The post-closure cost estimate is in accordance with 40 CFR 264.144. Costs for post-closure care activities are based on the owner/operator hiring a third party to conduct the work. The owner/operator will keep a copy of this post-closure cost estimate at the Asarco facility

during the post closure care period of the facility. Financial assurance for the amount specified on the post-closure cost estimate will be established prior to the receipt of any waste.

ATTACHMENT A

SITE MAP & INSPECTION FORMS

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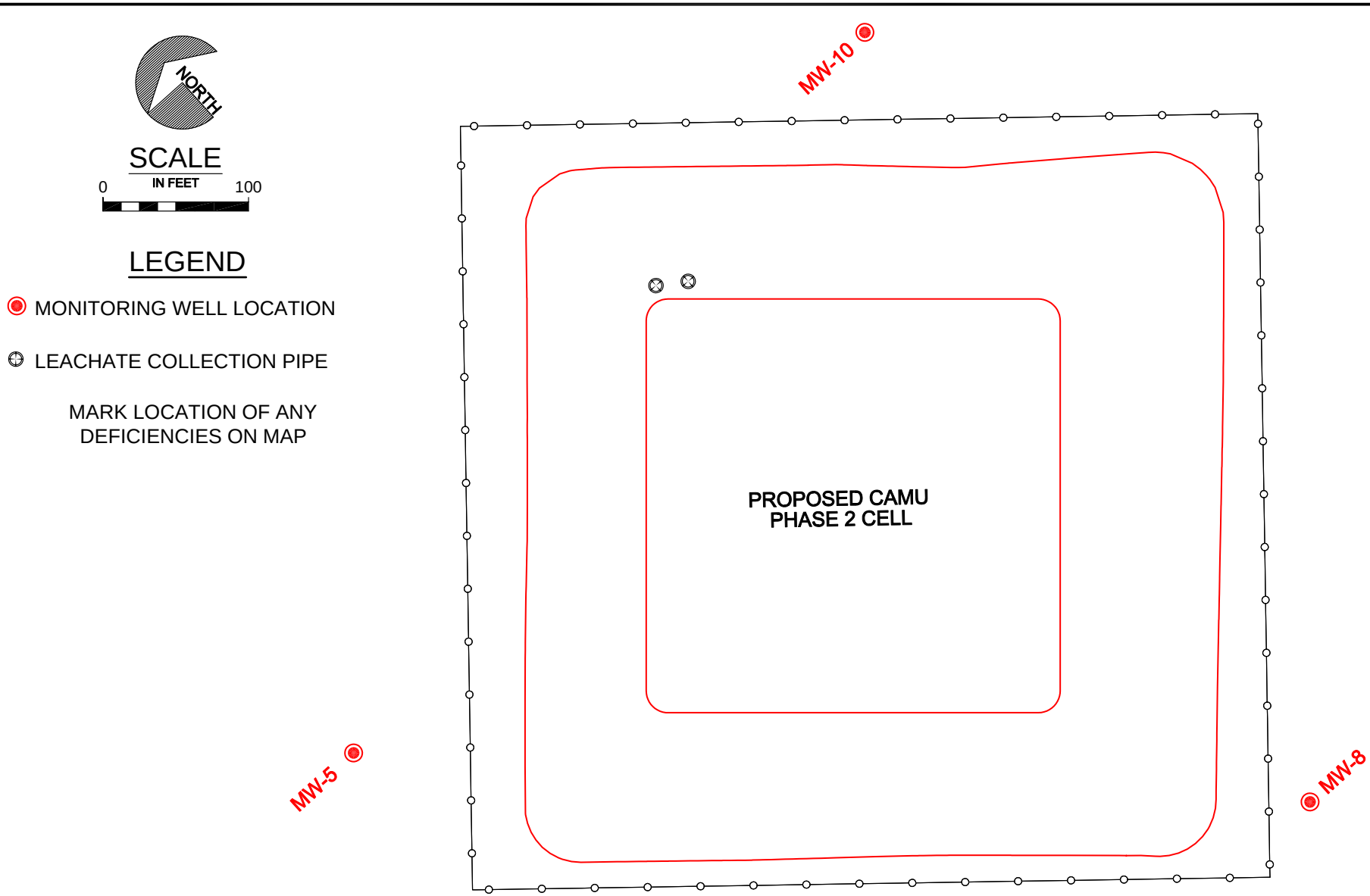


Hydrometrics, Inc.
Consulting Scientists and Engineers

ASARCO EAST HELENA CAMU PHASE 2 CELL OPERATION AND MAINTENANCE PLAN	**CAMU PHASE 2 CELL INSPECTION MAP**	**FIGURE** **A-2**

CAMU INSPECTION CHECKLIST

AREA INSPECTED	Cell No. PHASE 2 CELL		Inspected by: _____	Date:		
	ITEM NO.	CONDITION	OBSERVATION	ACTION NEEDED (Check)		
				MONITOR	INVESTIGATE	REPAIR
UPPER SURFACE	1	Surface Cracking				
	2	Animal Burrows				
	3	Low Area				
	4	Ruts or Puddles				
	5	Vegetation Condition				
	6	Noxious Weeds				
	7	Settlement/Subsidence				
	8	Erosion				
SIDE SLOPE	1	Slide, Slough, Scarp				
	2	Animal Burrows				
	3	Erosion				
	4	Vegetation Condition				
	5	Noxious Weeds				
	6	Exposed Liner				
	7	Seepage				
	8	Fencing				
	9	Settlement/Subsidence				

Additional Comments:

CAMU INSPECTION CHECKLIST

AREA INSPECTED	Cell No. PHASE 2 CELL		Inspected by: _____	Date:		
	ITEM NO.	CONDITION	OBSERVATION	ACTION NEEDED (Check)		
				MONITOR	INVESTIGATE	REPAIR
STORM WATER CONVEYANCES	1	Toe Ditches - Obstruction due to vegetation/sedimentation				
	2	Toe Ditches - evidence of erosion				
	3	Stormwater Basin - excessive vegetation/sedimentation				
	4	Stormwater Basin - presence of sand (washout of drainage layer)				
	5	Stormwater Basin - Evidence of erosion or overtopping				
	6	Upstream Diversion Ditch-excessive vegetation or sedimentation				
	7	Upstream Diversion Ditch - evidence of erosion				
	8	Upstream Diversion Ditch - evidence of overtopping				
LEACHATE COLLECTION SYSTEM/MONITORING WELLS	1	Condition of Leachate Sumps				
	2	Leachate Collection Sump-Depth (East pipe)				
	3	Leak Detection Sump-Depth (West pipe)				
	4	Monitoring Wells - Condition of Protective Surface Casing				
	5	Monitoring Wells - Presence of Locks				

Additional Comments:

ATTACHMENT B

POST-CLOSURE COST ESTIMATE

Table 1. CAMU Phase 2 Financial Reserve for Construction and Closure

Bid Item Number[1]	2007 CAMU PHASE 2 PROJECT COST SCHEDULE Task	Line Item Cost[2]	Source
30	Mobilization	$ 36,684.65	URS[3]
31	Access Roads	$ 226,665.82	URS[3]
32	Temporary Erosion & Site Access Controls	$ 34,919.94	URS[3]
33	Excavation & Stockpile	$ 169,625.82	URS[3]
34	Subgrade Preparation, Grade & Compact	$ 31,978.76	URS[3]
35	Compacted Clay Liner (1" Max)	$ 180,067.00	URS[3]
36	HDPE, 60 mil (Textured)	$ 263,152.00	URS[3]
37	Drainage GEOCOMPOSITE (250 mil, DS, 8 oz)	$ 316,644.50	URS[3]
38	Reinforced GCL (under secondary 60 mil HDPE Textured)	$ 225,620.75	URS[3]
39	Leachate Removal Structures	$ 47,861.12	URS[3]
40	Storm Water Retention Pond	$ 23,596.41	URS[3]
41	Import & Place Cushion Material (24")	$ 610,067.00	URS[3]
42	Load, Haul, Place & Compact Waste Material	$ 401,390.53	URS[3]
43	Environmental Health & Safety Requirements 2007	$ 58,749.35	URS[3]
44	Traffic Controls & Road Maintenance 2007	$ 22,567.00	URS[3]
45	Dust Control and Haul Road Maintenance 2007	$ 22,567.00	URS[3]
46	Temporary Cover, RPE25, Year 2007	$ 163,198.76	URS[3]
47	Permanent Run-On Diversion Ditches	$ 24,919.94	URS[3]
48	Seed, Fertilize & Mulch Off Plant	$ 22,567.00	URS[3]
49	Fence with Appurtences	$ 79,238.76	URS[3]
50	Quality Control Plan & Management	$ 22,567.00	URS[3]
51	Final Cap (Preliminary Budget Cost Only[4])	$ 972,724.05	URS[3]
	CAMU CONSTRUCTION COST	**$ 3,957,373.18**	
52	O&M Costs[5]	$ 101,975.47	Asarco/Hydrometrics[5]
	TOTAL CAMU CONSTRUCTION AND O&M COST	**$ 4,059,348.65**	
53	Additional 10%	$ 405,934.87	EPA
	TOTAL FINANCIAL ASSURANCE CAMU COST	**$ 4,465,283.52**	

Notes:

1. Bid item numbers are line item labels from the URS bid for the Cleaning and Demolition and the CAMU Phase 2 construction project. Bid item numbers and tasks 1 through 29 address the 2007 Cleaning and Demolition Project and are not shown on this Table. Bid item numbers 30 through 50 address construction of the CAMU Phase 2 Cell. Bid Item 51 is a preliminary cost if final closure of the Phase 2 Cell was implemented in 2007 (see Note 4 below).
2. Line item construction costs for construction of the CAMU in 2007. Line item costs are considered firm bid numbers and would be incorporated into the 2007 work contract. As a result, they are considered reliable for financial assurance purposes.
3. Source of line item construction costs is URS revised bid elements dated May 2007. Bid revisions were driven by EPA required CAMU design modifications and by construction schedule delays associated with the timing of EPA design approval.
4. Preliminary final cap construction estimate provided by URS in the event final closure were to be conducted in 2007. Final cap construction costs will also be updated at the time of cap construction and final bids for the cap have been received. Activities associated with placing waste in the CAMU in 2008, 2009 and/or subsequent years and temporary closure are considered part of the Montana Administrative Order of Consent (draft 2007). Costs associated with cleaning and disposal activities in 2008 and 2009 will be determined by competitive bid during years 2008, 2009 and/or any subsequent year.
5. Post-construction O&M costs. Costs are based on existing effort for the CAMU Phase 1 Cell and commercial contractor rates. Cost assume 30 years of O&M. Additional detail on O&M cost projections are in Table 2.

Table 2. Annual Operational and Maintenance Costs for East Helena CAMU Phase 2 Cell

Activity			Hrs	People	Rate *	Times/Year	Total
Mowing of Grass/Weed Abatement				1	$300 /yr	1	$300
Monthly Inspections			1	1	$68 /hr	12	$816
Semi - Annual Inspection		Inspection and Report			$3,500 each	2	$7,000
		Respond to Comments			$3,500 each	2	$7,000
Pump Leachate Collection/Leak Detection			4	2	$68 /hr	12	$6,528
Well Sampling/Monitoring	Labor						
		Prep	4	1	$68 /hr	4	$1,088
		Sampling	16	2	$68 /hr	4	$8,704
		Sample handling/Unload	4	1	$68 /hr	4	$1,088
	Equipment	Grundfos pump & controller		2	$175 /day	4	$1,400
		Generator		2	$55 /day	4	$440
		YSI multimeter		2	$70 /day	4	$560
		Water Tank		2	$48 /day	4	$384
		Truck		2	$35 /day	4	$280
				Wells			
	Analytical			11	$350 each	4	$15,400
						Grand Total	$50,988

* Outside contractor rates were used to calculate cost figures.

Financial Assurance	
Applying a 30 Year Good Accounting Practices for Financial Assurance (present value at 5 percent)	$101,975

ASARCO EAST HELENA PLANT

CONTRACTOR EQUIPMENT STAGING AREA

PROPOSED HAUL ROUTE

RAILROAD

PLANT WATER TREATMENT FACILITY

NON POTABLE WATER SOURCE

UPPER LAKE

RINGLING BUILDING ADDITIVE ALTERNATE BID ITEM F

TEMPORARY GATE, SEE 5/33

TEMPORARY GATE, SEE 5/33

RUNOFF CONTROL POND

EXISTING CAMU - PHASE 1 CELL

PROPOSED CAMU - PHASE 2 CELL

STOCKPILE AREA (SEE INSET)

SCALE (in Feet)

100 0 100 200 300

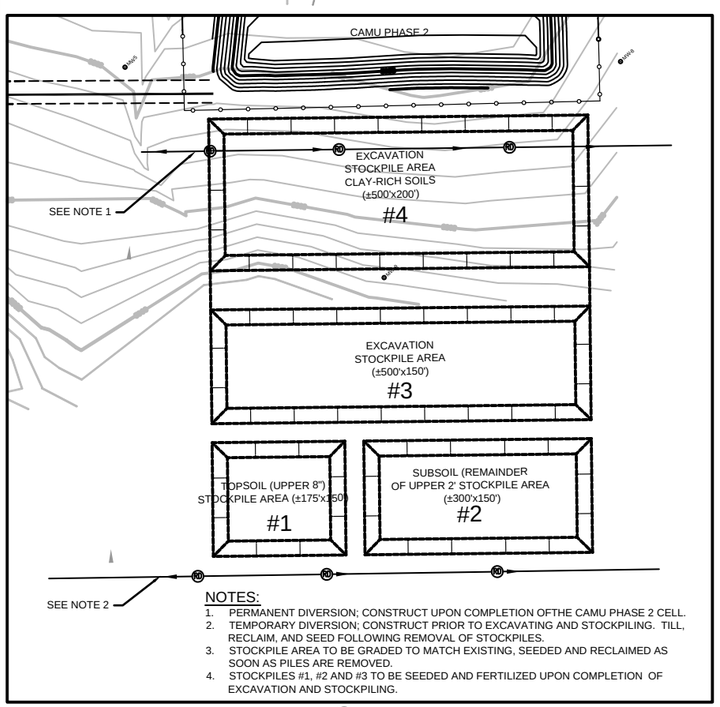
NORTH

LEGEND

- EXISTING ACCESS ROAD
- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- GRADE BREAK
- NATURAL DRAINAGE SWALE
- ROAD CULVERT
- PROPOSED PAVED ACCESS ROAD
- RO — RUN-ON DIVERSION DITCH
- SOF — SEDIMENT CONTROL FENCE AND TEMPORARY SITE ACCESS CONTROL FENCE (ORANGE POLY FENCE)
- EXISTING CHAIN LINK FENCE
- CHAIN LINK FENCE/ WOVEN WIRE FARM FENCE

NOTES:

1. CONSTRUCT PAVED HAUL ROADS BETWEEN THE DEMOLITION AREA AND THE CAMU PHASE 2 CELL.
2. DRY VACUUM SWEEPERS TO BE RUN CONTINUOUSLY ON HAUL ROADS DURING HAULING.
3. EXISTING GATES PROVIDE ACCESS TO THE ASARCO EAST HELENA PLANT
4. EXCESS SOIL THAT REMAINS IN STOCK PILES FOLLOWING CAMU PHASE 2 CELL CONSTRUCTION WILL BE ADDED TO CAP SUBSOIL AND GRADED TO A SMOOTH, DRAINING SURFACE PRIOR TO PLACEMENT OF CAP TOP SOIL.
5. A WOVEN WIRE FARM FENCE WILL BE INSTALLED IN LIEU OF THE CHAIN LINK FENCING IN 2007 AND REMAIN UNTIL COMPLETION OF THE CAMU PHASE 2 CELL CAPPING.



NOTES:

1. PERMANENT DIVERSION; CONSTRUCT UPON COMPLETION OFTHE CAMU PHASE 2 CELL.
2. TEMPORARY DIVERSION; CONSTRUCT PRIOR TO EXCAVATING AND STOCKPILING. TILL, RECLAIM, AND SEED FOLLOWING REMOVAL OF STOCKPILES.
3. STOCKPILE AREA TO BE GRADED TO MATCH EXISTING, SEEDED AND RECLAIMED AS SOON AS PILES ARE REMOVED.
4. STOCKPILES #1, #2 AND #3 TO BE SEEDED AND FERTILIZED UPON COMPLETION OF EXCAVATION AND STOCKPILING.

INSET
POTENTIAL STOCKPILE AREA

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE

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CHECKED BY	MWR	1/18/07
APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
5893 Bonham Avenue
(406) 442-5450

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
WASTE STOCKPILES AND HAUL ROUTES

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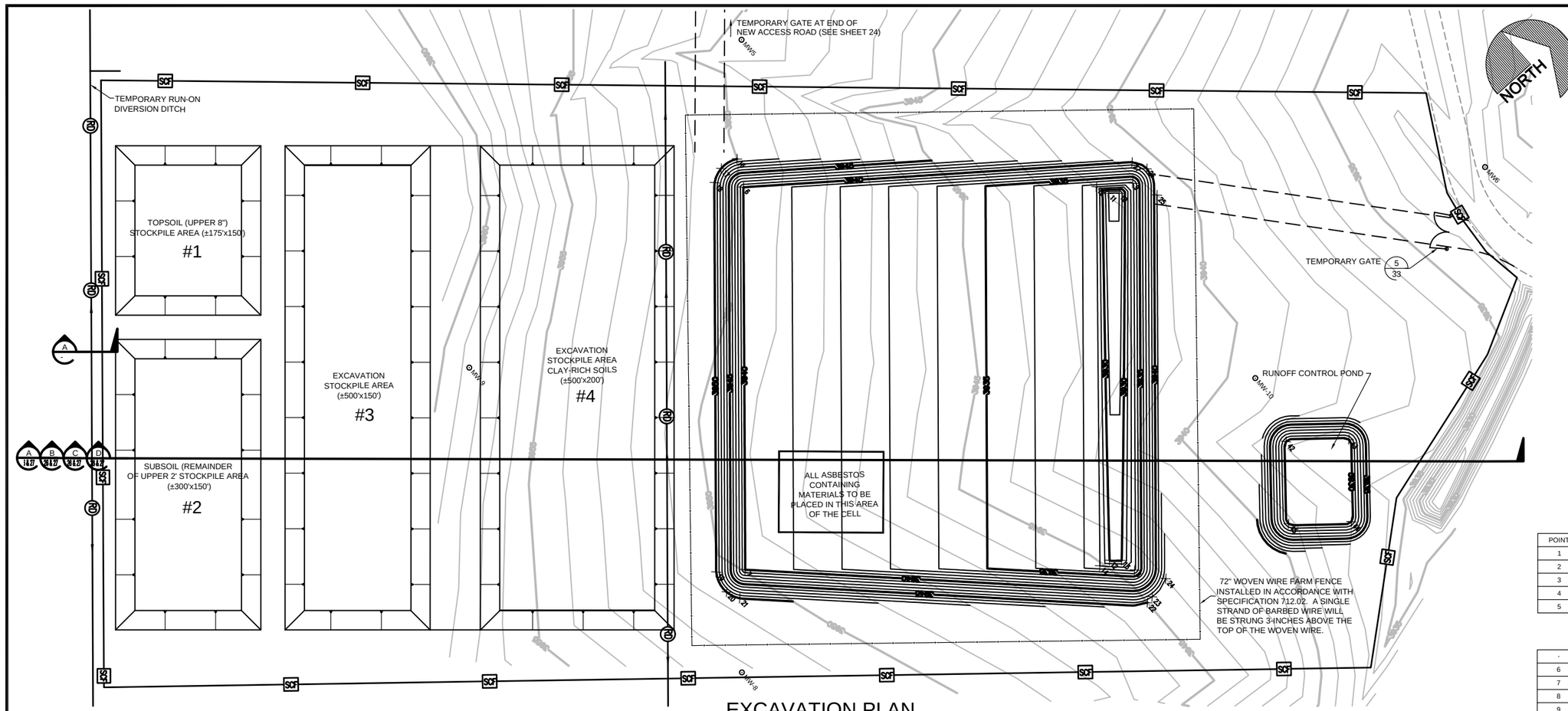


EXCAVATION PLAN

SCALE: 1"=60'

SCALE
(In Feet)

60 0 60 120 180

LEGEND

- LOCAL ACCESS ROAD
- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- GRADE BREAK
- PAVED ACCESS ROAD
- SCF — SEDIMENT CONTROL & SAFETY FENCE
- RD — RUN-ON DIVERSION DITCH
- DRAINAGE FLOW DIRECTION
- MW-10 MONITORING WELL

NOTES:

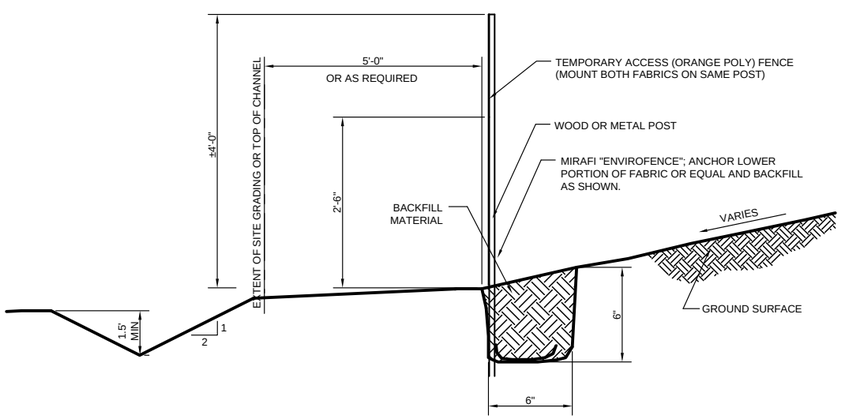
1. PLACE UPPER 8" TOPSOIL FROM EXCAVATION OF CELL INTO STOCKPILE #1.
2. PLACE REMAINDER OF UPPER 2' OF SOIL FROM EXCAVATION OF CELL INTO STOCKPILE #2.
3. PLACE CLAY (FROM SOUTHWEST PORTION OF CELL) EXCAVATION INTO STOCKPILE #4 AS DIRECTED BY ENGINEER.
4. PLACE REMAINDER OF CELL EXCAVATION IN STOCKPILE #3.
5. DO NOT DISTURB EXISTING MONITORING WELLS.
6. PROVIDE TEMPORARY GATES TO CONTROL ACCESS TO SITE.
7. INSTALL ACCESS AND SEDIMENT CONTROL FENCE PRIOR TO START OF EXCAVATION.

CONSTRUCTION PROJECT CONTROL POINTS

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	8812.08	7197.71	3952.51	MW5
2	9296.77	7807.35	3934.54	MW6
3	8376.8943	7685.1041	3954.97	MW-8
4	8376.8165	7262.8426	3961.72	MW-9
5	8974.659	7811.757	3942.6	MW-10

CONSTRUCTION EXCAVATION CONTROL POINTS

.	.	.	.	.
6	8711.937	7312.5609	3940	EXCAVATION_BOTTOM
7	8450.1242	7608.3295	3940	EXCAVATION_BOTTOM
8	8749.6262	7876.4498	3933	EXCAVATION_BOTTOM
9	9014.4111	7577.298	3933	EXCAVATION_BOTTOM
10	8997.091	7575.7032	3928	DRAINTRENCH_BOTTOM
11	8988.8514	7568.6057	3928	DRAINTRENCH_BOTTOM
12	8737.0634	7851.8259	3930	DRAINTRENCH_BOTTOM
13	8746.4231	7860.0798	3930	DRAINTRENCH_BOTTOM
14	8725.7628	7849.4088	3932.75	DRAINTRENCH_TOP
15	8984.017	7555.2358	3932.75	DRAINTRENCH_TOP
16	8726.5332	7286.3397	3950	EXCAVATION_TOP
17	8707.8086	7282.8366	3950	EXCAVATION_TOP
18	8693.0048	7289.2769	3950	EXCAVATION_TOP
19	8426.2244	7590.1808	3950	EXCAVATION_TOP
20	8420.4286	7612.6575	3950	EXCAVATION_TOP
21	8426.2952	7626.5707	3950	EXCAVATION_TOP
22	8737.0869	7910.3683	3945	EXCAVATION_TOP
23	8744.7786	7909.1352	3944	EXCAVATION_TOP
24	8767.7159	7904.5742	3944	EXCAVATION_TOP
25	9024.9614	7603.1552	3941	EXCAVATION_TOP
26	9035.2904	7575.7964	3940	EXCAVATION_TOP
27	9028.3586	7560.7496	3940	EXCAVATION_TOP
42	8954.6507	7881.8276	3930	TOE OF POND
43	9004.3701	7923.4589	3930	TOE OF POND
44	8949.7591	7988.3931	3930	TOE OF POND
45	8899.9962	7946.7662	3930	TOE OF POND



SECTION A
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ACCESS AND SEDIMENT CONTROL FENCE DETAIL

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	1	MWR	2/26/07	REVISED WOVEN WIRE SIZE, SHEET REFERENCE, & DRAINAGE ARROWS

REVISIONS	NO	BY	DATE

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APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
5893 Rosalyn Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
EXCAVATION SITE PLAN

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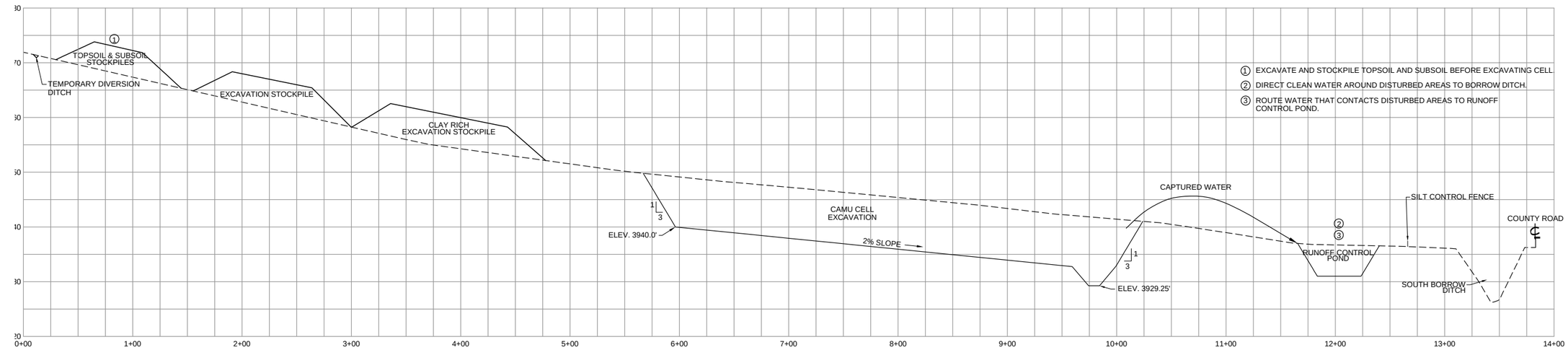
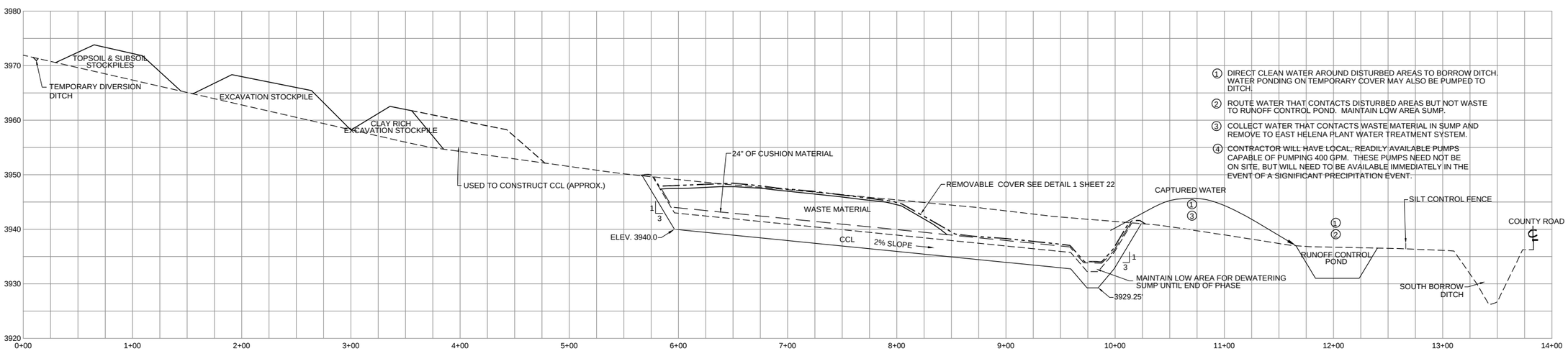


SECTION A – EXCAVATION PHASE

SCALE: (H) 1"=50' (V) 1"=10'



SECTION B – DURING INTERMEDIATE WASTE MATERIAL PLACEMENT PHASE

SCALE: (H) 1"=50' (V) 1"=10'

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE

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CHECKED BY	MWR	1/17/07
APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
EROSION CONTROL PLAN
WASTE PLACEMENT

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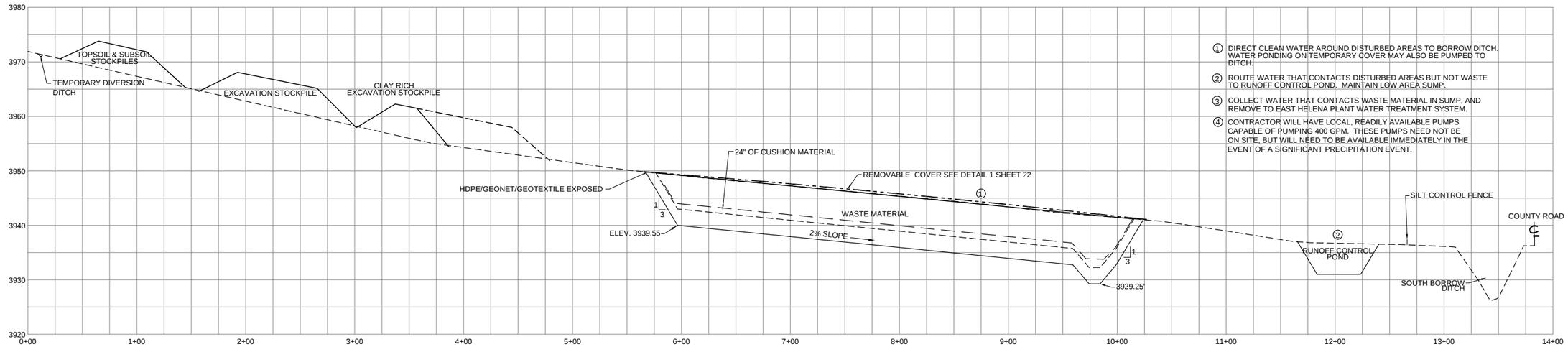
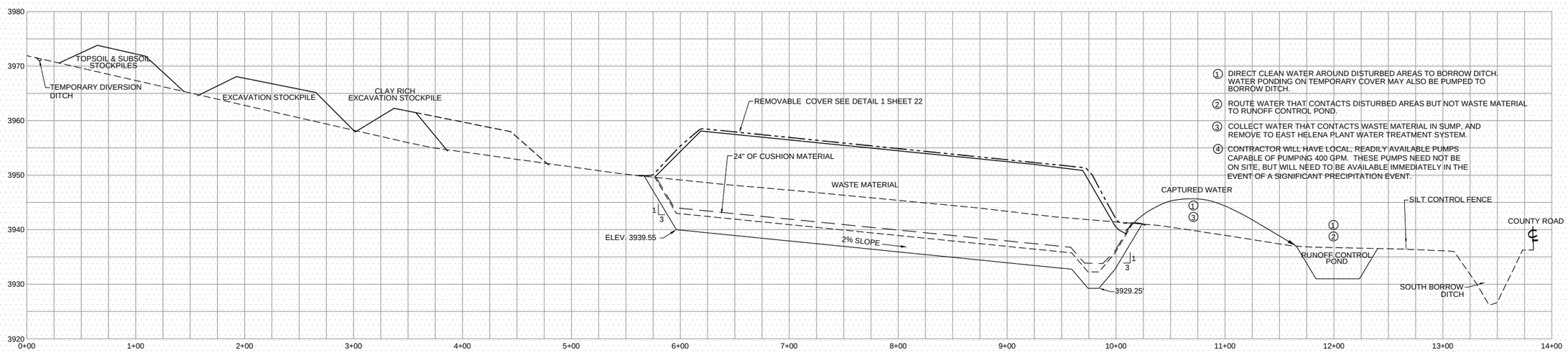


SECTION C – CLOSURE OF 2007 CONSTRUCTION YEAR WASTE MATERIAL PLACEMENT PHASE

SCALE: (H) 1"=50' (V) 1"=10'



SECTION D – FINAL WASTE MATERIAL PLACEMENT PHASE

SCALE: (H) 1"=50' (V) 1"=10'

(NOT INCLUDED IN THIS PHASE)

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

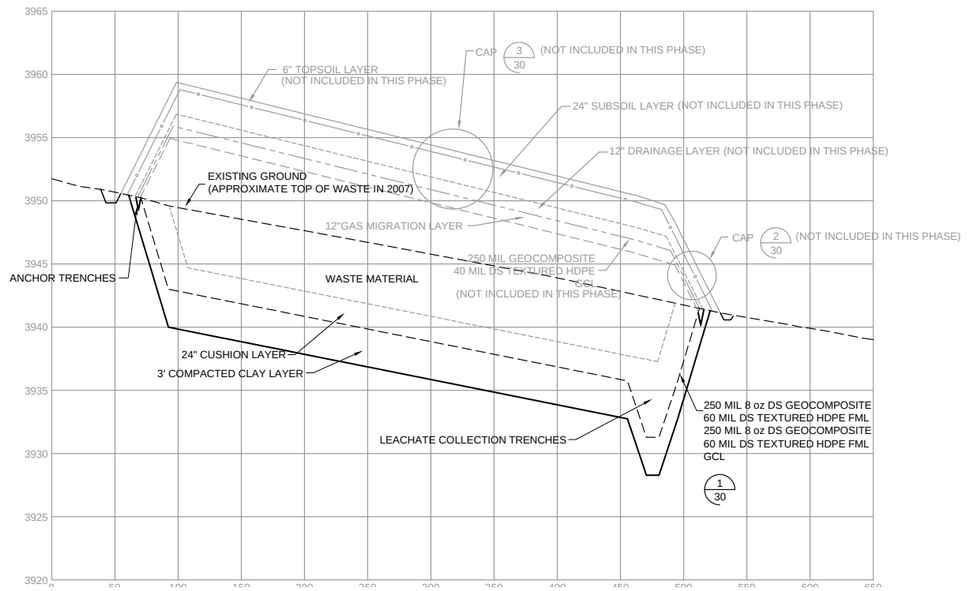
Project No.: 6052		
DRAWN BY	SDP	1/4/07
CHECKED BY	MWR	1/17/07
APPROVED BY	MJO	1/18/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

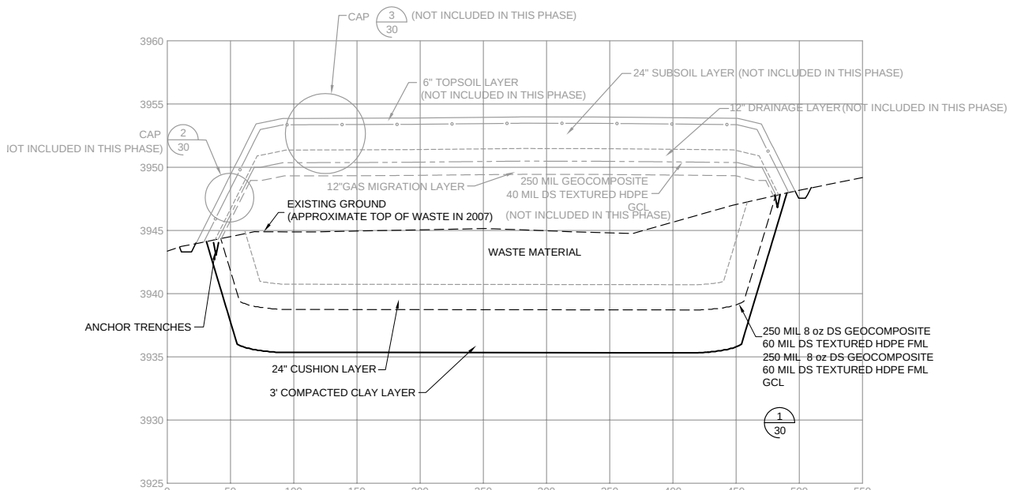
ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
EROSION CONTROL PLAN
WASTE PLACEMENT

DRAWING FILE NUMBER
605202H027.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 27
REV

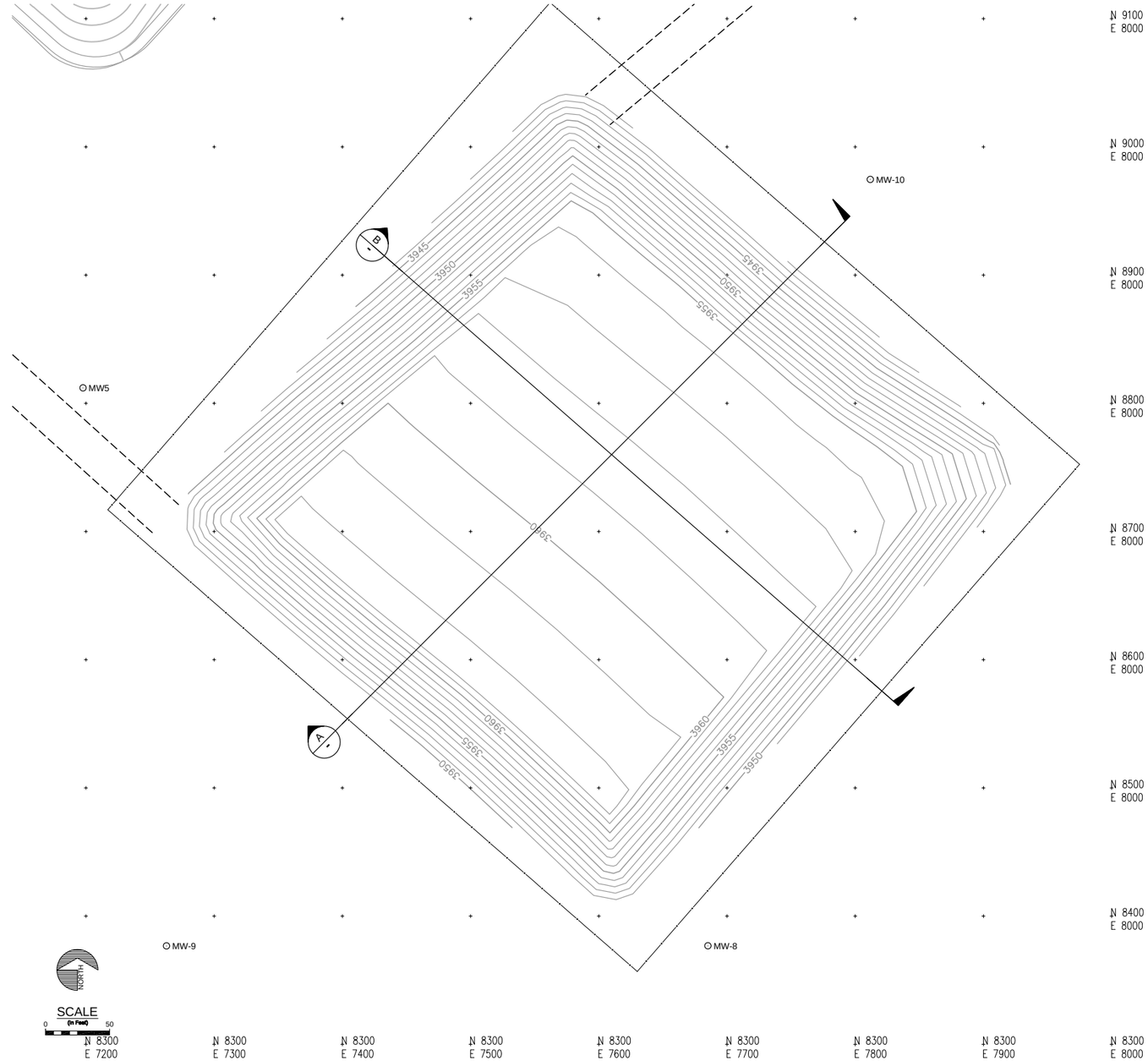
UPDATE TIME: 1:16PM
MWR \HEL\012407\:\Land Projects\605202\DWG\605202H027.dwg



SECTION A/-
SCALE: (H) 1"=60'
(V) 1"=6'



SECTION B/-
SCALE: (H) 1"=60'
(V) 1"=6'



CAMU PLAN VIEW
SCALE: 1"=50'

GRAYED BACK ITEMS NOT INCLUDED IN THIS PHASE

REVISIONS NO	BY	DATE	DESCRIPTION
1	MWR	4/26/07	REVISED BOTTOM LINER TO SHOW GCL AND TEXTURED HDPE

REVISIONS NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 6052		
DRAWN BY	SDP	12/18/06
CHECKED BY	MWR	1/18/07
APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

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Consulting Scientists and Engineers
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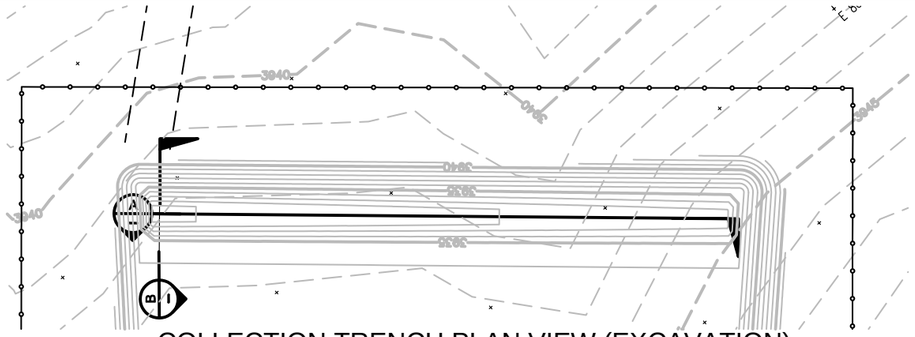
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
CROSS SECTIONS

DRAWING FILE NUMBER
605202H028.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 28
REV

UPDATE TIME: 5:49PM
SDP \HEL\012407\:\Land Projects\605202\DWG\605202H028.dwg



COLLECTION TRENCH PLAN VIEW (EXCAVATION)

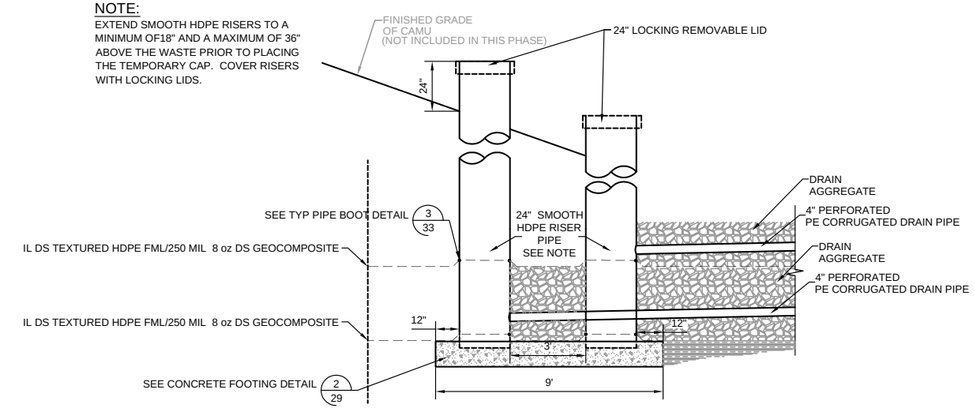
SCALE: 1"=50'

NOTE:
PROPOSED CONTOURS GRAYED BACK FOR CLARITY

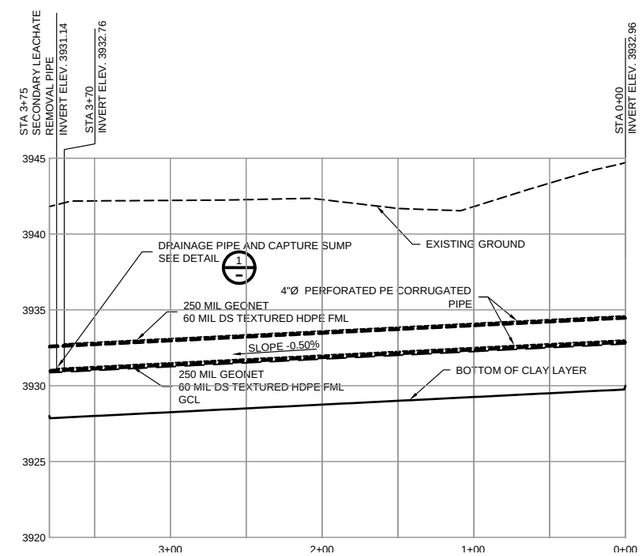
SCALE
0 (In Feet) 50

LEGEND
- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED PAVED ACCESS ROAD

NOTE:
EXTEND SMOOTH HDPE RISERS TO A MINIMUM OF18" AND A MAXIMUM OF 36" ABOVE THE WASTE PRIOR TO PLACING THE TEMPORARY CAP. COVER RISERS WITH LOCKING LIDS.

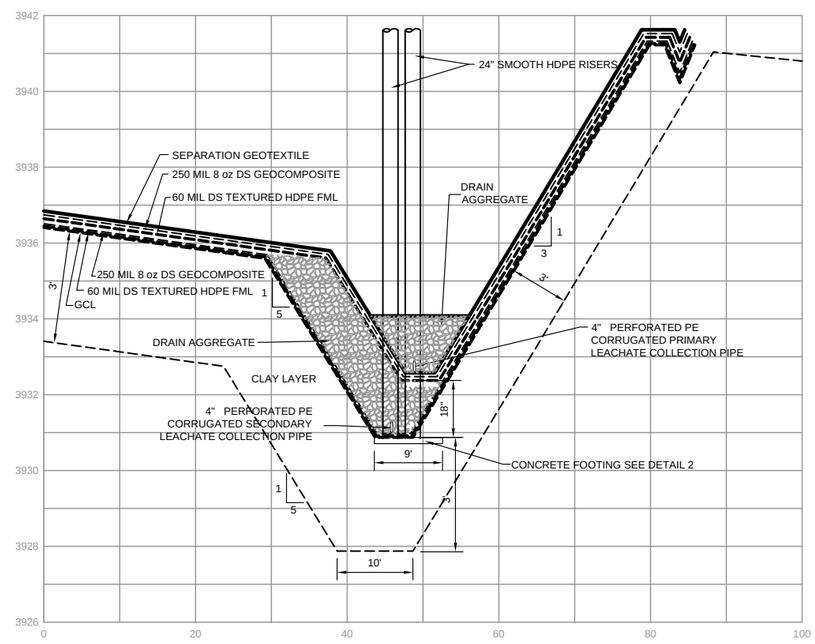


DETAIL 1 NTS — RISER PIPE SUMP



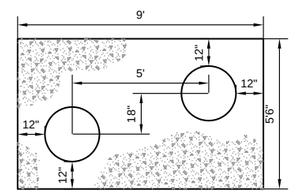
SECTION A
SCALE: 1"=50'
PROFILE OF DRAIN TRENCH

NOTE:
DRAIN AGGREGATE NOT SHOWN FOR CLARITY

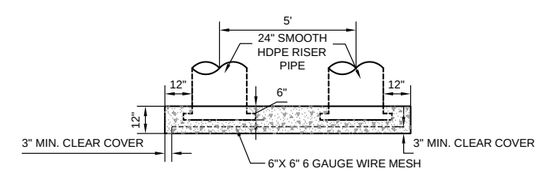


SECTION B
SCALE: (H)1"=10' (V)1"=2'
LEACHATE COLLECTION SYSTEM WITH LINERS

NOTES:
1. LINER, GEONET AND GEOTEXTILE NOT SHOWN TO SCALE.
2. COMPACTED CLAY LINER 3.0' MEASURED PERPENDICULAR TO THE SLOPE.



PLAN VIEW



SIDE VIEW

DETAIL 2 NTS — RISER PIPE CONCRETE FOOTING

REVISIONS	NO	BY	DATE	DESCRIPTION
	1	MWR	4/26/07	REVISED BOTTOM LINER TO SHOW GCL AND TEXTURED HDPE

REVISIONS	NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 6052		
DRAWN BY	SDP	12/12/06
CHECKED BY	MWR	1/17/07
APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

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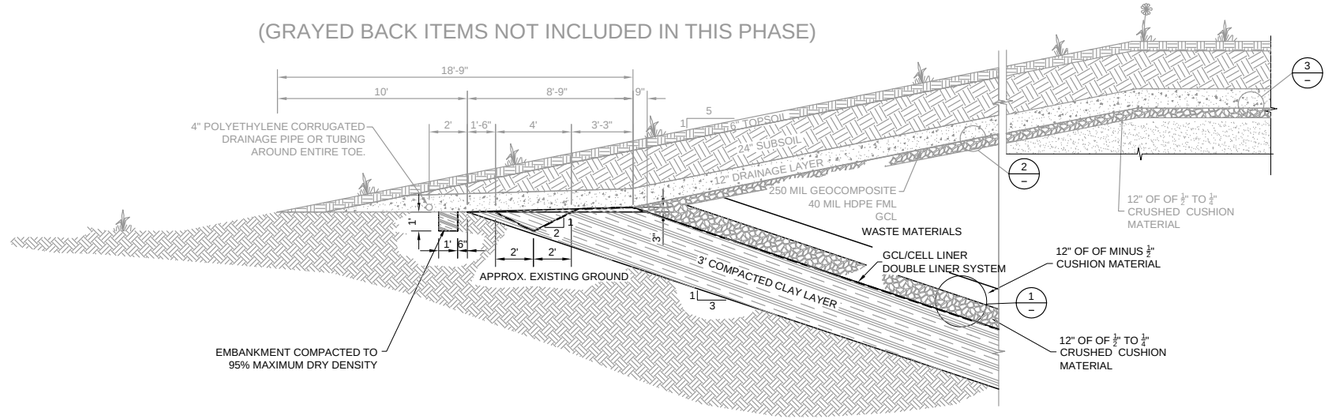
Consulting Scientists and Engineers
Helena, Montana 59601
5893 Rosalyn Avenue
(406) 449-4050

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
LEACHATE DETECTION, COLLECTION, AND REMOVAL SYSTEM
SECTIONS AND DETAILS

DRAWING FILE NUMBER: 605202H029.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER: 29
REV: 1

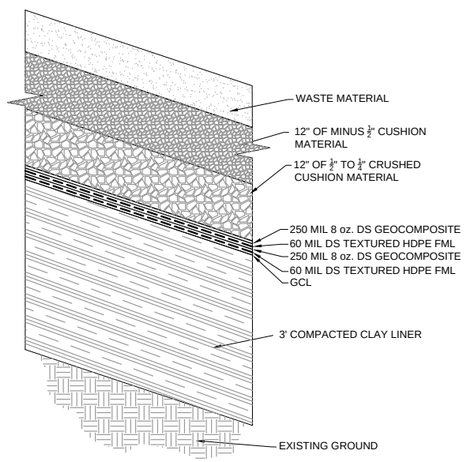
UPDATE TIME: 1:17PM
MWR \HEL\012407\:\:\Land Projects\605202\DWG\605202H029.dwg

(GRAYED BACK ITEMS NOT INCLUDED IN THIS PHASE)

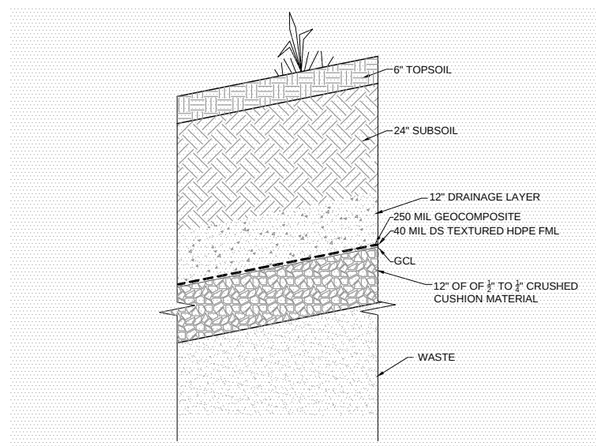


TYPICAL SECTION OF COMPLETED CAMU PHASE 2 CELL

SCALE: 1"=4'

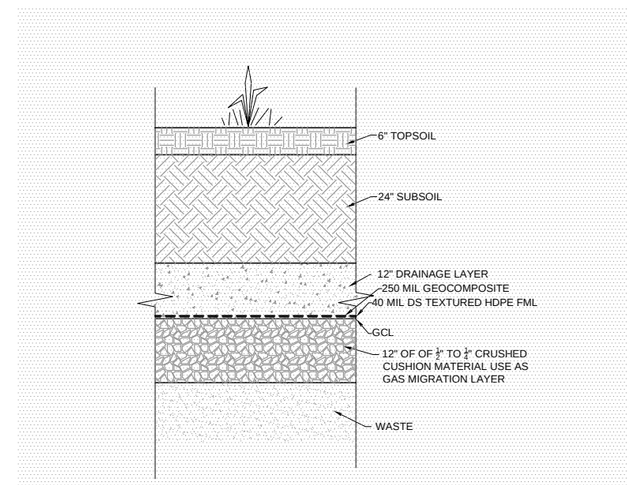


1 – DETAIL
TYPICAL BOTTOM LINER
SCALE: NTS



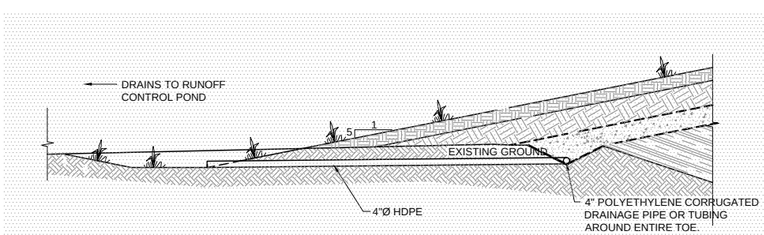
2 – DETAIL
TYPICAL CAP CONSTRUCTION ON SLOPES
SCALE: NTS

(NOT INCLUDED IN THIS PHASE)



3 – DETAIL
TYPICAL CAP CONSTRUCTION INCLUDING GAS MIGRATION LAYER
SCALE: NTS

(NOT INCLUDED IN THIS PHASE)



SECTION A – TOE DRAIN
SCALE: NTS

(NOT INCLUDED IN THIS PHASE)

REVISIONS NO	BY	DATE	DESCRIPTION
1	MWR	4/26/07	REVISED BOTTOM LINER TO SHOW GCL AND TEXTURED HDPE
1	MWR	4/26/07	REVISED CUSHION LAYER THICKNESS AND GRADATION

REVISIONS NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 6052		
DRAWN BY	SDP	12/28/06
CHECKED BY	MWR	1/11/07
APPROVED BY	MJO	1/12/07
SCALE: AS NOTED		

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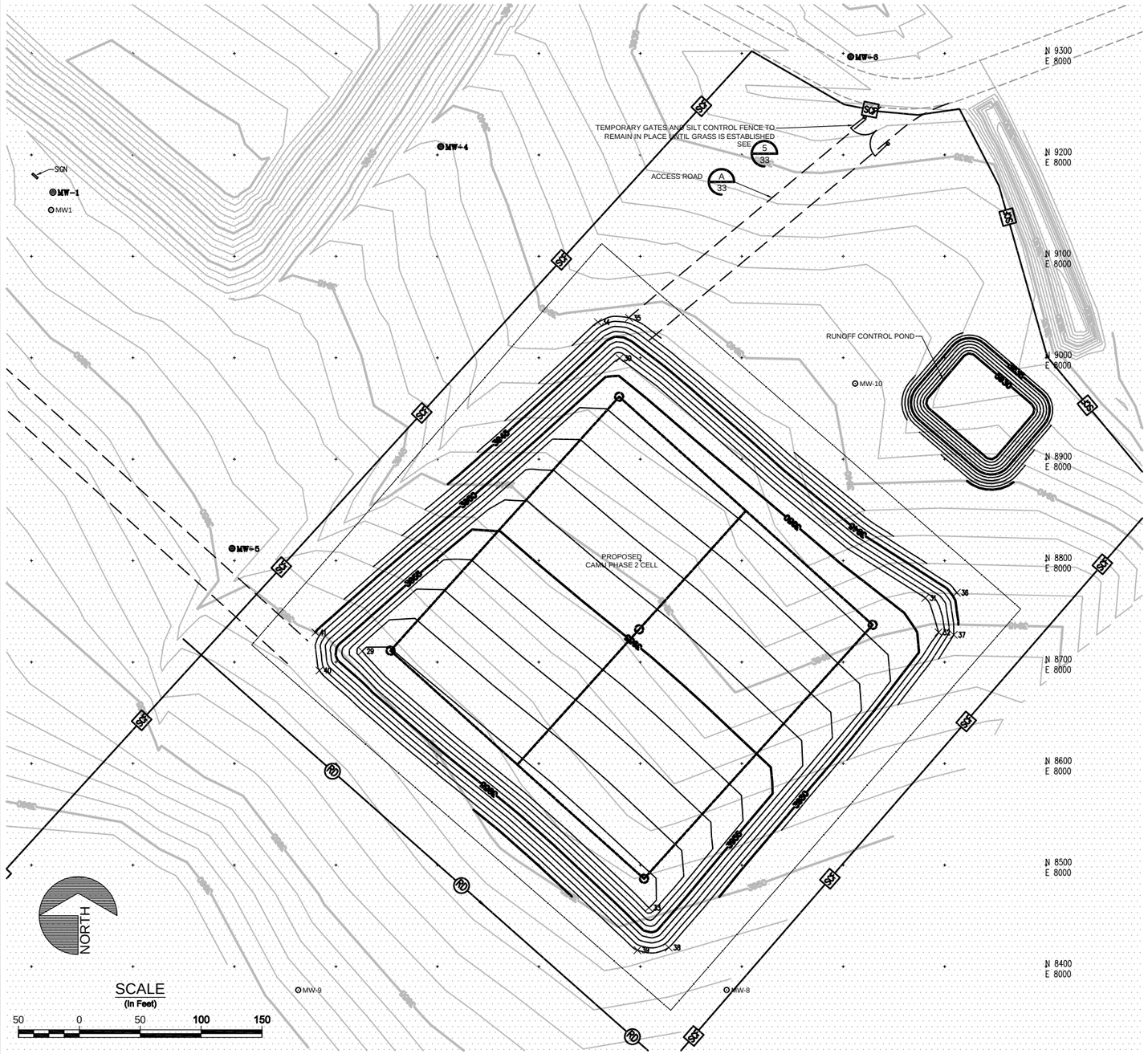
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
CAP AND BOTTOM LINER DETAILS

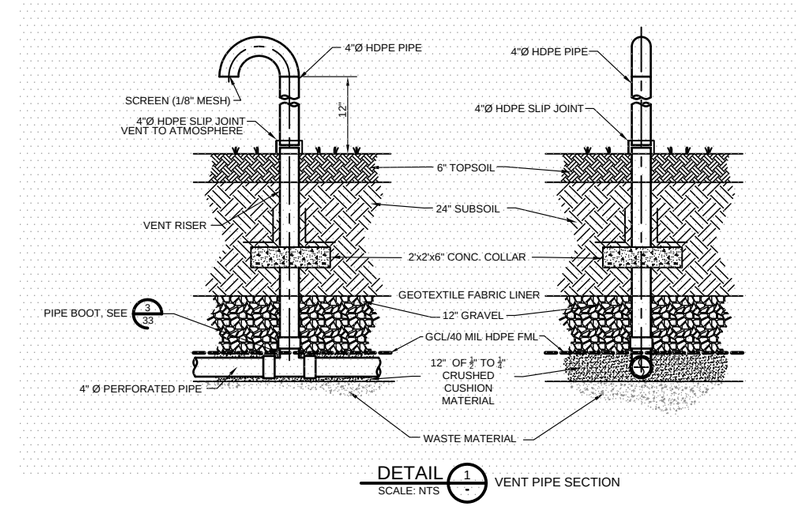
DRAWING FILE NUMBER
605202H030.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 30
REV

UPDATE TIME: 1:17PM
MWR \HEL\012407\:\:\Land Projects\605202\DWG\605202H030.dwg



FINISHED GRADE PLAN WITH GAS VENT AND PIPING LOCATIONS

SCALE: 1"=50'



DETAIL 1 VENT PIPE SECTION

SCALE: NTS

CONSTRUCTION PROJECT CONTROL POINTS

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	8812.08	7197.71	3952.51	MW5
2	9296.77	7807.35	3934.54	MW6
3	8376.8943	7685.1041	3954.97	MW-8
4	8376.8165	7262.8426	3961.72	MW-9
5	8974.659	7811.757	3942.6	MW-10

CONSTRUCTION CAPPING CONTROL POINTS

POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
29	8710.8343	7325.8935	3958.84	TOP OF CAP
30	8999.5717	7579.6401	3949	TOP OF CAP
31	8763.2501	7880.946	3949	TOP OF CAP
32	8729.3733	7893.8993	3949	TOP OF CAP
33	8457.9415	7608.451	3958.84	TOP OF CAP
34	9035.0968	7558.2053	3941	TOE OF CAP
35	9039.4102	7588.9005	3941	TOE OF CAP
36	8768.4777	7911.9393	3944	TOE OF CAP
37	8726.8943	7908.9421	3946	TOE OF CAP
38	8418.739	7628.0372	3951	TOE OF CAP
39	8416.0879	7597.2121	3951	TOE OF CAP
40	8691.8392	7283.8127	3951	TOE OF CAP
41	8729.3577	7279.8377	3950	TOE OF CAP

(THIS SHEET NOT INCLUDED IN THIS PHASE)

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

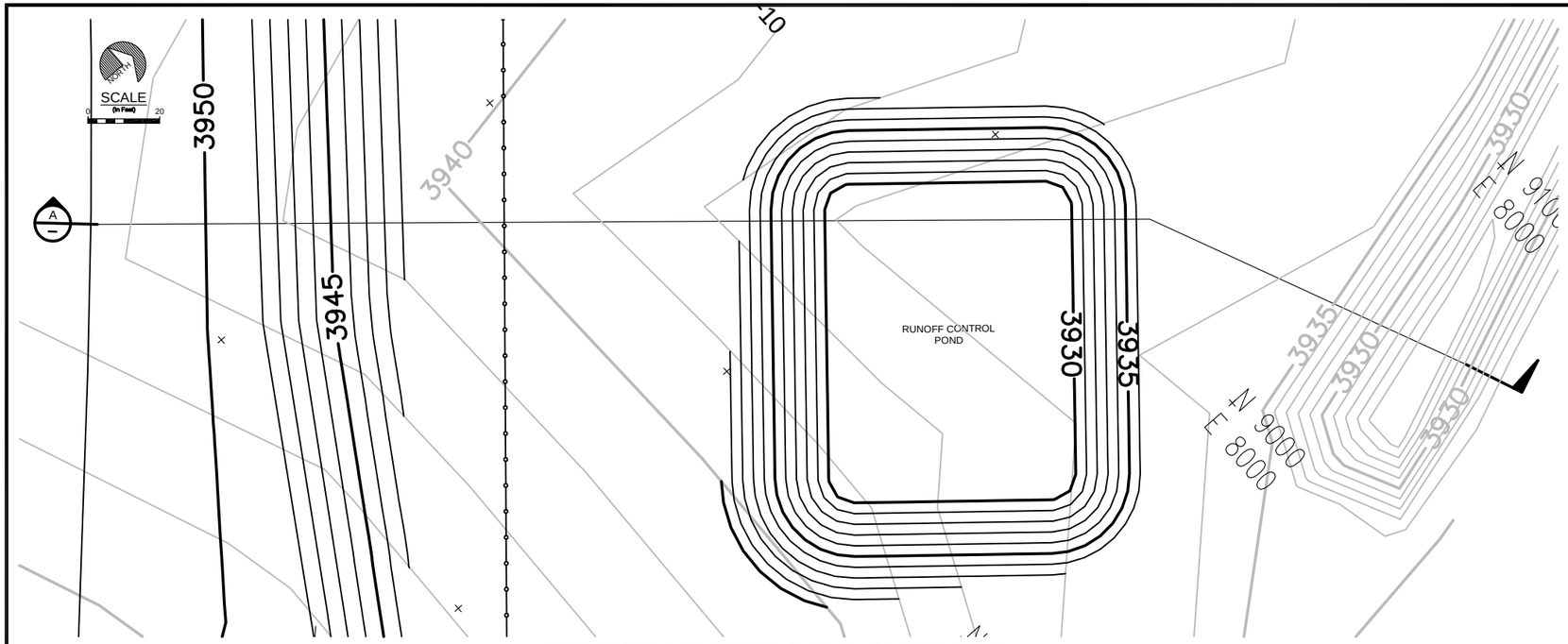
Project No.: 6052		
DRAWN BY	SDP	12/11/06
CHECKED BY	MRW	1/17/07
APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
FINISHED GRADE PLAN WITH GAS VENT LOCATIONS AND DETAILS

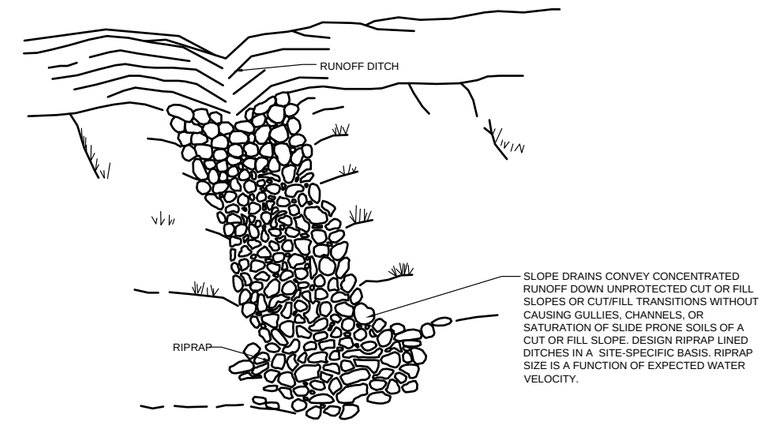
DRAWING FILE NUMBER
605202H031.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 31
REV

UPDATE TIME: 1:18PM
MWR \\EL\012407\I:\Land Projects\605202\DWG\605202H031.dwg

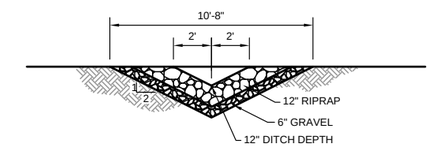


RUNOFF CONTROL POND PLAN VIEW

SCALE: 1"=20'

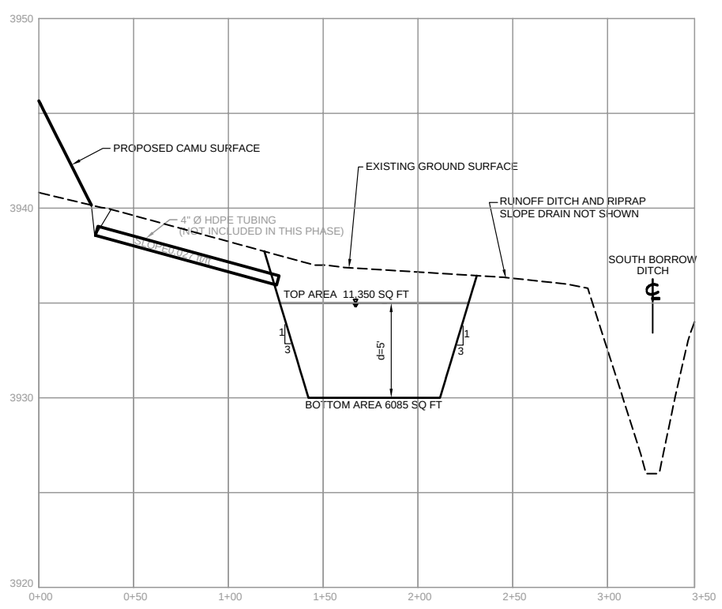


DETAIL 1 RIPRAP SLOPE DRAIN
SCALE: NTS



NOTE:
BANK PROTECTION TO BE TYPE 3.
USE CLASS I RIPRAP.

DETAIL 2 RIPRAP SLOPE DRAIN TYPICAL SECTION
SCALE: NTS



SECTION A RUNOFF CONTROL POND
SCALE: (H) 1"=40 (V) 1"=4'

(GRAYED BACK ITEMS NOT INCLUDED IN THIS PHASE)

PROJECT QUANTITY TABLE

(ROUGH QUANTITIES FOR BIDDING PURPOSES ONLY)

ITEM NO.	DESCRIPTION	QUANTITY	UNIT
1	Access Road-North(1510 ft long x 30 ft wide)	5034	SY
2	Access Road-South (383 ft long x 30 ft wide)	1277	SY
3	Excavation & Stockpile - Topsoil (upper 6")	3,864	CY
4	Excavation & Stockpile - Subsoil (next 16")	10,304	CY
5	Excavation & Stockpile - Cell Excavation	53,832	CY
6	Subgrade Preparation, Grade & Compact	23,700	SY
7	Compacted Clay Liner	22,000	CY
8	GCL	43,500	SY
9	HDPE, Double-Sided Textured 60 mil	43,500	SY
10	250 mil 8 oz. DS Drainage Geocomposite	43,500	SY
11	Leachate Collection & Removal Systems- 4" Perf Pipe	757	LF
12	Leachate Collection & Removal Systems-Drain Gravel	500	CY
13	Leachate Collection & Removal Systems-24" Stand Pipes	38	LF
14	Runoff Control Pond	2900	CY
15	Crushed ¾" to ¼" Material-Bottom of Cell	8,000	CY
16	Minus ¼" Material-Bottom of Cell	8,000	CY
17	Crushed 4" to 4" Material-Under Cap	7,100	CY
18	Load, Haul, Place & Compact Waste Materials	42,443	CY
19	Temporary Cover, RPE 25	24,500	SY
20	Load, Haul, Place & Compact Waste Materials-2008	21,275	CY
21	Load, Haul, Place & Compact Waste Materials-2009	2,100	CY
22	GCL	21,300	SY
23	HDPE, Double Sided Textured 40 mil	21,300	SY
24	Cap Drainage Collection, 4" HDPE	1,800	LF
25	Cap Drainage Culvert, 6" HDPE	71	LF
26	Cover Soil Layer	22,000	CY
27	Permanent Run-on Diversion Ditches	750	LF
28	Seed, Fertilize, & Mulch – Off Plant	13.1	ACRE
29	Woven Wire Farm Fence	2,200	LF
30	Chain Link Fence with Appurtenances	2,200	LF

(GRAYED BACK ITEMS NOT INCLUDED IN THIS PHASE)

REVISIONS NO	BY	DATE	DESCRIPTION
1	MWR	2/26/07	REVISED RUNOFF CONTROL POND EXCAVATION QUANTITY
2	MWR	4/26/07	UPDATED QUANTITY TABLE

REVISIONS NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 6052		
DRAWN BY	SDP	12/04/06
CHECKED BY	MWR	1/12/07
APPROVED BY	MJO	1/12/07
SCALE: AS NOTED		

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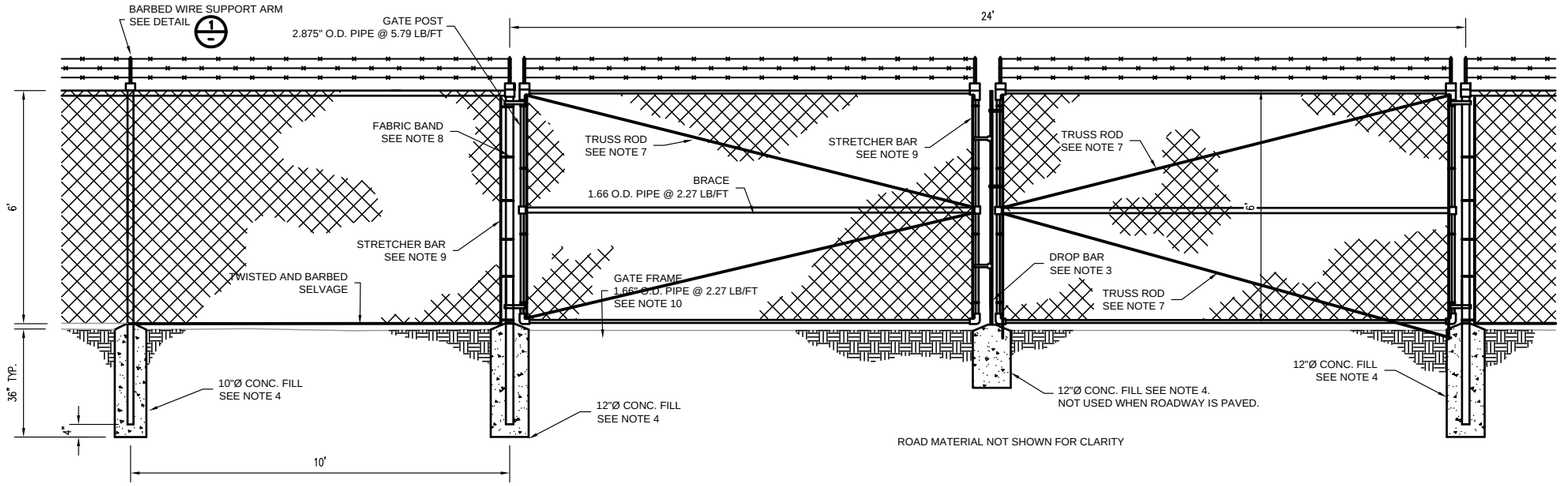
Consulting Scientists and Engineers
Helena, Montana 59601
3020 Bozeman Avenue
(406) 443-4150

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT

RUNOFF CONTROL POND PLAN AND RIPRAP SLOPE DRAIN DETAILS

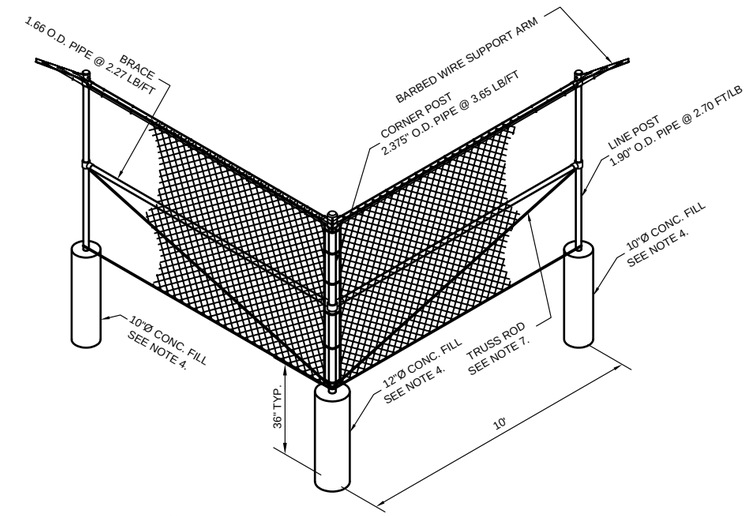
DRAWING FILE NUMBER
605202H032.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER 32
REV 2

UPDATE TIME: 2:43PM
MWR \HEL\022607\:\:\Land Projects\605202\DWG\605202H032.dwg



6-FOOT CHAIN LINK FENCE

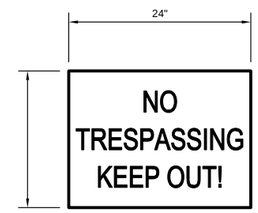
NTS



FENCE NOTES:

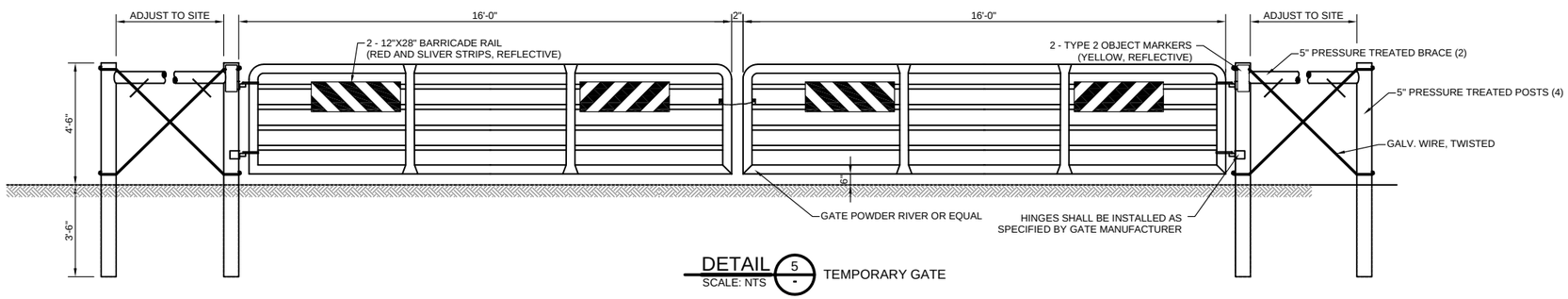
1. DO NOT INSTALL DOUBLE PANELS MORE THAN 300' APART.
2. PULL POST BRACING IS THE SAME AS IN THE CORNER
3. A DROP BAR LOCKING DEVICE IS REQUIRED FOR ALL DOUBLE GATE INSTALLATIONS. THE DROP BAR MUST BE ABLE TO BE INSERTED INTO THE CONCRETE BLOCK AT LEAST 6".
4. ALL CONCRETE IS CLASS "F" OR BETTER.
5. US 2-POINT 12-½ OR 13-½ GAUGE WIRE. PROVIDE THE PROJECT MANAGER CERTIFICATION THAT THE WIRE MEETS ASTM A 121 REQUIREMENTS.
6. FENCE FABRIC MUST HAVE 2" OPENINGS AND MEET AASHTO M 181 REQUIREMENTS. USE 9-GAUGE WIRE FOR FABRIC.
7. FURNISH ⅜" GALVANIZED TRUSS RODS WITH DROP-FORGED TURNBUCKLES OR ⅜" ALUMINUM TRUSS RODS WITH CAST ALUMINUM TURNBUCKLES.
8. STEEL BANDS MUST BE A MINIMUM OF ⅛" THICK BY ¾" WIDE. ALUMINUM BANDSMUST BE A MINIMUM OF ⅛" THICK BY ⅞" WIDE.
9. STEEL OR ALUMINUM STRETCHER BARS MUST BE AT LEAST ¼" THICK BY ¾" WIDE AND AT LEAST 2" SHORTER THAN THE FABRIC WIDTH USED.
10. THE GATE FRAME CORNERS MAY BE WELDED OR FASTENED AND REINFORCED WITH GALVANIZED MALLEABLE-IRON FITTINGS DESIGNED FOR THE USE.

DETAIL 1 / SCALE: NTS — BARBED WIRE SUPPORT ARM

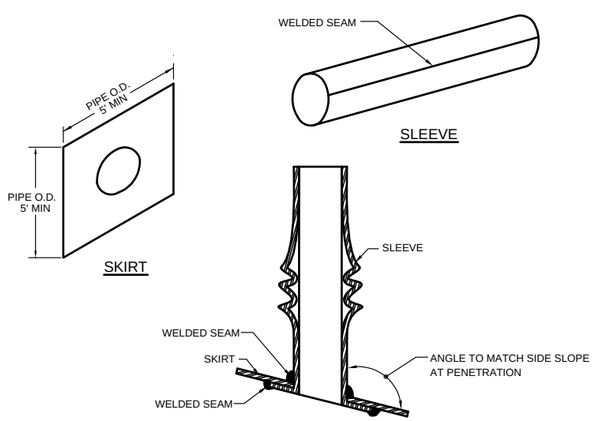


NOTE:
SIGNS TO BE MADE FROM ALUMINUM SHEET AS DESCRIBED IN THE SPECIFICAITONS. LETTERS WILL BE 2" HIGH (MIN.) TYPE A ACRYLIC REFLECTORS. BACKGROUND PAINT WILL BE RED. A BORDER SIMILAR IN COLOR WILL ALSO BE SUPPLIED. SIGNS TO BE PLACED ON EACH GATE AND MIDWAY ALONG THE FENCE ON NON-GATED SIDES.

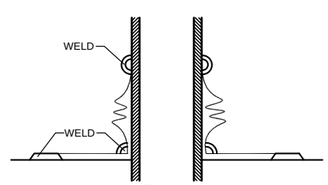
DETAIL 2 / SCALE: NTS — SIGN



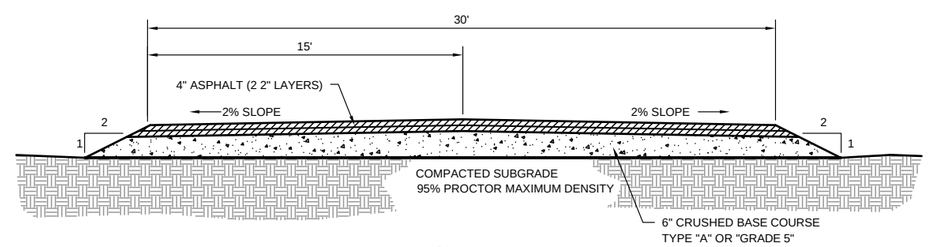
DETAIL 5 / SCALE: NTS — TEMPORARY GATE



DETAIL 3 / SCALE: NTS — TYPICAL PIPE BOOT



DETAIL 4 / SCALE: NTS — ACCORDIAN PIPE BOOT WELD



SECTION A — TYPICAL PAVED ACCESS ROAD

REVISIONS	NO	BY	DATE	DESCRIPTION

REVISIONS	NO	BY	DATE

SCALE VERIFICATION BAR IS ONE INCH ON ORIGINAL DRAWING
0 — 1
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Project No.: 6052		
DRAWN BY	SDP	11/25/06
CHECKED BY	MWR	1/18/07
APPROVED BY	MJO	1/19/07
SCALE: AS NOTED		

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana 59601
5625 Bainbridge Avenue
(406) 442-4480

ASARCO LLC - EAST HELENA PLANT
CAMU PHASE 2 CELL PROJECT
MISCELLANEOUS DETAILS

DRAWING FILE NUMBER: 605202H033.dwg
AUTOCAD 2004 DRAWING (DWG)
SHEET NUMBER: 33
REV: 1

UPDATE TIME: 2:59PM
SDP \HEL\012307\:\Land Projects\605202\DWG\605202H033.dwg

APPENDIX J

PROJECT SPECIFICATIONS

APPENDIX J

PROJECT SPECIFICATIONS

The Standard Specifications for Road and Bridge Construction, edition of 1995, prepared by the Montana Department of Transportation and Montana Transportation Commission, hereinafter referred to as the "Standard Specifications," shall be applied to Project work as specified below and shall govern this Project and form the basis of this Contract, except as modified in these Contract Documents. Contractor shall note the 1995 Standard Specifications shall be used as modified herein without subsequent amendments or newer publications made by the Montana Department of Transportation and Montana Transportation Commission. The Standard Specifications are modified herein as detailed in the following divisions. Division and subdivision numbers refer to corresponding numbers of the Standard Specifications. Additional division or sections numbers may be used to specify items of work not included in the Standard Specifications.

Copies of the 1995 Standard Specifications may be obtained from Montana Department of Transportation, Contract Plans Section, 2701 Prospect Avenue, P.O. Box 201001, Helena, Montana 59620-1001, Telephone (406) 444-6215.

DIVISION 200 - EARTHWORK
DIVISION 600 - MISCELLANEOUS CONSTRUCTION
DIVISION 700 - MATERIALS

DIVISION 200 – EARTHWORK

SECTION 203 - EXCAVATION AND EMBANKMENT:

Add the following subsections to this section.

203.06 DESCRIPTION OF CAMU PROJECT EARTHWORK

This specification covers the requirements for labor, supervision, equipment and materials associated with the earthwork operations shown on or implied by the design Drawings, or herein specified. Earthwork activities shall include, but not be limited to project layout, soil testing, site drainage, dust control, clearing, disposal, excavation, subgrade preparation, protection and removal of known underground utilities, fill and backfill, embankments, finish grading and site restoration.

203.07 CONSTRUCTION REQUIREMENTS OF CAMU PROJECT EARTHWORK

203.07.1 Grade Control and Layout of Work

The Contractor shall furnish all stakes, markers, tools, equipment and labor required to lay out the work from bench marks and/or control point markers indicated on the drawings. The Contractor shall not disturb existing survey monuments or bench marks without the consent of the Engineer. Markers that are accidentally disturbed by earthwork operations shall be replaced at the Contractor's expense by a licensed land surveyor. Copies of all survey notes will be given to the Engineer within one day after survey is conducted. Restaking and remarking of layout stakes caused by misinterpretation of the specifications will be at the Contractor’s expense. It is recommended that the surveyor meet with the Engineer to review grades and dimensions, prior to commencing layout surveys. During construction of the compacted clay liner, the Contractor must provide a system for tracking stakes used for layout to ensure that none are lost within the compacted clay layer.

203.07.2 Inspection and Testing

The Owner may employ independent engineering firms for Quality Assurance inspection and testing. Contractor shall cooperate with the Owner’s oversight personnel. The Owner will pay for Quality Assurance testing. However, if initial testing indicates that the Contractor has not complied with the Contract Documents, then the costs of subsequent testing associated with the non-compliance will be deducted from the Contract price. Quality Assurance testing will include but not be limited to the tests listed in Tables 4-1, 4-2, and 4-3.

The Contractor is required to conduct Quality Control testing. Costs for these tests will paid by the Contractor.

TABLE 4-1. STOCKPILE ACCEPTANCE TESTING

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Soil Type and Quality	Visual	Continuous	Maximum particle size <1 inch	Reject any excavated material that has not been screened to 1 inch minus
Liquid and Plastic Limits	ASTM D-4318	1 per 1,000 cy	PI>8	Reject portions of the stockpile not meeting the standard or conduct additional hydraulic conductivity tests with failing soils
Remolded Hydraulic Conductivity	ASTM D-5084	1 per 3,500 cy or minimum of 6 tests	Hydraulic conductivity must not exceed $1x10^{-6}$cm/sec	Reject portions of the stockpile not meeting standard.

TABLE 4-2. QC TESTING FOR CCL PLACEMENT

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Soil Type and Quality	Visual	Continuous	Maximum particle size <1 inch	Reject all material that has not been screened to 1 inch minus
Scarification	Visual/Tape Measure	100%	Surface scarified to a depth of 0.5-2.0 inches and a spacing of 6-12 inches before accepting additional lifts	Recompact and/or scarify any surface not meeting standard
In-Place Density	ASTM D-2922	5 per acre per lift	95% of maximum dry density Less than 3% of all densities may not meet the standard above. Of those not meeting standard, no dry density less than 5 pcf less than 95% of maximum dry density. Sample locations shall be selected by the Engineering Inspector based on grid pattern established at project outset.	Reject and reprocess those areas with dry density less than 5 pcf less than 95% of maximum dry density or if cumulative failures exceed 3% of all tests
In-Place Water Content	ASTM D-3017	5 per acre per lift	Less than 3% of all measured water content may have water content wetter than +2% or dryer than –3% of optimum	Reject or reprocess material that exceeds both +2%/-3% criteria
Construction Stakes for Grade Control	Daily Inventory	Daily	Contractor must return all construction stakes used for grade control at the end of each shift to the Engineering Inspector	Reject and replace day's work if stake or portion of stake used near CCL boundary is missing
Proctor Moisture Density Curve	ASTM D-698 or AASHTO T-99	1 per 2,500 cy	N/A	N/A
Compactive Effort	Visual	Continuous	Contractor to establish rolling pattern and equipment that produces necessary compaction	Rework all areas not sufficiently compacted
Lift Thickness	Visual/Tape Measure	5 per acre per lift	No loose lift thickness shall exceed 6 inches. Smaller lifts may be necessary to meet compaction requirements	Remove excess lift thickness.
Hole Repair	Visual	100%	Firmly packed	Reject and replace holes not repaired or incompletely repaired.

TABLE 4-3. QA TESTING FOR CCL PLACEMENT

Parameter	Test Method	Frequency[1]	Test Standard	Rejection Criteria
Soil Type and Quality	Visual	Continuous	Soil must be fine-grained (all particles <1 inch), clay-like and free of debris	Reject all material that does not meet standard
Scarification	Visual/Measuring Tape	100%	Surface scarified to a depth of 0.5-2.0 inches and at a spacing of 6-12 inches	Reject and recompact and/or scarify any surface not meeting standard
Proctor Moisture Density Curve	ASTM D-698 or AASHTO T-99	1 per 2,500[2] cy	N/A	N/A
In-Place Density	Electrical Gauge	1 per acre per lift[2]	95% of maximum dry density Less than 3% of all densities may not meet the standard above. Of those not meeting standard, no dry density less than 5 pcf, less than 95% of maximum dry density	Reject and reprocess those areas with dry density less than 5 pcf less than 95% of maximum dry density or if cumulative failures exceed 3% of all tests
In-Place Water Content	Electrical Gauge	1 per acre per lift[2]	Less than 3% of all measured water content may have water content wetter than +2% or dryer than –3% of optimum	Reject or reprocess material that exceeds both +2%/-3% criteria
In-Place Density	ASTM D-1556	1 per every 10 tests above	N/A	Use to corroborate electrical gauge testing
In-Place Water Content	ASTM D-2216	1 per every 10 tests above	N/A	Use to corroborate electrical gauge testing
Hole Repair	Visual	1 per every five QC tests of same	Firmly packed	Reject and replace holes not repaired or incompletely repaired

Notes:

(1) Frequency noted is a minimum. Inspectors may perform additional tests if conditions change.

(2) Minimum of one test required.

203.07.3 Protection and Safety

Open Excavations. Provide barricades and/or other safety equipment as required to protect any equipment, vehicles and workers from any open excavation.

A. Protection of Property. The Contractor shall protect adjacent property and avoid damage to such property. Adjacent property damaged due to the Contractor's operations shall be repaired or replaced. The repairs and/or replacement shall be equal to existing improvements and shall match existing finish and dimensions.

B. Utilities. The Contractor is responsible for obtaining off-site utility locations as required by law. He will notify the Engineer prior to digging adjacent to utilities.

203.07.4 Subgrade and Fill Protection

During construction, fills and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times.

Finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the Contractor until completion and acceptance of the work. The storage or stockpiling of materials on the finished subgrade will not be permitted.

203.07.5 Site Drainage

Excavation, fill and backfill work areas shall be continually and effectively drained. Water shall not be permitted to accumulate in excavations or foundation areas. The Contractor shall construct suitable dikes, drains or provide pumping equipment, as required, to divert water flows away from the work areas.

203.07.6 Dust Control and Haul Road Maintenance

Control all dust produced from the project site. Prevent the spread of dust and avoid creation of a nuisance in the surrounding area. The Contractor shall prepare and submit a Dust Control Plan to the Owner for approval before construction begins. The Dust Control Plan will address methods to be used to minimize dust during sodding, hauling waste placement, grading and earthwork operations. It will also describe haul road sweeping and maintenance operations.

203.07.7 Excavation

A. General Requirements. The Contractor shall excavate every type of material encountered within the limits of the project, to the lines, grades and elevations indicated and as specified herein. Test pit and boring logs for the CAMU site are available from the Engineer.

B. Excavations For Cell Construction

1. The excavation shall be carried down to the elevations shown on the design Drawings. If suitable material in the bottom of the excavation is removed for the

Contractor's convenience, the subgrade shall be restored by the Contractor and at his expense, to a condition at least equal to the undisturbed foundation as determined by the Engineer.

2. The Contractor shall remove any surface layer of unsuitable material at the planned grade of the excavation, as determined by the Engineer, from the site.

C. Excavations for Ditches and Drainage Structures. Excavations for ditches and drainage structures shall be accomplished by cutting accurately the line, grade and cross-section required. Trenches and pits shall be of sufficient size to accommodate the installation of piping and structures. Excessive open ditch excavation shall be backfilled with satisfactory materials to the grades shown on the design Drawings. The Contractor shall maintain all excavations free from detrimental quantities of brush, sticks, trash and other debris.

D. Soil Salvage

1. The Contractor shall stockpile the top 8 inches of excavated soil for use as topsoil in the landfill cap.

2. The Contractor shall stockpile the next 16 inches of soil for use as subsoil in the landfill cap.

3. The remainder of excavated clayey sand clay, and silt (sandy loam) material from the landfill cell excavation shall be stockpiled for use in construction of the compacted clay liner. Clay rich soils will be segregated and stockpiled separately from sandier soils. The Engineer will determine material types. Determination limits to be concurred by Contractor.

4. Stockpiles shall be covered or provided with runoff containment in accordance with best management practices for preventing storm water pollution.

E. Subgrade Preparations

1. **General Requirements.** Subgrade shall be shaped to the line, grade and cross-section and compacted as specified for all required embankments and in the CAMU cell. This operation shall include plowing, disking and any moistening or aeration required to obtain proper compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory material as directed by the Engineer.

   Low areas resulting from the removal of unsatisfactory material shall be brought up to the required grade with satisfactory materials, and the entire subgrade shall be shaped to the line, grade and cross-section and compacted as specified.

   After rolling, the elevation of the finished subgrade shall not vary more than 0.2 foot from the established grade and approved cross-section.

2. **Compaction.** Compaction shall be accomplished by sheepsfoot rollers to at least 90 percent of Proctor maximum dry density.

203.07.8 <u>Embankment</u>

A. Materials

1. **Compacted Clay Liner.** The compacted clay liner shall consist of clay-rich sandy loam material from excavation required for the landfill cell. Cobbles and rock fragments having maximum dimensions of more than 1-inch shall be screened from clay soil used in these liners. Should cobbles and rock fragments of such size be found in otherwise approved earth fill materials, they shall be removed by the Contractor before the materials in the earth fill are rolled and compacted. No brush, roots, sod, or other perishable or unsuitable materials shall be placed in the clay liner or earth cap. Clay-rich soils will be used for the compacted clay liner. Soils with less clay content will be used for the cover soil.

2. **Cushion Material.** The CAMU Phase 2 Cell shall have cushion course placed between the installed liner systems and the larger graded backfill placed in the center of the cell. The cushion material shall be 24" perpendicular to the liner systems along the bottom and sides of the cell. The bottom 12" of the cushion layer shall consist solely of imported gravel between ½" and ¼". The top 12" shall consist of imported gravel passing the ½" screen. This 24" cushion layer will be maintained over the side walls and bottom of the cell at all times.

3. **Waste Material.** The CAMU Phase 2 cell backfill materials shall consist of materials from source area excavations and demolition debris. Backfill materials are required to have 100% of the material to be less than 2 feet in diameter and no liquid wastes will be placed in the CAMU Phase 2 Cell. It is anticipated that debris and concrete from demolition will require size reduction to meet the required gradations. All material requiring size reduction will be resized at the structure demolition site and all stored material requiring size reduction will be resized at the location the material is stored.

4. **Leachate Collection Trench Drain Materials**. The leachate collection trench drainage material shall consist of well graded sand and gravel that is subrounded to round, screened and washed free of vegetable matter, clays, and other deleterious substances that could in time change the hydraulic conductivity of the drainage layer. The gradation of the drainage layer material shall lie within the range shown in Table 3.

5. **Topsoil and Subsoil**. The Contractor shall obtain topsoil and subsoil from soil salvage stockpiles, as described in section 203.07.7 (D)(1) and 203.07.7 (D)(2). Topsoil shall be free of trash, rocks, hard lumps of soil, and stubble. Subsoil shall be free of sharp or jagged rocks, roots, and debris.

TABLE 3. LEACHATE COLLECTION TRENCH DRAINAGE MATERIAL (ASTM C33, SIZE 7, COARSE AGGREGATE)

Sieve Size	Percent Passing
3/4”	**100**
1/2”	**90 – 100**
3/8”	**40 – 70**
#4	**0 – 15**
#8	**0 - 5**

B. Placement

1. **Compacted Clay Liner.** Compacted clay liner shall be shaped to the line, grade and cross-section and compacted as specified. This operation shall include placement of suitable clay material in lifts not to exceed 6 inches after compaction, disking and any moistening or aeration required to obtain proper compaction. Particles exceeding 1 inch in diameter shall be screened from material to be used in the CCL. Any other unsatisfactory material shall be removed and replaced with satisfactory material as directed by the Engineer.

   Following compaction of any lift or portion of a lift, the fill shall be kept moist. If, in the opinion of the engineer, the prepared surface of any layer of earth fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it shall be moistened and/or worked with harrow, scarifier, or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer of earth fill material is placed.

   The compacted surface of each lift shall be scarified prior to placement of additional lifts. Scarification shall consist of roughening of the entire surface of the lift and, at a minimum, the roughening shall consist of parallel furrows nominally one inch in depth (ranging from 0.5 to 2.0 inches) and spaced no further than 12 inches apart. If scarification is to be done with a disc harrow, the disc gangs shall be turned perpendicular to the line of travel (if possible) and individual disks should be as straight as possible (instead of cupped). This will provide scarification while minimizing the mixing action produced by a disc. The scarification depth shall be considered as part of the maximum depth of the lift to be placed.

   If, in the opinion of the Engineer, the compacted surface of any layer of the earth fill in place is too wet for proper compaction of the layer of earth fill material to be placed thereon, it shall be removed; allowed to dry; or be worked with harrow, scarifier, or other suitable equipment to reduce the moisture content to the required amount; and then it shall be recompacted before the next succeeding layer of earth fill material is placed.

2. **Waste Material.** The contractor shall provide a temporary 25-mil RPE OR Liner for the waste material placed in the landfill cell. Special care must be taken to ensure that the waste is covered prior to significant occurrences of precipitation. In addition, the Contractor shall ensure that the waste is placed in a manner that will ensure that the water which falls on the temporary liner will drain to a sump without coming in contact with the waste material and without significant ponding of the water on the temporary liner. The water reaching the sump shall immediately be discharged to the storm water retention pond shown on the Drawings. Therefore, the storm water retention pond shall be constructed prior to placing waste material into the landfill cell. Any storm water coming in contact with the waste material shall not be discharged but shall be removed by the Contractor to the Plant water treatment system.

3. **Leachate Collection Trench Drain Material**. The Contractor shall place the drain material in a single layer, taking care to protect the underlying flexible membrane layer.

C. Compaction

1. **Compacted Clay Liner.** Except for final preparation of the clay liner to receive the flexible membranes, compaction shall be accomplished by sheepsfoot rollers. The sheepsfoot roller shall have compaction feet of sufficient length to fully penetrate the lift thickness being placed. A smooth drum roller shall be used to provide a smooth top surface of the clay liner once it is ready to receive the flexible membrane liner. The bottom clay liner in the landfill cell shall be compacted to 95 percent of Proctor maximum dry density. Compact the top 6 inches of the subgrade to 90 percent Proctor maximum dry density prior to placement of the compacted clay liner.

   a. **Moisture Control.** The standard optimum moisture content is defined as, "That moisture content which will result in a maximum dry unit weight of the soil when subjected to the ASTM D-698-70, Method A., Proctor Compaction Test." the maximum dry weight, in pounds per cubic foot, obtained by the above procedure is the Proctor maximum dry density.

      The moisture content of the clay liner material prior to and during compaction shall be distributed uniformly throughout each layer of the material. The allowable ranges of placement moisture content are based on design considerations. The moisture control shall be such that the moisture content of compacted earth fill, as determined by tests performed by the Engineer, shall be within the following limits:

      Material represented by the samples tested having a placement moisture content more than 2 percent dry of the standard optimum condition, or more than 3 percent wet of the standard optimum condition will be rejected and shall be removed or reworked until the moisture content is between these limits.

Within the above limits, and based on a continuous record of tests made by the Engineer on previously placed and accepted material, the uniformity of placement moisture content shall be such that:

No more than 3 percent of the samples of accepted liner material will be drier than 2 percent dry of the standard optimum moisture content, and no more than 3 percent will be wetter than 3 percent wet of the standard optimum moisture content.

The average moisture content of all accepted embankment material shall be between 0 and 3 percent wet of the standard optimum moisture content.

The Engineer will inform the Contractor when the placement moisture content is near or exceeds the limits of uniformity specified above, and the Contractor shall immediately make adjustments in procedures as necessary to maintain the moisture content within the specified limits.

b. **Density Control.** Density control of compacted earth fill shall be such that the dry density of the compacted material, as determined by tests performed by the Engineer shall conform to the following limits:

1) **Compacted Clay Liner.** Material represented by samples having a dry density less than 90 percent of its Proctor maximum dry density will be rejected. Such rejected material shall be rolled until a dry density equal to or greater than 95 percent of its Proctor maximum dry density is obtained.

Within the above limit and based on a continuous record of tests made by the Engineer on previously placed and accepted embankment, the uniformity of dry density shall such that:

No more than 3 percent of the material represented by the samples tested shall be at dry density less than 95 percent of Proctor maximum dry density.

The average dry density of all accepted embankment material shall be not less than 95 percent of the average Proctor maximum dry density.

c. Hole Repair. The placement of survey stakes (if used) as well as the performance of density tests, and hydraulic conductivity tests may require the penetration of lifts of the CCL. The contractor shall repair these penetrations by placing two-inch thick lifts of CCL material into the penetration and thoroughly tamping the lift by hand until the penetration has been filled. The tamping bar or item shall be roughly the same size and shape as the penetration.

2. **Cushion Layer.** The Contractor shall not compact the cushion layer but shall lightly roll the layer using nonvibratory compaction equipment with a static weight of 1.5 tons or less to ensure its stability under equipment traffic. Carefully roll the layer under the guidance of the Engineer to ensure that the underlying flexible membrane liner is not damaged.

3. **Leachate Collection Drain Layer.** The Contractor shall not compact the leachate collection drain layer but shall lightly roll the layer using nonvibratory compaction equipment with a static weight of 1.5 tons or less to ensure its stability under equipment traffic.

4. **Drain Layer.** The Contractor shall not compact the drain layer, but shall lightly roll the layer using nonvibratory compaction equipment with a static weight of 1.5 tons or less to ensure its stability under equipment traffic. Carefully roll the layer under the guidance of the Engineer to ensure that the underlying flexible membrane liner is not damaged.

5. **Gas Migration Layer.** The Contractor shall not compact the gas migration layer but shall lightly roll the layer using nonvibratory compaction equipment with a static weight of 1.5 tons or less to ensure its stability under equipment traffic.

6. **Subsoil.** The Contractor shall lightly roll the subsoil using nonvibratory compaction equipment with a static weight of 1.5 tons or less to ensure its stability under equipment traffic.

7. **Waste Materials.** The Contractor shall compact waste soils with a minimum of eight (8) passes (4 cycles) of a padfoot roller. Place the waste soils in a maximum lift thickness of 2 feet. The initial lift, placed directly on the leachate collection geocomposite, shall be no less than 1 foot in thickness and shall be composed of crushed slag, imported gravel, or select fill having particle size less than ½-inch and greater than ¼-inch. This same material shall be used for the last 12-inch lift that will have the cap geosynthetic clay liner placed over it. The second shall be of a similar thickness and material, but having particle size less than ½" . This same material shall be used in the second-to-last 12-inch lift that will have the cap placed over it. This waste cover material shall be approved by the Engineer. No waste material containing sharp, jagged rocks, concrete, roots debris, or any other material, which may puncture the HDPE-FML will be used in this protective layer.

   The Contractor may choose the equipment and manner with which to place the initial lift of waste material in the cell. However, it must be satisfactorily demonstrated to the Engineer that both the equipment and manner used to place the waste material over the liner will not have any detrimental effect on the liner.

D. Finish Grading

The surface of all excavation, fill, embankment and subgrade shall be finished to a reasonable smooth and compact surface in accordance with the lines, grades and cross-sections shown. The degree of finish for all graded areas shall be within 0.2 foot of the grades and elevations indicated. Gutters and ditches shall be finished in manner that will result in effective drainage.

END OF SECTION

DIVISION 600

MISCELLANEOUS CONSTRUCTION

SECTION 622 GEOSYNTHETICS CONSTRUCTION

622.01 MATERIALS

Replace with the following paragraph.

Furnish materials meeting the following requirements:

Geotextiles	Subsection 713.13
Geomembranes	Section 623
Geocomposite	Section 624
GCL	Section 625

SECTION 623 FLEXIBLE MEMBRANE LINER (FML)

Add the following new section.

623.01 DESCRIPTION

A. Scope. The work covered by these Specifications consists of furnishing and installing high-density polyethylene (HDPE) and reinforced polyethylene (RPE) flexible membrane liners where shown on the Drawings.

B. Definitions used in this section.

1. **Air Lance**. Consists of a stream of air forced through a 3/32" air nozzle at the end of a hollow metal tube for conducting a commonly used nondestructive test method to determine seam continuity and tightness of relatively thin, flexible geomembrane.

2. **Bodied Chemical Fusion Agent**. A chemical fluid containing a portion of the parent geomembrane that, after application of pressure and after the passage of time, results in the chemical fusion of two essentially similar geomembrane sheets, leaving behind only that portion of the parent material.

3. **Geomembrane**. An essentially impermeable synthetic membrane used as a solid or liquid barrier. Synonymous term for flexible membrane liner (FML).

4. **Seaming Boards**. Smooth wooden boards, conveyor belt, or similar hard surface (preferably 1" X 12" X 8', or more), placed beneath the area to be seamed to provide a uniform surface to apply roller pressure in the fabrication of field seams.

5. **Tensiometer**. A device containing a set of opposing grips used to place a geomembrane seam in tension for evaluating its strength in shear or in peel.

6. **Vacuum Box Assembly**. Consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge for conducting a nondestructive test method which develops a vacuum in a localized region of a geomembrane seam in order to evaluate the seam's tightness and suitability.

623.02 QUALITY ASSURANCE

A. Fabricator/Installer Qualifications

1. The installer shall have worked in a similar capacity on at least five (5) projects similar in complexity to the project described in the Contract Documents and with each project involving at least 100,000 square feet of a similar product.

2. Installation supervisor/field engineer shall have worked in a similar capacity on at least two (2) jobs similar in size and complexity to the project described in the Contract Documents.

3. The manufacturer shall perform the quality control tests listed in Table 4 at the manufacturing plant. Provide all quality control certificate to the Engineer as specified in Section 623.03(B) of these Special Provisions.

TABLE 4. GEOMEMBRANE SPECIFICATIONS

PROPERTY	TEST METHOD	REQUIREMENT		
		DEMO CAP & TEMP CAMU CAP	CAMU CELL	CAMU CAP
Gauge (mils nominal)	ASTM D-1593	20	60	40
Tear Strength (pounds)	ASTM D 1004 or ASTM D 751	125	42	28
Tensile Strength 1. Yield Stress (lb/in) 2. Break Stress (lb/in) 3. Yield Elongation (%) 4. Break Elongation (%)	ASTM D 6693 or ASTM D 2261	340	 126 90 12 100	84 60 12 100
Puncture Resistance (lb)	ASTM D 4833	150	90	60
Stress Crack Resistance (Hours)	ASTM D 5397 Appendix	N/A	300	300

B. Delivery, Storage and Handling

1. Deliver geomembrane to the site only after the Engineer receives and approves the required submittals. Immediately remove damaged or unacceptable material from the site and replaced at no cost to the Owner.

2. Store geomembrane on pallets to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, direct heat of the sun or other damage. Stack geomembrane no more than 3 rolls or 1 pallet high.

3. Repair all geomembrane damaged during handling to the satisfaction of the Engineer. Immediately remove from the site and replace geomembrane determined by the Engineer to be irreparably damaged. Repair, removal and replacement shall be solely at the Contractor's expense.

C. Warranty

1. The geomembrane installer shall warrant his workmanship to be free of defects for one (1) year after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, geomembrane attachments to appurtenances, and penetration seals. The installer shall also obtain and furnish the Owner a material warranty from the geomembrane manufacturer. The material warranty shall be for defects or failure due to weathering for ten (10) years after final acceptance.

2. Should a defect or failure occur within the aforesaid periods, the installer shall bear all costs for repair and/or replacement of the geomembrane and shall in addition bear all costs for the excavation of any cover backfill that is required to be removed in order to repair and/or replace the geomembrane. All materials removed to allow repairs to be made shall be reinstalled by the installer in accordance with these Contract Documents.

623.03 SUBMITTALS

A. Submit the following documents to the Engineer no later than three (3) weeks prior to installation of the geomembrane:

1. Complete written instructions for storage, handling, installation and seaming of the geomembrane which are in compliance with the Specifications and conditions of warranty.

2. Panel layout drawings showing both fabricated and field seams, and details not conforming with the Drawings (if any).

3. Qualification of the geomembrane installer, including the resume of the field engineer installation supervisor to be assigned to this project, including dates and duration of employment.

4. Installer's Quality Control Manual.

B. Submit the following documents to the Engineer prior to the shipment of the geomembrane to the site.

1. Polymer compound data

    a) Statement of production date or dates.
    b) Laboratory certification that the materials meet Specifications.
    c) Certification that all materials are from the same manufacturer.
    d) Copy of quality control certificates issued by manufacturer.
    e) Statement that no reclaimed polymer is added to the compound.

2. Geomembrane data.

    a) Statement of production date or dates
    b) Laboratory certification that the materials meet the Specification.
    c) Copy of quality control certificates issued by the manufacturer.
    d) Reports of tests defined in Table 5-1 from the manufacturer.

TABLE 5-1. MANUFACTURER'S QA TESTS FOR FML

Property	Test Method	Test Frequency	Test Standard(1)			Rejection Criteria
			OR RPE	HDPE 60 mil	HDPE 40 mil	
Gauge (mils nominal)	ASTM D-1593	1 per lot	20	60	40	Material must meet all standards <u>before</u> delivery to site
Tear Strength (pounds)	ASTM D-1004		70	42	28	
Tensile Strength 5. Yield Stress (lb/in) 6. Break Stress (lb/in) 7. Yield Elongation (%) 8. Break Elongation (%)	ASTM D-638 Type IV		300	 126 90 12 100	 84 60 12 100	
Puncture Resistance (lb)	ASTM D-4833		150	80	60	
Stress Crack Resistance (Hours)	ASTM D-5397		N/A	300	300	
Specific Gravity	ASTM D-1505			≥0.94	≥0.94	

Notes:
(1) Values shown are minimum average roll values.

C. Submit the following to the Engineer prior to start of the FML installation:

1. Warranties for material and installation as specified hereinafter for review to the Owner.

2. Certificate of acceptance of prepared subgrade for each area to be covered by an HDPE FML, signed by the installation supervisor.

D. During installation, submit to the Engineer results of Contractor quality control testing as specified in 623.06 TESTING.

E. Upon completion of the installation, submit to the Engineer the following:

1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.

2. Manufacturer's and Installer's warranties as specified hereinafter.

3. Record drawings showing location of panels, seams, repairs, patches, and destructive samples, including detailed measurements.

623.04 MATERIALS

A. Description of Materials

1. Geomembrane liner shall be top quality products, recommended by the manufacturer for this specific type of work, and shall have been satisfactorily demonstrated by prior use to be suitable and durable for such purposes.

2. Extrudate Rod or Bead shall be made from the same resin as the geomembrane liner with carbon black. Additives shall be thoroughly dispersed in the extrudate.

B. Physical Characteristics

The HDPE geomembrane liner:

1. Shall be textured on both sides.

2. Shall be formulated from a high density polyethylene resin with a specific gravity greater than or equal to 0.94. All resins shall be of the same type and no batch shall be blended with recycles or seconds.

3. Shall be uniform in color, thickness, and size. The material shall be a flexible, durable, watertight product free of pinholes, blisters, holes, bubbles, gels, undispersed resins or carbon black, and other contaminants. Processing aides, antioxidants and other additives shall not exceed a combined maximum total of 1 percent by weight, ignoring carbon black, and 3.5 percent by weight including carbon black.

4. Shall have the minimum physical property characteristics, as outlined in Table 4. Certified test results showing that the sheeting meets or exceeds the Specification shall be submitted per Section 623.03.

5. Shall be supplied in rolls labeled with thickness, length, width, manufacturer, plant location, and identification number.

The RPE geomembrane shall be OR RPE 25 as supplied by Layfield Plastics or an approved equal. The geomembrane shall conform to the manufacturer’s material properties table. All values are Typical Values unless otherwise noted.

623.05 INSTALLATION

A. Subgrade Preparation

The subgrade to be lined:

1. Shall be maintained in a dry enough condition for equipment to operate without rutting.

2. Shall be smooth and free of projections and sharp objects that can damage the lining. Remove rocks, hard clods, and other such material, and roll the subgrade so as to provide a smooth compact surface. The smoothed subgrade will limit liner bridging to less than 1 inch.

3. Shall be inspected prior to geomembrane installation to ascertain its suitability for installation in compliance with the terms of the product warranty and the requirements of this Specification. For HDPE geomembranes, submit to the Engineer a signed certification that the prepared subgrade surface is satisfactory. Installation of geomembrane without providing written certification shall constitute acceptance of the subgrade by the Contractor.

4. Shall have round edges at anchor trenches or edges shall be cushioned with geotextile and backfill.

B. Geomembrane Installation

1. Only layout the amount of geomembrane that can be seamed during that same day. Assign each panel a simple and logical identifying code number or letter. For HDPE geomembrane, identify the panels with each appropriate code on the layout design referenced in 623.03 A.2.

2. Do not damage geomembrane by handling, traffic, or leakage of hydrocarbons or any other means. Do not wear damaging shoes or engage in activities that could damage the geomembrane. Open or unroll geomembrane panels using methods that will not damage, stretch or crimp the geomembrane. Prevent excess condensation on the geomembrane such that the underlying surface is not adversely impacted. Protect underlying surface from damage. Provide sufficient material to allow for geomembrane shrinkage and contraction. Use methods that minimize wrinkles between adjacent panels. Place ballast on geomembrane to prevent uplift from wind. Use ballast that will not damage geomembrane. Do not allow vehicle traffic directly on geomembrane. Remove folded or wrinkled material that exceeds 6 inches in width. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for testing and/or repair. Any portion of the lining damaged during installation shall be removed or repaired by using an additional piece of the same membrane as specified herein. The liner shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching the liner to fit is not

permissible. Backfill anchor trenches as soon as possible after installation of liner and geocomposite, if applicable.

3. Place and seam geomembrane only when ambient temperatures, measured six inches above the geomembrane, are between 40 degrees F and 100 degrees F, unless otherwise specified or approved. Installation below 40 degrees F shall occur only after verifying that the geomembrane can be seamed according to Specifications and approval by the Engineer. Do not install geomembrane during precipitation, in the presence of excessive moisture, in areas of ponded water, or in the presence of excessive winds. Protect the geomembrane from wind uplift during installation through the use of sand bags or other suitable weights.

4. Repair all damaged geomembrane and test damaged areas prior to backfilling.

C. Pipe Boots. Fit and seal pipes, manholes, and other penetrations of the geomembrane with shop fabricated boots as shown on the Drawings. Match the flange portion of the boot to the angle of the slope or bottom where the pipe or manhole enters the liner for a smooth fit without excess stretching of the material.

D. Seaming

1. Seam Layout shall:

   a) Orient seams parallel to line of maximum slope, i.e., orient down, not across, slope.
   b) Keep butt seams at least ten (10) feet horizontally away from toe of slope.
   c) For HDPE geomembrane, use seam numbering system compatible with panel numbering system.

2. Trial field seaming shall be accomplished by the Contractor on-site for HDPE FMLs.

   a) Conduct trial seams on pieces of geomembrane to verify adequate seaming methods and conditions.

   b) Conduct trial seams:

      1) At beginning of each seaming period;
      2) At least once for each four seaming hours;
      3) For each seaming apparatus in use;
      4) At least once per shift for each person performing seaming; and
      5) Whenever changes in climatic conditions could effect seam quality.

   c) Make test seam in the location of seaming and in contact with subgrade or geosynthetic (same condition as the geomembrane to be seamed).

d) Make test seam sample at least two (2) feet long and eleven (11) inches wide with the seam centered lengthwise.

e) Cut two, 1-inch wide test strips from opposite ends of the trial seams.

f) Cut specimens constant 1-inch wide and clamp at 90 degree angle in tensiometer.

g) Quantitatively test field specimens for peel adhesion (ASTM D3083) first, and bonded seam strength (ASTM 3083) second. Insure that these tests are performed in this order.

h) A trial seam sample passes when the following results are achieved for both tests.

   1) The break is film tearing bond (FTB);
   2) The break is ductile; and
   3) The strength of break is at least 80% of the specified sheet strength.

i) Repeat the trial seam in its entirety if one (1) of the trial seam samples fails in either peel or shear mode.

j) Notify Engineer when repeated trial seam fails and do not continue seaming until deficiencies or adverse conditions are determined and corrected, and two (2) consecutive successful trial seams are achieved.

3. Use the following seaming procedure for HDPE geomembranes.

a) Do not begin seaming on liner until all trial seam test samples made by the equipment to be used passes tests as defined above.

b) Form seams per manufacturers written instructions. Wipe the contact surfaces of the panels clean to remove all dirt, dust or other substance. Use solvent for cleaning contact surfaces of field joints and for other required uses as recommended by the manufacturer. Apply a hot wedge or hot knife seaming tool to the overlapped panel edges creating a continuous thermal bond between the panels. Smooth out any wrinkles. Field seams shall have a strength of at least 80% of the specified sheet strength.

c) Extend seaming to the outside edge of panels to be placed under the anchor berm and in the anchor trench.

d) If there is not firm substrate, use a seaming board directly under the seam overlap to achieve proper support.

e) If seaming operations are carried out at night, provide adequate illumination.

f) Cut fish mouths or wrinkles at the seam overlaps along the ridge of the wrinkle in order to achieve a flat overlap. Seam the cut fish mouths or wrinkles and patch any portion where the overlap is less than three (3) inches with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

g) Seam only when ambient temperature, measured 6 inches above the geomembrane is between 40 degrees F and 100 degrees F unless other limits are accepted, in writing, by the Engineer.

4. Use a stitched "Z" fold for RPE geomembranes.

E. Defects and Repairs

1. Inspection

a) During installation and seaming, visually examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination. Mark areas suspected of deficiencies. Remove areas of geomembrane requiring more than one patch per 5,000 square feet and replace at no additional cost to the Owner.

b) Repair each suspect location both in seam and non-seam areas shall be repaired and non-destructively tested. Do not proceed with work which will cover locations which have been repaired until passing test results are achieved.

2. Repair Procedures

a) Repair all portions of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. Provide a written recommendation for method of repair to the Engineer prior to initiating repair and obtain approval of the repair procedure from the Engineer prior to making repair. Methods which are acceptable to the Engineer and their application are as follows:

1) Capping. Cap for repair of large lengths of failed seams.
2) Patching. Patch large (over 3/8 inch diameter) holes, tears (over 2 inches long), undispersed raw material, and contamination by foreign matter.
3) Remove and Replace. Remove the unsatisfactory material and replace with new material seamed into place.

b) In addition

1) Abrade surfaces of the geomembrane which need repaired no more than one-half (1/2) hour prior to the repair.
2) Clean and dry all surfaces at the time of repair.

3) Extend patches or caps at least six (6) inches beyond the edge of the defect and all corners of patches shall be rounded with a radius of at least three (3) inches.
4) Cut the geomembrane below large caps to avoid water or gas collection between the sheets.

c) Nondestructively test each repair using the methods described in Section 623.06 of these Special Provisions. Repairs which pass the non-destructive test shall be considered an adequate repair. Large caps shall be of sufficient length to require destructive test sampling, at the discretion of the Engineer. Redo repairs that have failed tests and retest until a passing test results.

623.06 TESTING

A. General

1. Quality control testing, including laboratory testing, field seam testing, and destructive testing in accordance with Table 5-2 shall be performed by the Contractor and observed at the discretion by the Engineer.

2. HDPE field seams shall be non-destructively tested over their full length by pressurizing the seam for dual-hot-wedge method seams in the HDPE geomembranes, or using a vacuum test unit, air lance, or other approved method for seams in RPE geomembranes or in HDPE geomembranes where the dual-hot-wedge method could not be used. Non-destructive testing shall be carried out as the seaming progresses, not at the completion of all the field seaming.

B. Vacuum Testing

1. The equipment shall consist of the following:

   a) A vacuum box assembly.

   b) A steel vacuum tank and pump assembly equipped with a pressure control and pipe connections.

   c) A rubber pressure/vacuum hose with fittings and connections.

   d) A soapy solution and applicator.

2. The following procedures shall be followed:

   a) Energize the vacuum pump and reduce the tank pressure to approximately ten (10) inches of water.

   b) Place the box over the wetted seam area (soapy solution).

TABLE I-1. QUALITY CONTROL CRITERIA FOR FML

Parameter	Test Method	Frequency	Standard	Test Rejection Criteria
Surface Conditions	Visual Inspection	100%	No holes, ridges, voids, rocks, roots, ruts or other non-conformities	Reject and replace all surfaces with any of the items at left
Anchor Trenches	Visual/Tape Measure	100%	See dimensions on project plans	Reject and repair all non-conforming trenches
FML Placement	Visual	100%		Reject and replace non-conforming panels
Seaming	Visual	100%		
Seam Tensile Strength (HDPE only)	ASTM D-638, type M-1	1 per 500 feet of seam	Base material properties – see Table 5-1	Reject and replace non-conforming seams
Seam Shear & Peel (HDPE only)	ASTM D-4437	1 per 500 feet of seam	Shear strength: 120 lb/in – 60 mil 80 lb/in – 40 mil Peel strength: 91 lb/in(2) – 60 mil 78 lb/in(3) – 60 mil 60 lb/in(2) – 40 mil 52 lb/in(3) – 40 mil	Reject and replace non-conforming seams
Trial Seam	ASTM D-3083	1) Beginning of each shift of seaming and every four hours thereafter 2) At any change in seam operator, equipment or weather	Break must be a ductile film tear with at least 80% of minimum sheet strength	Repeat trial seaming until standard is met
Air lance Vacuum Box or Internal Pressure(3)	ASTM D-4437 ASTM D-4437 or As described in specifications	100%	Ripples or bubbles Bubbles emerging from seams Loss of pressure ≤4 psi in 7 minutes	Identify, repair and replace leaking seams

Notes:
(1) Hot wedge seams only
(2) Extrusion fillet weld only
(3) HDPE

c) Ensure that a leak-tight seal is created.

d) For a period of not less than fifteen (15) seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

e) All areas where soap bubbles appear shall be marked and repaired in accordance with repair procedures described in Section 623.05E.

f) Conduct vacuum testing per ASTM 4437.

C. Air Lance Testing

1. Equipment shall consist of an air lance that can provide a minimum air pressure of 30 psi and a maximum air pressure of 40 psi.

2. The following procedures shall be followed:

a) The air nozzle shall be held at a 45 degree angle to the field seam approximately 2" off the edge of the material.

b) The air shall be directed toward the seam edge, upper edge and surface to detect loose edges.

c) Riffles indicating unbonded areas within the seam or other undesirable seam conditions shall be patched in accordance with repair procedures described in Section 623.05 (E). The patch should then be tested using the same air lance test method.

d) Conduct air lance testing per ASTM 4437.

D. Destructive Testing of Seams in HDPE FMLs

1. The Engineer will direct the Contractor to perform destructive seam tests at selected locations. The purpose of these tests is to evaluate seam strength. Perform seam strength testing as the seaming work progresses, not at the completion of all field seaming.

2. Location and Frequency

a) Collect destructive test samples shall be collected at a minimum frequency of one (1) test location per five hundred (500) feet of seam length, unless otherwise directed by the Engineer.

b) Samples, in addition to the minimum frequency, shall be taken as required by the Engineer.

c) Test location shall be determined during seaming and may be prompted by suspicion of insufficient adhesive, contamination, offsets, or any other potential cause of imperfect seaming. The Engineer will select the locations. The Engineer will not notify the Installer in advance of selecting locations where seam samples will be taken.

d) The Engineer reserves the right to increase the frequency in accordance with the actual performance results of samples taken.

3. Sampling Procedure

a) Samples shall be cut at locations designated by the Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing.

b) All holes in the geomembrane resulting from destructive sampling shall be immediately repaired in accordance with repair procedures specified in Section 623.05 (E).

4. Size of Samples. The samples shall be eleven (11) inches wide by twenty-four (24) inches long with the seam centered lengthwise. Two (2) 1-inch wide strips shall be cut from each end of the sample and these shall be tested (shear and peel) in the field by the installer. The remaining sample shall be cut into two (2) parts and distributed as follows:

a) One (1) portion for the Contractor, eleven (11) inches by eleven (11) inches.

b) One (1) portion to the Engineer or archive storage, eleven (11) inches by eleven (11) inches

5. Field Testing. The two (2), one (1) inch wide strips described in Section 623.06 (D)(4) shall be tested in the field by the installer and witnessed by the Engineer, by tensiometer, for peel and shear, respectively. Test strips shall meet the peel and shear values specified for trial seams in Section 623.05 (D)(2). If any field test sample fails to pass, then the procedures outlined in that Section shall be applied.

6. Procedures for Destructive Test Failure. The following procedures shall apply whenever a sample fails the destructive test, whether performed by field or laboratory testing:

a) The seam shall be reconstructed between any two (2) passed test locations, or

b) The seaming path can be traced to an intermediate location (at least ten (10) feet minimum from the location of the failed test in each direction) and a small sample taken for an additional field test at each location. If these additional samples pass

the field tests, then full laboratory samples shall be taken. If these laboratory samples pass, then the seam shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam should be reconstructed.

7. Acceptance of Seams - All acceptable seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. In cases exceeding one hundred and fifty (150) feet of reconstructed seam, a sample taken from within the reconstruction zone must pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were seamed by the same personnel and/or apparatus or seamed during the same time shift.

E. Geomembrane Wrinkle. When seaming of a geomembrane liner is completed, or when seaming of a large area of a geomembrane liner is completed, and prior to placing overlying materials, the Engineer shall identify the location of excessive geomembrane wrinkles. Wrinkles so identified shall be cut, re-seamed and tested.

F. Seams That Cannot Be Non-Destructively Tested. The following procedures shall apply to locations where seams cannot be non-destructively tested:

1. All such seams shall be cap-stripped with the same geomembrane.

2. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.

G. Engineering Observation. If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the Engineer and Contractor for uniformity and completeness.

H. Geomembrane Acceptance. The Contractor shall retain ownership and responsibility for the geomembrane until acceptance by the Owner. The geomembrane shall be accepted by the Owner when:

1. Conformance test results meet the requirements of the Contract Documents.

2. Required documentation including warranty from the manufacturer, fabricator and installer has been received and accepted.

3. The installation is complete and accepted by the Engineer.

4. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.

5. Written certification documents, including as-built drawings, have been received by the Engineer.

623.07 ANCHORAGE

Anchor CAMU liners using edge trenches as shown on the drawings. Anchor RPE for cleaning and demolition caps using treated 2 x 4 lumber or metal straps as shown on the drawings.

SECTION 624 - GEOCOMPOSITE

Add the following new section:

624.01 DESCRIPTION

The work covered by these Specifications consists of furnishing and installing high density polyethylene (HDPE) geonet heat bonded and sandwiched between two layers of 8 oz/yd^2 non-woven geotextile where shown on the Drawings or directed by the Engineer.

624.02 MATERIALS

A. Drainage Net

The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide for planar flow. The drainage net shall be manufactured of polyethylene resin produced in the United States and compounded and manufactured specifically for the intended application. The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.945 - 0.955
Melt Index, g/10 min.	ASTM D 1238 Condition E	< 1.0

Labels on each roll shall identify the thickness of the material, the width and length of the roll, lot and roll numbers, and name of the manufacturer. The drainage net rolls shall meet the requirements in this specification.

B. Geotextile

The geotextile shall be a non-woven, needle punched polyester or polypropylene fabric manufactured in the United States for the specific application. The geotextile rolls shall be 15 feet wide and shall meet the requirements in this specification.

C. Geocomposite

The geocomposite shall consist of the HDPE drainage net heat bonded and sandwiched between two layers of geotextile to create a double-sided geocomposite. The geocomposite shall be 13.5 feet wide. The geotextiles shall extend a minimum of 6 inches beyond the edges of drainage net on both sides of the geocomposite roll. The geotextile shall not be bonded to the drainage net within 6 inches from the edges of the rolls.

Materials shall have the minimum physical property characteristics, as outlined in Table 5 and Table 6. Certified test results showing that the sheeting meets or exceeds the Specification shall be submitted per Section 624.03 (E).

TABLE 5. GEONET SPECIFICATIONS

PROPERTY	TEST METHOD	MINIMUM REQUIREMENT
Thickness (mils nominal)	ASTM D-751	250.0
Compressive Strength (pounds/inch^2)	ASTM D 1621	100.0
Transmissivity @ 4000 psf (gal./min./ft.)	ASTM D 4716	0.5

TABLE 6. GEOTEXTILE SPECIFICATIONS

PROPERTY	TEST METHOD	MINIMUM REQUIREMENT
Unit Weight (oz/yd^2)	ASTM D-5261	8
Grab Strength (pounds)	ASTM D 4632	200
Permittivity (sec^{-1})	ASTM D 4491	1.3
UV Stability, % ret. (500 hr)	ASTM D 4355	70

624.03 INSTALLATION

A. Surface Preparation

1. Prior to deployment of the geocomposite, the Contractor shall inspect the underlying geomembrane surface to ascertain its suitability for installation in compliance with the terms of the product warranty and the requirements of this Specification.

2. Round edges of anchor trenches as recommended by the geocomposite manufacturer or cushion with geotextiles and backfill.

B. Geocomposite Installation

1. Only install enough panels that can be secured during that same day.

2. Do not damage geocomposite by handling, traffic, or leakage of hydrocarbons or any other means. Do not wear damaging shoes or engage in activities that could damage the geomembrane. Open or unroll geocomposite panels using methods that will not damage, stretch or crimp the geocomposite. Use methods that minimize wrinkles between adjacent panels. Place ballast on geocomposite to prevent uplift from wind. Use ballast that will not damage geocomposite. Repair damage to underlying materials prior to completing deployment of geocomposite. Do not allow vehicle traffic directly on geocomposite. Remove folded material. Visually inspect geocomposite for imperfections. Mark faulty or suspect areas for repair. Any portion

of the geocomposite damaged during installation shall be removed or repaired by using an additional piece of the same geocomposite as specified herein. The geocomposite shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching the geocomposite to fit is not permissible. Backfill anchor trenches.

C. Securing Geocomposite

1. Seam Layout shall meet the following requirements:

   a) Orient seams parallel to line of maximum slope, i.e., orient down, not across, slope.

2. The seaming procedure used shall be as follows:

   a) Field connections will be made to secure factory fabricated panels or rolls of geocomposite together in the field. Connections shall be formed by lapping the edges of panels a minimum of 2 inches. Any wrinkles shall be smoothed out.

   b) Secure overlapped edges of the geonet by plastic ties approximately every five (5) feet along the panel length. Use plastic ties that are white or a bright color for easy inspection. Do not use metallic ties.

   c) Extend connections to the outside edge of panels to be placed under the anchor berm and in the anchor trench.

   d) If securing operations are carried out at night, provide adequate illumination.

D. Defects and Repairs

1. Inspection

   a) During installation and securing, examine all areas of the geocomposite for defects, tears, undispersed raw materials and all sign of contamination by foreign matter. The surface of the geocomposite shall be clean at the time of the examination. Mark all areas suspected of deficiencies.

   b) Repair each suspect location.

2. Repair Procedures

   a) Repair all portions of the geocomposite exhibiting a flaw by removing the unsatisfactory material and replacing with new material that is overlapped and secured in place.

E. Geocomposite Acceptance. The Contractor shall retain ownership and responsibility for the geocomposite until acceptance by the Owner. The geocomposite shall be accepted by the Owner when:

1. Conformance test results meet the requirements of Table 6-1.

2. Required documentation including warranty from the manufacturer, fabricator and installer has been received and accepted.

3. The installation is complete and accepted by the Engineer.

4. Written certification documents, including as-built drawings, have been received by the Engineer.

5. Submittals shall be the same as those required for geomembrane in Section 623.

TABLE 6-1. CONFIRMATION SAMPLING FOR GEOCOMPOSITES

PARAMETER	TEST	MINIMUM TEST FREQUENCY	REJECTION CRITERIA
Crush Strength	ASTM D-1621	1 per lot(1)	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.
Thickness	ASTM D-5199	1 per lot(1)	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.
Transmissivity	ASTM D-4716 Width @ 14.5 psi Normal pressure & 0.1 ft/ft hydraulic	1 per lot(1)	Reject any lot sampling unit or lots that do not meet ASTM-D-4759, Section 5.

Notes:

(1) A lot is the smaller of 100,000 square feet or one production run.

SECTION 625 - GEOSYNTHETIC CLAY LINER (GCL)
Add the following new section:

625.01 DESCRIPTION

A. The work covered by these Specifications consists of furnishing and installing geosynthetic clay liner (GCL where shown on the Drawings or directed by the Engineer.

B. **Definitions Used In This Section**

Geosynthetic Clay Liner (GCL). A manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics. The GCL will be reinforced.

Minimum Average Roll Value. The minimum average value of a particular physical property of a material, for 95 percent of all of the material in the lot.

Overlap. Where two adjacent GCL panels contact, the distance measuring perpendicular from the overlying edge of one panel to the underlying edge of the other.

625.02 QUALITY ASSURANCE

1. Manufacture's Qualifications:
   The GCL manufacturer must have produced at least 10 million $ft^2$of GCL, with at least 8 million square feet installed.

2. Installer's Qualifications:
   The GCL installer must either have installed at least 1 million ft^2 of GCL, or must provide to the Engineer satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.

3. Product Quality Documentation:
   The GCL manufacturer shall provide the Engineer with manufacturing QA/QC certification for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:
   a) Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss.
   b) Manufacturer's test data for finished GCL product(s) of bentonite mass/area, GCL tensile strength and GCL peel strength (if applicable) demonstrating compliance with the index parameters.
   c) GCL lot and roll numbers supplied for the project (with corresponding shipping information).
   d) Manufacturer's test data for finished GCL product(s) of GCL index flux, permeability and hydrated internal shear strength data demonstrating compliance with the performance parameters.

4. Delivery, Storage and Handling
   a) Deliver GCL to the site only after the Engineer receives and approves the required submittals. Damaged or unacceptable material shall be immediately removed from the site and replace at no cost to the owner.
   b) Prior to shipment, the GCL manufacturer shall label each roll, identifying:
      (1) Product identification information (Manufacturer's name and address, brand name, product code).
      (2) Lot number and roll number.
      (3) Roll length and weight.
   c) The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.
   d) All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) rays.
   e) The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the GCL are the responsibility of the Contractor, Installer or other designated party.
   f) A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.
   g) The party responsible for unloading the GCL should contact the manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.
   h) Storage of the GCL rolls shall be the responsibility of the installer. Ad dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well-drained.
   i) Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).
   j) All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.
   k) The integrity and legibility of the labels shall be preserved during storage.

5. Warranty

   a) The installer of the GCL to be used in the work shall warrant his workmanship to be free of defects for two (2) years after final acceptance of the work. This warranty shall include, but not be limited to, all seams, anchor trenches, GCL attachments to appurtenances, and penetration seals. The GCL installer shall also obtain and furnish the Owner a warranty from the GCL manufacturer for the materials used. The material warranty shall be for defects or failure due to weathering for 10 years, with

temperatures ranging from (-) minus 30 degrees Fahrenheit to (+) plus 110 degrees Fahrenheit, after the completion of the work on a prorata basis.

b) Should a defect or failure occur within the aforesaid periods, the GCL installer shall bear all costs for repair and/or replacement of the GCL and shall in addition bear all costs for the excavation of any cover backfill that is required to be removed in order to repair and/or replace the GCL. All materials removed to allow repairs to be made shall be reinstalled by the GCL installer in accordance with these special provisions.

625.03 SUBMITTALS

Two copies of the following documents shall be submitted by the Contractor at least three weeks prior to the shipment of the GCL to the site.

1. Conceptual description of the proposed plan for placement of the GCL panels over the area of installation.
2. GCL manufacturer's MQC Plan for documenting compliance of these specifications.
3. A representative sample of the GCLs.
4. A project reference list for the GCL(s) consisting of the principal details for at least ten projects totaling at least 10 million square feet in size.
5. Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with Table 7-1.

625.04 MATERIALS

1. The GCL shall be a needle punched reinforced GCL comprised of a uniform layer of granular sodium bentonite encapsulated between a scrim reinforced non-woven and a virgin staple fiber non-woven geotextile and shall comply with all of the criteria listed in this specification. The needle punched fibers should be thermally fused to the scrim reinforced non-woven geotextile to enhance the reinforcing bond.
2. Reinforced GCL shall be used on this project.
3. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet in length and 13.8 feet in width. Short rolls (those manufactured to a length greater than 70 feet but less than a full-length roll) may be supplied at a rate no greater than 3 per truckload or 3 rolls every 36,000 square of GCL, whichever is less.
4. A 12 -inch overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.
5. The granular bentonite or bentonite sealing compound used for seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer.

TABLE 7-1. ACCEPTANCE TESTING FOR GCL

Parameter	Test Method	Frequency	Test Standard	Rejection Criteria
Mass per Unit Area	ASTM D-5993	1 per lot(1)	0.75 lb/ft^2 MIN	Materials must pass all acceptance testing before delivery to site
Hydraulic Conductivity	ASTM D-5887		5×10^{-9}cm/sec MAX	
Shear Strength	ASTM D-5321		500 psf MIN	
Peel Strength	ASTM D-4632		15 lbs MIN	

Notes:

(1) All material used on the project must be from the sampled lot.

625.05 GCL INSTALLATION

The Contractor shall install the geosynthetic clay liner (GCL) in accordance with the plans and with these special provisions. In the event of conflict, the more stringent procedure shall apply unless approved otherwise by the Engineer and EPA.

625.05.1 Subgrade Preparation

The subgrade to receive GCLs shall be prepared and compacted in accordance with the project specifications and plans, and shall be smooth, firm, and free of: vegetation, construction debris, sticks, sharp rocks, ice, abrupt changes in elevation, standing water, cracks larger than one-quarter inch in width, and any other foreign matter that could contact the GCL.

625.05.2 Placement

1. Needle punched GCL shall be placed on top of the Compacted Clay Liner and on the site wide cap as shown on the plans.

2. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) should be in accordance with the Engineer's or manufacturer's recommendations. Unless otherwise specified, however, the GCL shall be installed such that the product name printed on one side of the GCL faces up.

3. Subgrade slope transitions will be uniformly curved and smooth prior to placement of the GCL. Care shall be taken when placing GCL that the subgrade is free of sharp changes in slope and uneven or variable radius curved transitions which may lead to unacceptable wrinkles or poor contact with the subgrade.

4. Equipment which could damage the GCL shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

5. Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a skip sheet or rub sheet may be used to reduce friction damage during placement.

6. The GCL shall be placed so that seams are parallel to the direction of the maximum slope. Seams should be located at least 3 feet from the toe and crest of slopes steeper than 4H:1V.

7. All GCL panels should lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.

8. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it will be removed and replaced. The Engineers, CQA inspector, and GCL supplier should be consulted for specific guidance if premature hydration occurs.

625.05.3 Anchorage

As directed by the Plans, the end of the GCL roll shall be placed in an anchor trench at the top of the slope. The front edge of the trench should be rounded so as to eliminate any sharp corners. Loose soil should be removed from the floor of the trench. The GCL should cover the entire trench floor and the rear trench wall.

625.05.4 Seaming

1. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Supplemental bentonite is required if the GCL has one or more non-woven needle-punched geotextiles.

2. The minimum dimension of the longitudinal overlap should be 12 inches. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches.

3. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

4. Bentonite-enhanced seams are constructed between the overlapping adjacent panels and described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6-inch line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot.

625.05.5 Detail Work

1. The GCL shall be sealed around penetrations and embedded structures embedded in accordance with the design drawings and the GCL manufacturer.

2. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process.

625.05.6 Damage Repair

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches is achieved around all of the damaged area. Dry bentonite or bentonite mastic shall be applied around the damaged area at a rate of one-half pound per square foot prior to placement of the patch. The Contractor may wish to use an adhesive to affix the patch in place so that it is not displaced during cover placement.

625.05.7 Cover Placement

1. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of geosynthetic material placed over the GCL. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation.

2. When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.

3. Cyclical wetting and drying of GCL covered only with geomembrane can cause overlap separation. Soil cover should be placed promptly whenever possible. Geomembranes should be covered with a white geotextile and/or operations layer without delay to minimize the intensity of wet-dry cycling. If there is the potential for unconfined cyclic wetting and drying over an extended period of time, the longitudinal seam overlaps should be increased based on the project engineer's recommendations.

4. To avoid seam separation, the GCL should not be put in excessive tension by the weight or expansion of textured geomembrane on steep slopes. The project Engineer should be consulted about the potential for GCL tension to develop.

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626.00 INSTALLATION SPECIFICATION —RPE® GEOMEMBRANE

Add the following new section:

626.01 SCOPE

A. The work covered by this specification consists of the supply (and installation) of an RPE geomembrane at the locations shown on the drawings (as directed by the Engineer).

B. The supply (and installation) of this liner shall be in accordance with the following references:

1. ASTM D751-89, Standard Test Methods for Coated Fabrics.

2. ASTM D3020-89, Standard Specification for Polyethylene and Ethylene Copolymer Plastic Sheeting for Pond, Canal, an Reservoir Lining.

3. ASTM D4545-86(91), Standard Practice for Determining the Integrity of Factory Seams Used in Joining Manufactured Flexible Sheet Geomembranes.

626.02 MATERIAL CHARACTERISTICS

A. The sheeting shall be suitably formulated from first quality polyethylene materials. The geomembrane shall consist of a high strength, oriented-tape HDPE scrim coated on both sides with an impervious HDPE coating for OR RPE 25. RPE materials prepared for temporary covers or other exposed application will have UV stabilizers added to the impervious coating and UV stabilizers added to the scrim tapes. The RPE material shall be pigmented to produce a uniform color such as black, blue, or silver.

B. The sheeting shall be capable of being sealed to itself using a stitched "Z" fold or heat-sealing technique.

C. The sheeting shall be supplied in the widest widths possible to minimize fabrication seaming. Roll widths shall be not less than 3.5 m.

626.02.01 <u>Manufacturer's Statement</u>

Upon request, the manufacturer of the RPE sheeting shall submit a certification that the material meets the manufacturer's specifications. Material index quality control tests shall be performed a minimum of every 18,000 kg (40,000 lbs), once per shift, or at the start of a new material run.

626.02.02 <u>Material Properties</u>

The geomembrane shall be OR RPE 25 as supplied by Layfield Plastics or an approved equal. The geomembrane shall conform to the manufacturer's material properties table. All values are Typical Values unless otherwise noted.

626.02.03 <u>Warranty</u>

A. Contractor shall provide Owner with a warranty guaranteeing a minimum of three year satisfactory liner performance from defects and UV-degradation.

626.03 FABRICATION

A. On all projects larger than 20,000 m^2 (200,000 ft^2), submit a panel layout in accordance with the project submittal requirements. On the panel layout, indicate the proposed arrangement of panels, fabricated seam orientation, field seam location, and anchor trench locations.

B. Individual roll widths of RPE shall be fabricated into large panels to minimize field seaming. All fabrication welds shall be a minimum of 25 mm (1 inch) wide. Heat welding techniques shall be used for shop fabrication such that all shop welds will provide a delamination of the coating from the scrim when tested. Peel testing will meet the requirements for a "Film Tear Bond" (FTB) Peel Adhesion. The minimum FTB rating shall be AD-DEL.

C. Fabrication welding shall be tested for Bonded Seam strength at a rate of three samples for every 915 lineal meters (3,000 ft) of welded seam. At the fabricator's option, one sample may be taken from each 300 lineal meters (1,000 ft) of welded seam or every 5 shop seams (whichever is greater). Seam samples will be tested for shear strength. Fabricated seam strengths shall conform to the shop seam strength values. Seams samples shall also be qualitatively tested for peel adhesion with a Film Tear Bond rating being obtained on all seams. Seams that do not meet the strength or FTB criteria are to be repaired and retested.

D. Fabricated panels shall be accordion folded in one direction and neatly rolled in the other. Each panel shall be protected with an opaque, weather resistant covering and marked with panel dimensions and unfolding directions. All panels shall be delivered and stored in a protected area until ready for installation.

626.03.01 <u>Installation</u>

A. Prepared surfaces shall be smooth and free of sharp objects, rocks, and organics (roots). A 10 ounce geotextile shall be placed under the liner in all areas.

B. Installation shall be performed in a logical sequence by an installer/contractor experienced in lining installations.

C. Place panels according to the drawings and the panel layout. Sufficient thermal slack shall be incorporated during placement to ensure that harmful stresses do not occur in service. Distribute slack wrinkles evenly.

D. All field seams shall be tightly bonded using tape seaming technology. Six inch wide polyisobutylene-butyl sealant tape shall be used at penetrations and for all field seams.

E. Full contact between the tape and the material will be the standard of acceptance.

F. All field seams shall be non-destructively tested along their entire length using the Air Lance Test (ASTM D4545) or the Mechanical Point Stress Test (ASTM D4545). Patches and seams around pipe penetrations and fitments shall be tested using the Point Stress Test (ASTM D4545). All discontinuities detected by any test method shall be repaired.

G. Repairs shall utilize the same material as the geomembrane, or a material compatible with the geomembrane, and shall extend a minimum of 300 mm (12 inches) beyond the defect. Repairs shall be accomplished with tape seaming techniques utilizing a tape appropriate to existing site conditions. All repairs are to be tested using Air Lance or Mechanical Point Stress methods as applicable (ASTM D4545).

H. Protect the geomembrane from wind uplift during installation through the use of sand bags or other suitable weights. Backfill anchor trenches and place design backfill on geomembrane as soon as practical. Placement of backfill should be monitored continuously, and any damaged areas repaired and tested.

I. Shingle RPE seams in the direction of water flow as applicable. If possible, backfill in the direction of flow to prevent application of stresses to field seams.

J. Pipe Boots. Fit and seal pipes, manholes, and other penetrations of the geomembrane with shop fabricated boots as shown on the Drawings. Match the flange portion of the boot to the angle of the slope or bottom where the pipe or manhole enters the liner for a smooth fit without excess stretching of the material.

627.00 SOIL AMENDMENTS, SEEDBED PREPARATION, AND SEED MIX

Add the following new section.

627.01.1 <u>Soil Amendments, Seedbed Preparation, And Seed Mix</u>

A. <u>Topsoiling</u>. Topsoil shall cover all embankment, backfill, site grading and exposed cut slope areas in accordance with Standard Specification 610. Application rates shall be a minimum of 4 inches at all sites unless otherwise designated in the specifications or on the Drawings.

B. <u>Seedbed Preparation</u>. After the project site has been graded to final plan specifications the site to be seeded shall be cultivated to provide a uniform seedbed surface. The seedbed shall be cultivated sufficiently to reduce the soil to a state of good tilth when the soil particles on the surface are small enough to lie closely enough together to prevent the seed from being covered too deeply for optimum germination. Prior to executing the seeding, fertilizing, and mulching work items, the seedbed at all sites shall be prepared and conditioned so these items can most efficiently be completed in conformance with Standard

Specification 610. The seeding, fertilizing, and mulching work items shall be executed only after the seedbed has been accepted by the Engineer.

C. Seeding and Fertilizing. All areas at the sites disturbed in the execution of the work shall be seeded and fertilized. These areas include that acreage disturbed under the designated work items.

Other areas which are disturbed by the Contractor's operation, will also require seeding and fertilizing. Any such disturbed areas will be considered as site damage and will not be measured or considered for payment. The cost of this work shall be absorbed solely by the Contractor.

All disturbed areas shall be seeded with the designated Grass Mix. Two mixes are provided. One mix is for use on land designated for return to agricultural use and the other applies to all other disturbed areas.

The Contractor shall accomplish this work in accordance with the Fertilizing and Seeding Subsection and the Mulching Subsection of Standard Specification 610, and also in accordance with the provisions contained herein.

1. Fertilizer. Fertilizer shall be applied at the rates specified below. Exceptions will be made for seed drills that are capable of incorporating the fertilizer and seed directly into the seedbed uniformly at the specified rates. Fertilizer shall be applied to the prepared seedbed prior to seeding or mulching and shall be blended with the topsoil as called for in Standard Specification 610, or concurrently with the seed (as “no till” drills allow).

   Fertilizer shall be applied to the prepared seedbed prior to seeding. The fertilizer shall be incorporated into the soil by discing, raking, or shallow plowing to the full depth of the topsoil or to a maximum depth of 6 inches, whichever is less. Fertilizer shall be incorporated with equipment operated at right angles to the slope of the land.

   All areas, except areas that will be returned to agricultural production within one year of project completion, shall be fertilized with a balanced inorganic chemical fertilizer with the following nutrients:

   Composition 26-10-5 150 lbs/acre

   All required fertilizer certificates shall be provided to the Engineer a minimum of three days prior to fertilizing. The certification shall include the guaranteed analysis of the fertilizer(s) stated in terms of the percentages of nitrogen (N), available phosphorus (P205) and potash (K20) in that order. The fertilizer specification may be changed by the Owner to a fertilizer mix based on specific site soil samples at no cost to the Owner.

2. Seed Certification. Seed certifications as required by Standard Specification 610 shall be submitted to the Engineer prior to any seeding. The Contractor shall also submit a copy of the bill or other documentation from the seed supplier showing actual bulk weights of the individual seed types combined in the mix. The required certifications and documentation shall be provided to the Engineer at least three days prior to seeding.

3. Seeding. The following application rates for seed are based on the drill seeding method. The seed mixture shall be uniformly distributed over the areas shown on project plans. All planting shall be done between October 15 and May 20 of a given year, except as specified in writing by the Owner. Seed shall be drilled at a depth of 1/2 inch utilizing a pasture or rangeland type drill (including custom seeders, furrow drills, disc drills or no-till drills) with a roller/cultipacker integral to the seed drill equipment. Broadcast seeding method will not be utilized on this project. Hydraulic seeding will be allowed only on areas too steep for drill seeding. Where the hydraulic seeding method is used, the application rates listed below must be doubled at no additional cost to the Owner.

4. Tracking. Tracking will be required only on areas where mulch tilling cannot be accomplished.

DISTURBED AREAS DESIGNATED FOR RETURN TO AGRICULTURAL PRODUCTION

Common Name	Scientific Name	Variety	Seed Application Rate (PLS lbs/acre)[1]
Regreen	Triticum x Elytrigia	---	30
Total seeded species (PLS lbs/acre)[1]			30

[1] PLS (Pure Live Seed) seeding rate is based on drill seed application.
PLS seeding rate will be doubled for broadcast or hydroseeded applications.

DISTURBED AREAS NOT DESIGNATED FOR RETURN TO AGRICULTURAL PRODUCTION

Common Name	Scientific Name	Variety	Seed Application Rate (PLS lbs/acre)[1]
Streambank wheatgrass	Agropyron riparium	Sodar	2
Pubescent wheatgrass	Agropyron dasystachyum	Critana	2
Western wheatgrass	Agropyron smithii	Rosana	3
Bluebunch wheatgrass	Agropyron spicatum	Secar	3
Crested wheatgrass	Agropyron cristatum	Ephraim	2
Sideoats grama	Bouteloua curtipendula	Pierre	3
Regreen	Triticum x Elytrigia	---	10
Cicer milkvetch	Astragalus cicer	---	5
Total seeded species (PLS lbs/acre)[1]			30

[1] PLS (Pure Live Seed) seeding rate is based on drill seed application.
PLS seeding rate will be doubled for broadcast or hydroseeded applications.

D. Tackifier. Tackifier shall be applied with all hydromulched areas at the manufacturer's recommended rate of forty (40) pounds per acre for slopes flatter than 2:1 and eighty (80) pounds per acre for slopes 2:1 or steeper.

1. Summer Erosion Control Procedure. In the event the construction is completed after April 30 but before October 15, the disturbed areas shall then be either mulched immediately with a vegetative mulch of straw or hay, applied at a rate of 4,000 pounds per acre or a soil stabilizer applied at the manufacturer's recommendation with a hydroseeder. The mulch shall be anchored into the seedbed as specified in Standard Specification 610.

   A “no-till” drill with “no-till” coulters may be used to seed and fertilize directly into the mulched areas requiring permanent seeding after the October 15 date. After October 15, fertilizer shall be applied to the work areas at the application rate noted and incorporated into the soil as specified in Standard Specification 610. Seed shall then be applied by drilling methods only.

END OF DOCUMENT

DIVISION 700 - MATERIALS

SECTION 708 – CONCRETE, PLASTIC, AND FIBER PIPE

(Add the following new subsection.)

708.08 POLYETHYLENE SMOOTH WALL PIPE

Furnish smooth wall polyethylene pipe meeting ASTM F714, DR 21 for pipes 75 to 600 mm (3 to 24 inches), and SDR 26 for pipes 650 to 1200 mm (26 to 48 inches). Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

SECTION 716 - FLOWABLE FILL

(Add the following subsection.)

716.01 GENERAL

This section covers furnishing and placing of flowable fill. Flowable fill shall be placed in utilities as specified on drawings.

716.02 MATERIALS

Control Density Fill - (CDF) is used as a low strength, self consolidating fill material for confined spaces which can be easily excavatable at a later time. CDF is characterized by a high maximum slump of 8 inches. CDF is not a structural concrete and should not be used in such applications. CDF may be used as a trench backfill, structural backfill, pipe bedding, or pipe filling for abandonment in place. CDF shall consist of Portland cement, aggregates, water and fly ash. Chemical admixtures and other mineral admixtures may be used. The actual mix proportions and flow characteristics shall be determined by the producer of the CDF to meet site conditions. Mix designs and performance tests shall be submitted to the Engineer for approval.

Portland Cement

Portland cement shall conform to the requirements of ASTM C150, Type I or Type II.

Aggregates

The aggregates shall conform to the requirements of ASTM C33. The amount of material passing the #200 sieve shall not exceed 15 percent. Also, liquid limit and plasticity index shall not exceed 25 and 5, respectively.

Chemical Admixtures

Chemical admixtures shall conform to the requirements of ASTM C494.

Water

Water shall be free of oils, acids, alkalies, organic matter or other deleterious substances.

Fly Ash

Fly ash shall conform to the requirements of ASTM C618, Class C or F.

The contractor will perform occasional quality assurance tests on the flowable fill consisting of casting three cylinders for comprehensive strength testing. The required minimum compressive strength value at 28 day age is 200 psi. Compressive strength test specimens are to be cast according to ASTM C31, and tested according to ASTM C39.

The Contractor will provide the Contracting officer with a mix design from a testing laboratory generally conforming to the requirements of ASTM E329 within 15 days after Notice to Proceed. Mix design strengths at 7 and 14 days shall also be reported within 3 days after the test is taken.

716.03 EXECUTION

General Requirements

Plug and abandonment of the site underground utilities will occur as site cleaning and demolition activities are completed but before grading and capping activities begin.

Comply with ASTM C94 for Measuring, Mixing, Transporting, and Placing the Flowable Fill, and as herein specified.

Mix and place Flowable Fill only when the air temperature is at least 35 degrees F and rising. At the time of placement, Flowable Fill shall be at least 40 degrees F. Stop mixing and placement when the air temperature is 40 degrees and falling.

Flowable Fill shall be placed by methods that preserve the quality of the material in terms of compressive strength, flow, homogeneity, plasticity and workability. The material shall be transported, placed, and/or consolidated so that it flows easily through all utility corridors and pipes. It shall have the flow, consistency, and workability such that the material is self-compacting.

Protect freshly placed Flowable Fill from premature drying, excessive cold, or hot temperatures. The air in contact with the backfill surface shall be maintained at temperatures above freezing.

Plug and Abandonment Prior to Backfill, Grading, and Capping

All underground utilities underlying temporary capping areas will be plugged and abandoned prior to backfill, grading, and capping activities.

Pipe Segments – Designated pipe segments, which include manholes and small vaults, shall be plugged with Flowable Fill. Plugging shall begin at the down gradient location, such as a manhole or small vault, and proceed upgradient to ensure effective filling of the conduit.

END OF DOCUMENT

APPENDIX K

WASTE MATERIAL CATEGORIES AND QUANTITIES

ENTACT.
environmental services

3129 Bass Pro Drive
Grapevine, Texas
76051

August 8, 2006

Mr. Blaine Cox
Mr. Jon Nickel
ASARCO LLC
100 Smelter Road
P.O. Box 1230
East Helena, MT 59635

RE: ENTACT's Planning Estimates: 2007/2008 Waste Streams and Cost Estimate
ASARCO East Helena Plant, East Helena, MT

Dear Sirs,

Following on-site data collection efforts that occurred during the week of July 10, 2006, ENTACT has thoroughly reviewed our notes, photos, and site to provide the attached information to assist ASARCO with 2007 and 2008 planning activities. The data provided herein is for planning and budgetary purposes only and does not represent a quote by ENTACT to perform the work. These costs and quantities are intentionally conservative to insure that your budget and CAMU design capacity is not exceeded once construction activities begin.

We appreciate the opportunity to generate this information and look forward to the next opportunity to compete for work in East Helena.

Respectfully submitted,

Jeff McCord
ENTACT

Enclosure

ENTACT Planning Estimates
ASARCO East Helena Facility
2007/2008 Scope Items

2007

	Disposal Materials (cubic yards)	Deco/Demo/Cap $
Area 1-Bag house Area exc. Stack	4120	[redacted]
Area 2-Acid Area exc. Stacks	2100	[redacted]
Area 3-Monier Flue	1650	[redacted]
Area 4-Blast Furnace Flue	6250	[redacted]
Area 5-Carpenter Shops and PH/BFHE	130	[redacted]
Area 6-Blast Furnace Bldg.	140	[redacted]
Area 7-BF Sup. And Loc. Crane Shed	160	[redacted]
Area 8-Paint Shop Motor Storage	250	[redacted]
Area 9-Garage and Rail	125	[redacted]
Area 10- 2 Brkg. Floor/Sinter Bldg./charge Rails	1370	[redacted]
Area 11-Baghouse	130	[redacted]
Area 12-Sample Mill and Related Bldgs.	2100	[redacted]
Area 13-Ore Yard and Thawhouse	980	[redacted]
Total	19,505	[redacted]

2008

	Disposal Materials (cubic yards)	Deco/Demo/Cap $
Area 1-Stacks (Oak Park Chimney)	20662	[redacted]
Area 2-Truck Loading/Spray Dryer/Silos	250	[redacted]
Area 3-Direct Smelt	400	[redacted]
Area 4-Machine and Blacksmith Shop	180	[redacted]
Area 5-Lunch room/Storage/Pump/Scale	85	[redacted]
Area 6-Slag Handling Pad/Storage/Oxy.	635	[redacted]
Area 7-High Lead/Refractory/Sanitary/MR	443	[redacted]
Area 8-Main Office/LMPT/Cont CH&LR	1090	[redacted]
Area 9-Storage/Annex/Rail	540	[redacted]
Total	24,285	[redacted]

2009

	Disposal Materials (cubic yards)	Deco/Demo/Cap $
Area 1 - New Ore Storage	12000	$ -
Total	12,000	$ -

Notes & Assumptions:

Disposal Material volumes account for swell of concrete, cinder block, brick, and other materials for management purposes. In-place volumes for the CAMU will vary depending on sizing and placement requirements. Does not represent a firm quote. For budgetary and planning purposes only.

APPENDIX L

THIRD PARTY INDEPENDENT OVERSIGHT

April 30, 2007

Jon Nickel
Asarco LLC
P.O. Box 1230
East Helena, MT 59635

RE: QUALITY ASSURANCE FOR CONSTRUCTION AT THE PHASE 2 CAMU CELL AT THE EAST HELENA SMELTER

Dear Mr. Nickel:

I am pleased to submit this proposal to provide quality assurance at the Phase 2 CAMU cell at East Helena. We will provide construction observation, testing oversight, engineering review, and reporting for the proposed construction.

Project Description

According to plans provided by Hydrometrics, the cell will be approximately 455 x 455 feet and 11 feet deep, about 6 feet of which will be below existing grade. The primary components of the cell are: the bottom liner system; the cover system, the leachate collection and removal system; the leak detection, collection, and removal system; the surface runon control system; and the surface runoff control system.

Anticipated Conditions

Previous borings within 200 to 1,000 feet of the site indicate the site may be underlain by 12 to 20 feet of inorganic silt and clay, 7 to 15 feet of gravel and cobble with variable matrix, and then fine grained sediments derived from volcanics from 35 to maximum exploration depth at about 50 feet.

Scope of Services

The following items of service are proposed:

Specific Performance Standards for the CAMU are addressed in the Design Analysis Report (Hydrometrics, January 2007). One of the Performance Standards for the CAMU required establishment of a Construction Quality Assurance (CQA) program to ensure that the constructed cover meets or exceeds all design criteria and specifications in accordance with 40

CFR 264.19 and 40 CFR 264.303. The Construction Quality Assurance Program (CQAP) along with the Construction Quality Assurance Project Plan (CQAPP) and the performance standards set forth in the Design Analysis Report constitutes the CQAP.

The overall requirements for inspection and quality assurance of the CAMU components, as defined in this CQAP and the Design Analysis Report, are the responsibility of the Supervising Contractor (Hydrometrics, Inc.) with oversight and approval by the Independent Quality Assurance Team (IQAT). The IQAT team will consist of Womack & Associates, Inc. personnel.

Specific Quality Control Assurance activities will include (as outlined in the CQAPP):

- Review and approval of all Work Plans, design documents, and construction plans and specifications
- Road materials testing
- Waste materials testing
- Clay liner materials testing
- HDPE liner materials and seam testing
- Inspection of Geonet installation and seaming
- Report preparation and tabulation of test data

Experience and Personnel

WAI has performed many similar projects involving isolation of metallic and other industrial wastes. Projects have involved design services, construction observation, and final reports for other smelters, metal and coal mines, and landfills. Specific projects of this type include the following:

- Asarco Tacoma Smelter Superfund site: geotechnical investigation, construction observation, design modifications, and final reports for the on-site containment facility (OCF), which is very similar in concept to CAMU Phase 2. WAI has been involved in the Tacoma Smelter remediation from start to finish over a period of about 20 years, performing geotechnical investigation and design for many other aspects of the project, including seismicity, slope stability, liquefaction assessment, and final development design.
- Other Asarco smelters: as shown on the attached SOQ, WAI has performed geotechnical investigation and design projects for Asarco CERCLA sites in a half dozen other western states, including the East Helena project, although WAI was not involved in design or investigation of the CAMU projects.
- PPL Montana Colstrip power plant: WAI has been involved in mitigation of seepage issues at the effluent holding ponds and other facilities. These projects include

detailed investigation and analysis of dam embankment stability, liner design for holding pond cells, seepage cutoff trenches, and plant foundation elements.

- CR Kendall Mine, Lewistown, Montana: WAI has been involved in all aspects of the geotechnical investigation, design, and construction observation of leach pad liners and final reclamation covers and liners.
- Jackson Hole transfer facility, Wyoming: WAI is designing MSE walls for construction of surface facilities above the reclamation cover of the abandoned landfill. In some cases the clay cover has been or will be penetrated and remediation is required.
- Grouse Creek tailings, Idaho: WAI performed geotechnical investigation and construction observation for the lined tailings impoundment and waste rock repositories at Grouse Creek. The embankments are as much as 350 feet tall and were built on large landslides, requiring installation of shear keys as much as 175 feet deep.

WAI has performed site investigations for building foundations and ponds at East Helena. Our personnel are very familiar with local geology, seismicity, and geotechnical conditions. Ray Womack, P.E., P.G., and Dave Cameron, P.E., will be responsible for the work. Other technical specialists will be involved as needed. Resumes are attached in the SOQ.

Womack & Associates, Inc.,

Ray Womack, P.E.

Client Signature Date

WOMACK & ASSOCIATES, INC. STATEMENT OF QUALIFICATIONS

1.0 BACKGROUND AND EXPERIENCE

Ray Womack established a consulting practice in Billings, Montana, in 1982 which grew into Womack & Associates, Inc. (WAI). The firm's main office is in Jackson, Wyoming. WAI specializes in geotechnical engineering, engineering geology, and geomorphology. We work in a large geographical area, routinely performing projects throughout the western United States and abroad. Our work has consisted of a mix of commercial, residential, and industrial projects. We have provided geotechnical consulting services for many hotels, schools, roads, and high-end residences. Our industrial experience has been gained from work on large mine structures and cleanups at contaminated industrial sites, including many CERCLA (Superfund) projects. We have particular expertise in evaluation of slope stability and seismicity.

At present the staff consists of two geotechnical engineers, two geologists, and a drafter. Although we are a small firm, we have been involved in many large, complex projects, and we believe our background and experience prepare us very well to address the problems that occur at complex sites. Resumes for our professional staff are available upon request, and brief discussions of their experience follow.

Ray Womack, P.E., P.G., President and Principal Engineer, has more than 30 years experience as a geotechnical engineer and geoscientist. Mr. Womack holds degrees from Virginia Polytechnic Institute (BS-geophysics) and Colorado State University (MS-earth resources: geology). He is registered as a Professional Engineer in six states and as a Professional Geologist. He is a member of the Association of Engineering Geologists and the American Society of Civil Engineers. Mr. Womack has written many papers and presented technical courses dealing with landslides, risk assessment, and river mechanics.

Mr. Womack has conducted foundation investigations, stability analyses, and geologic hazards evaluations in 17 states, including most of the Rocky Mountain states. He has worked extensively in southern and eastern Africa, as well as Guatemala, Haiti, Kazakhstan and the Republic of Georgia. He has prepared foundation reports for hundreds of structures, including mine facilities, railroads, power plants, hotels, schools, and roads. He has been responsible for investigation of many landslides and other difficult sites. He has led or been involved in geotechnical efforts at numerous environmental projects, including Asarco CERCLA projects in Tacoma, Washington; East Helena, Montana; Murray, Utah, and elsewhere.

David Cameron, P.E., has 21 years professional experience, including 14 years as a geotechnical engineer. He is a graduate of the University of Colorado at Denver (B.S., Civil Engineering). Mr. Cameron works under contract to WAI in Bozeman. He has been responsible for slope stability issues along the proposed 119-mile Tongue River Railroad and the Central Montana Railway. He prepared cover designs for the hazwaste landfill at the Asarco Tacoma Smelter. Major mining projects have included the Cyprus Miami and Magma Pinto Valley copper projects in Arizona, the Chino and Ortiz projects in New Mexico, the Bullfrog Mine in Nevada, Grouse Creek and Black Pine mines in Idaho, Rock Creek and Zortman in Montana, and Freeport Indonesia in Irian Jaya.

Colin O'Farrell received his B.A. (2003) and M.S. (2005) in Earth Sciences from Dartmouth College. His research interests include geomorphology and hydrogeology. Mr. O'Farrell has authored several peer-reviewed publications in the field of geomorphology and presented papers at several conferences, primarily involving glacial and fluvial research in Alaska. At Womack & Associates, he has worked on projects involving slope stability and engineering geology for retaining walls, roads, waterways, and foundations.

Jason Rolfe graduated from the University of California at Santa Barbara in 2000 with a B.S. in Geological Sciences. Mr. Rolfe worked for Cotton Shires & Associates in the South Bay Area of California on projects involving landslide investigation and mitigation, neotectonics, and expansive soils. Since 2001, Mr. Rolfe has worked in Jackson on projects including soil science, slope instability, foundations, retaining walls, and environmental hazard assessments. Mr. Rolfe led the exploration effort for the new Jackson Hole aerial tram, including rock slope assessments for heavily loaded foundations adjacent to cliff faces. He is an ACI Grade I Concrete Field Technician, a member of the Geological Society of America, and Secretary of the Geologists of Jackson Hole.

Josh Gilstrap graduated from Oregon State University in 2006 with a B.S. in Civil Engineering, with an emphasis in Geotechnical Engineering. During college, he worked for Stormwater Management, Inc., and the City of Portland, on projects involving stormwater treatment and a large scale road assessment for the city's private watershed. At Womack & Associates, he has been involved in slope stability, roadway design, foundation design, environmental hazard assessment, and construction observation.

2.0 GEOTECHNICAL ENGINEERING

WAI provides site investigation and design services for earthworks, dams, roads, railways, and other structures. Many of our projects have involved landslides and other slope stability problems. Monitoring instruments, including extensometers, tiltmeters, and slope indicators have frequently been installed. In seismically active areas, we have analyzed seismicity and liquefaction potential for sensitive structures. A short list of selected projects follows:

- Tongue River Railroad geotechnical investigation and design
- Beartooth Highway Emergency Repair
- Jackson Hole Aerial Tram slope stability and foundations
- BNSF Yellowstone River slope stability mitigation
- Central Montana Railway landslide mitigation
- Asarco Ray copper electrowinning facility settlement, Arizona
- Asarco Mission tailings impoundments, Arizona
- Asarco lead battery recycling plant, North Carolina
- Hazwaste landfill, roads, landslide mitigation, seismicity, Asarco Tacoma smelter
- PPL Montana impoundments, Colstrip
- Bearpaw Reservoir, Montana DNRC
- BLM dams, near Zortman
- Stillwater Mine East Boulder access road, near Big Timber
- Western Energy settlement investigations, Colstrip
- Dinosaur National Monument landslide, Colorado
- Buffalo Jump landslide
- Cathedral Mountain landslide litigation
- Big Sky landslides
- Schools at Malta, Glasgow, Drummond, and Billings
- Jackson and Wilson Schools, Wyoming
- Teton Science School, Jackson, Wyoming
- Beaver Creek and Gros Ventre housing facilities, Grand Teton National Park
- JY and Moose Visitor Centers, Grand Teton National Park
- Four Seasons Resort, Teton Village, Wyoming
- Renaissance Hotel, Teton Village, Wyoming
- Teton Lodge, Teton Village, Wyoming
- Teton Club, Teton Village, Wyoming
- Red Lodge Mountain slope stability and lined water storage
- Navajo Reservation bridges, New Mexico and Arizona
- Moonlight Basin, Big Sky

3.0 ENVIRONMENTAL PROJECTS

WAI has provided geotechnical and geological services on major environmental cleanups, including CERCLA sites in several states. These sites are large industrial facilities with numerous problems and complex geotechnical requirements. Several of the projects have been ongoing for more than nine years. The Asarco Tacoma Smelter CERCLA site has been particularly challenging, involving geotechnical design of a hazardous waste landfill on a sensitive site adjacent to Puget Sound. The site is seismically active and subject to serious

potential settlement, liquefaction, and slope stability problems. Our experience and background on environmental projects includes the following:

- Hazardous waste landfill design
- Seismic and liquefaction analysis
- Slope stability
- Foundation design
- Geosynthetic covers and liners
- Site investigations

WAI has worked on the following environmental projects:

- Asarco Tacoma Smelter CERCLA site, Washington
- Asarco Murray Smelter CERCLA site, Utah
- Asarco East Helena Smelter CERCLA site
- Asarco Omaha Smelter CERCLA site, Nebraska
- Asarco Yak Tunnel CERCLA site, Leadville, Colorado
- Asarco Beckemeyer CERCLA site, Illinois
- Asarco Henrietta CERCLA site, Oklahoma
- Pacific Recycling CECRA sites, Billings
- Asarco lead battery recycling plant, North Carolina
- Major refinery gasoline plume interception, Billings
- Pennsylvania Power and Light (PPL) interception drains, Colstrip, Montana
- PPL fly ash and process water impoundments, Colstrip
- Rosebud Power fly ash pond, Colstrip
- Columbia Falls aluminum landfill cover
- Getter Trucking facilities, Wyoming, North Dakota, Montana
- Lander and Winkleman Dome oil fields, Wyoming
- Hardscrabble oil field, North Dakota
- Four Eyes oil field, Montana
- Brush Lake oil field, Montana
- Injection wells, North Dakota and Montana

4.0 ACTIVE MINES

Ray Womack has worked on coal and hardrock projects in Montana since 1978. WAI has been involved in design, operation, and closure of many major projects in Montana and the western U.S. Our background includes the following areas of work:

- Slope stability--heap leach pads, waste repositories, landslides
- Reclamation--covers, liners, water treatment facilities
- Dams
- Major diversions
- Foundations for surface facilities

4.1 HARDROCK MINES

Hardrock mining projects include the following:

- Pegasus Zortman
- Stillwater platinum
- Asarco Rock Creek
- Noranda Crown Butte
- Phelps Dodge/Canyon Resources MacDonald and Sevenup Pete
- CR Kendall
- Basin Creek
- Hecla Grouse Creek, Idaho
- Stibnite, Idaho
- Echo Bay Republic, Washington
- CR Briggs, California
- Sonora Mining, California
- Asarco Ray and Mission, Arizona
- Asarco Coy, New Market, and Young zinc mines, Tennessee
- Cambior Carlota, Arizona
- Bolnisi heap leach, Republic of Georgia
- Jezkazgan copper leach, Kazakhstan

4.2 COAL MINES

Coal projects include the following:

- Westmoreland Absaloka
- Montco
- Bull Mountains (Louisiana Land and Exploration)
- Wesco Cook Mountain
- Consolidation Coal Otter Creek
- Meridian Cook Creek
- Meridian Circle West
- Ft. Union, Wyoming
- Consolidation Coal Ash Creek, Wyoming

5.0 GEOMORPHOLOGY

WAI has performed stream channel investigations and remediation projects for mines, conservation districts, and landowners. Ray Womack has published technical papers and has served as an expert witness and consultant in litigations involving boundary disputes and erosion problems along rivers. His work on stream channel erosion has been cited in a number of textbooks. The company has recently prepared cumulative impact assessments for channel training projects along the Yellowstone River near Billings, the first study of its type to be performed in this region. We are currently doing similar assessments for proposed channel training projects along the BNSF railroad Yellowstone River corridor between Billings and the North Dakota line. Specific projects include the following:

- Yellowstone cumulative impact study, Yellowstone Co.
- BNSF Yellowstone cumulative impact study
- Clark Fork litigation, Missoula
- Yellowstone litigation, Sidney
- Missouri River litigation, Culbertson
- Sun River litigation, Cascade County
- Careless Creek erosion, Musselshell County
- Two Medicine Canal blowout, Blackfoot Reservation
- Alder and McGinnis Canal failures, Blackfoot Reservation
- Douglas Creek erosion, Colorado
- Carter Gulch debris flows and channel reclamation, Zortman
- Ruby Gulch channel reclamation, Zortman

6.0 CLIENT LIST

6.1 INDUSTRIAL CLIENTS

Asarco • BNSF • Cambior • Canyon Resources • Central Montana Railway • Consolidation Coal • Darling International • Echo Bay Minerals • Exxon Billings Refinery • Getter Trucking • Hecla Mines • Koch Materials • Montana Power Co. • Montco • Nance Petroleum • Noranda • Pacific Recycling • Pegasus Gold • Pennsylvania Power and Light (PPL Montana) • Phelps-Dodge • Stillwater PGM • The Industrial Company (TIC) • Tongue River Railroad • Western Energy • Westmoreland Resources • Zortman Mining Inc.

6.2 PUBLIC CLIENTS

Billings Public Utilities Department • City of Lander, Wyoming • Montana Dept. Environmental Quality • Montana Dept. Fish Wildlife and Parks • Montana Dept. Natural Resources and Conservation • Montana Dept. Transportation • Northern Cheyenne Housing Authority • U.S. Bureau of Indian Affairs • U.S. Department of Justice • U.S. Forest Service • U.S. National Park Service • U.S. Public Health Service • U.S. NRCS • Wyoming Dept. of Environmental Quality

6.3 PRIVATE CLIENTS

Briarwood Country Club • Dreyfus Property Group • Grand Targhee Ski Resort • Leon Hirsch • Jackson Hole Ski Corporation • Michael Keaton • Moonlight Basin Ranch • Red Lodge Mountain Ski Area • Snake River Associates • State Farm Insurance • Travelers Insurance

6.4 ENGINEERS AND ARCHITECTS

A&E Architects • CTA Architects Engineers • Carney Architects • Charney Architects • CDM • Engineering Inc. • Fluidyne • Jonathan Foote Architects • Golder Associates • Hydrometrics • Jacobsen Construction • Jorgensen Engineering • McLaughlin Architects • Miller Levine Architects • Morrison-Maierle • R.D. Nielson Architects • Rendezvous Engineering • SK Geotechnical • Schafer & Associates • Daniel Smith Architect • Thomas Dean & Hoskins • URS Corp.

6.5 ATTORNEYS

Brown et al • Corette et al • Crowley • Edwards • Felt Law Firm • Jardine • Landoe • Matovich & Keller • Molloy Law Firm • Moulton • Stacey and Walen

7.0 PUBLICATIONS AND PRESENTATIONS

Womack, W.R., 2006, Landslides triggered by hurricane Stan in western Guatemala, investigation and mitigation in a developing environment: 40th Annual Symposium on Engineering Geology and Geotechnical Engineering, Utah State University.

O'Farrell, C.R., and Bingham, M., Using geomorphology as a tool for teaching quantitative reasoning: Journal of Geoscience Education. in preparation.

O'Farrell, C.R., Heimsath, A.M, Lawson, D.E., Jorgensen, L.M., Evenson, E.B., Larson, G., Above the glacier: non-glacial erosion rates and processes feeding the Matanuska Glacier, Alaska: Geomorphology., in review, also presented at American Geophysical Union Annual Meeting, December 2005, San Francisco, CA.

O'Farrell, C.R., Heimsath, A.M., and Kaste, J.M., 2006, Quantifying hillslope erosion rates and processes for a coastal California landscape over varying timescales: Earth Surface Processes and Landforms, in press, also poster presentation at American Geophysical Union Annual Meeting, December 2004, San Francisco, CA.

O'Farrell, C.R. Quantifying erosion rates due to snow avalanche: International Snow Science Workshop, September 2004, Jackson, WY. Poster Presentation.

Mokwa, R., W.R. Womack, and D.P. Cameron, 2004, Quantifying the risk of construction in landslide prone areas: Proceedings for ASCE Geo-Trans Geotechnical Engineering for Transportation Projects, Special Publication No. 126, p. 2010-2019.

Womack, W.R., 2004, River changes and property boundary disputes: Montana Bar Association CLE, Miles City, Montana.

Womack, W.R., and D.P. Cameron, 2003, Risks and consequences of remobilization of ancient landslides: Short course presented at Geohazards Symposium, MSU Engineering Festival, Bozeman, Montana.

Womack, W.R., 2003, Permitting within a corridor management plan: Great Northern Environmental Stewardship Association Meeting, Kalispell, Montana.

Womack, W.R., and K. Boyd, 2002, Alteration of Yellowstone River form and habitat over the past 50 years: Yellowstone River Floodplain Workshop, Billings, Montana.

Womack, W.R., 2002, Water storage in the coal fields of the Northern Plains; lessons from failures: Montana: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., and K. Boyd, 2001, Stream channel restoration and the illusion of function: Montana Mine Design, Operations, and Closure Conference, Whitefish, Montana.

Womack, W.R., 2001, Response and recovery of the Missouri River downstream of Ft. Peck Dam, with resulting property boundary disputes *in* Applying Geomorphology to Environmental Management: Water Resources Publications, Ft. Collins, Colorado, p. 429-456.

Womack, W.R., and R. Perkins, 2000, Effects of management on river form and habitat in Yellowstone County: Assn. Montana Floodplain Managers Conference, Butte.

Womack, W.R., 1999, Yellowstone River geomorphology: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., F.R. Greguras, G.S. Vick, D.K. Nation, and T. Aldritch, 1998, Hidden hazard: liquefaction assessment for a buried glacial stream valley at a Superfund site offshore of Tacoma, Washington: Proceedings for Geo-Institute ASCE Geotechnical Earthquake Engineering and Soil Dynamics III, Geotechnical Special Publication No. 75, Reston, Virginia.

Womack, W.R., J. Volberding, and L. Johnson, 1998, Geotechnical case study SevenUp Pete Joint Venture, McDonald Gold Project: Northwest Geology, v. 28, p. 53-89.

Cameron D.P., and B.R Bronson, 1997, Leach facility construction on placed rockfill overburden: Proceedings of the Fourth International Conference on Tailings and Mine Waste, Tailings and Mine Waste, Colorado State University, A.A. Balkema.

Womack, W.R., J. Volberding, and L. Johnson, 1997, Glacial geology and landslides at the SevenUp Pete site, Montana: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., and D.J. van Zyl, 1997, Geological uncertainty and risk: Short course presented at Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 1997, Historical perspective of river management activities and their cumulative effects: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., 1996, Montana landslides; diagnosis, prevention, and cure: Short course presented at Montana Joint Engineers Conference, Fairmont.

Hutchison, I.P.G, M.L Leonard, and D.P. Cameron, 1995, Remedial alternatives identification and evaluation. Proceedings of the Summitville Forum, Colorado State University, A.A. Balkema.

Womack, W.R. and G. Rome, 1989, Irrigation waste water triggers severe natural channel erosion: Amer. Soc. Agri. Engineers International Summer Meeting, Quebec.

Womack, W.R., 1984, Detection of shallow abandoned room and pillar workings using high resolution earth resistivity: Proceedings of the National Symposium and Workshops on Abandoned Mine Land Reclamation, p. 42-62.

Womack, W.R., and S.A. Schumm, 1977, Terraces of Douglas Creek, northern Colorado: an example of episodic erosion: Geology, v.5, p. 72-76.

Womack, W.R., 1976, Applications of Thermal Infrared Scanning to Engineering Geology in South Africa: South African Symposium on Remote Sensing.

W. RAYMOND WOMACK, P.E., P.G.
Principal Engineer
Womack & Associates, Inc.

Slope Stability
Dams
Mining Structures
Foundations
Environmental Projects
River Mechanics

SUMMARY OF EXPERIENCE

Mr. Womack has more than 30 years experience in geotechnical engineering and engineering geology, providing site investigations, design, and construction supervision. Project experience includes earth fill and tailings dams; landfills; copper and gold mining projects; coal mines; railroads; commercial, municipal, and residential construction; and hazardous waste and ground water pollution sites in 17 states and 7 countries outside the US. Mr. Womack has particular expertise in investigation and mitigation of landslides and other slope stability problems, including seismic and liquefaction studies. He has presented short courses and technical papers, as well as provided expert consulting and witness services in litigations involving foundations, slope failures, and river changes. He has worked extensively in southern Africa, and has also been involved in mining projects in the Republic of Georgia and Kazakhstan. Mr. Womack is involved in disaster relief and engineering design for projects in developing countries, including landslide mitigation in Guatemala, flood control in Haiti, rockfall problems in India, and several projects in Uganda and Kenya.

EDUCATION AND TRAINING APPLICABLE TO LANDFILL PROJECTS

- Virginia Polytechnic Institute — B.S. Geophysics, 1970
- Colorado State University — M.S. Earth Resources (Geology), 1975

Course work at Virginia Tech and Colorado State included soil mechanics and foundations, hydrology, engineering geology, and numerous courses in geology and geophysics.

Applicable Continuing Education Training

- Static and Seismic Slope Stability for Waste Containment Facilities, University of Wisconsin, 1995
- Soil, Geomembrane, and Composite Liners and Covers for Landfills, University of Wisconsin, 1995
- Design and Construction Considerations for Geomembrane-Lined Fill Structures, short course at Montana Tech Mine Design, Closure, Operations, and Closure Conference, 1997
- Tensar and Maccaferri Design Courses

REGISTRATIONS & AFFILIATIONS

- Professional Engineer in Arizona, Colorado, Idaho, Montana, Washington, and Wyoming
- Professional Geologist in Wyoming

- American Society of Civil Engineers (ASCE)
- Association of Engineering Geologists (AEG)
- 1988-1989 President, Billings Engineers Club
- American Scientific Affiliation (ASA)

PROFESSIONAL HISTORY

- Womack & Associates, Inc., Principal Engineer/Engineering Geologist, 1982-Present
- Geowest, Inc., Billings, MT, Project Manager, 1979-1982
- IntraSearch, Inc. (Spectrum), Billings, MT, Geological Engineer, 1978-1979
- Partridge, de Villiers & Associates (South Africa), Engineering Geologist, 1975-1978

TECHNICAL PRESENTATIONS AND PUBLICATIONS

Womack, W.R., and C. O'Farrell, 2006, Landslides triggered by Hurricane Stan in western Guatemala: investigation and mitigation in a developing environment: 40th Annual Symposium on Engineering Geology and Geotechnical Engineering, Utah State University.

Mokwa, R., W.R. Womack, and D.P. Cameron, 2004, Quantifying risks of construction in landslide-prone areas: Proceedings of ASCE Geotrans Conf., Los Angeles, Geotechnical Special Publication 126, p. 2010-2019.

Womack, W.R., 2004, River changes and property boundary disputes: Montana Bar Association CLE, Miles City, Montana, also presented at 2005 Montana Association of Registered Land Surveyors Conference.

Womack, W.R., 2004, Engineering volunteerism: Montana Geotechnical Group, MSU Engineering Festival, Bozeman, Montana.

Womack, W.R., 2003, Permitting within a corridor management plan: Great Northern Environmental Stewardship Association Meeting, Kalispell, Montana.

Womack, W.R., and D.P. Cameron, 2003, Risks and consequences of remobilization of ancient landslides: Short course presented at Geohazards Symposium, MSU Engineering Festival, Bozeman, Montana.

Womack, W.R., 2002, Lessons learned from failures and near-failures of water retention facilities in the coal fields of the Northern Great Plains: Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 2002, Alteration of Yellowstone River form and habitat over the past 50 years: American Rivers Conference, Billings, Montana.

Womack, W.R., 2001, Response and recovery of the Missouri River downstream of Ft. Peck Dam, with resulting property boundary disputes: Applying Geomorphology to Environmental Management (ed D. Anthony, M. Harvey, J. Laronne, and M. Mosley), Water Resources Publications, Ft. Collins, Colorado, p. 429-456.

Boyd K.F., and W.R. Womack, 2001, Stream channel restoration and the illusion of function: Mine Design, Operations, and Closure Conference, Whitefish, Montana (Also presented at Assoc. Montana Flood Plain Managers Conference).

W.R. Womack, 2000, Effects of management on river form and habitat in Yellowstone County: Montana Flood Plain Managers Conference, Billings (Also keynote speech at Yellowstone River Roundtable, Billings).

Womack, W.R., 1999, Yellowstone River geomorphology: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., F.R. Greguras, G.S. Vick, D.K. Nation, and T. Aldrich, 1998, Hidden hazard: liquefaction assessment for a buried glacial stream valley at a Superfund site offshore of Tacoma, Washington: Proceedings for

Geo-Institute ASCE Geotechnical Earthquake Engineering and Soil Dynamics III, Geotechnical Special Publication No. 75, Reston, Virginia.

Womack, W.R., J. Volberding, and L. Johnson, 1998, Geotechnical case study SevenUp Pete Joint Venture, McDonald Gold Project: Northwest Geology, v. 28, p. 53-89.

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Womack, W.R., 1997, Geological uncertainty and risk: Short course presented at Mine Design, Operations, and Closure Conference, Polson, Montana.

Womack, W.R., 1997, A historical perspective of river management activities and their cumulative effects: Conference on Yellowstone River Problems and Control Efforts, Billings, Montana.

Womack, W.R., 1996, Montana landslides; diagnosis, prevention, and cure: Short course presented at Montana Joint Engineers Conference, Fairmont.

Womack, W.R. and G. Rome, 1989, Irrigation waste water triggers severe natural channel erosion: Amer. Soc. Agri. Engineers International Summer Meeting, Quebec.

Womack, W.R., 1984, Detection of shallow abandoned room and pillar workings using high resolution earth resistivity: Proceedings of the National Symposium and Workshops on Abandoned Mine Land Reclamation, p. 42-62.

Womack, W.R., and S.A. Schumm, 1977, Terraces of Douglas Creek, northern Colorado: an example of episodic erosion: Geology, v.5, p. 72-76.

Womack, W.R., 1977, Engineering geology for civil engineers: Senior level course at The University of the Witwatersrand, Johannesburg, South Africa.

Womack, W.R., 1976, Applications of thermal infrared scanning to engineering geology in South Africa: South African Symposium on Remote Sensing, Johannesburg.

Author of numerous private reports on geotechnical engineering, engineering geology, and river mechanics.

SLOPE STABILITY

PROJECT	LOCATION
Jackson Hole Aerial Tram	Wyoming
Beartooth Highway Reconstruction	Montana
Hurricane Stan Disaster Response	Guatemala
Dinosaur National Monument Landslide	Colorado
Hecla Grouse Creek Mine Landslides	Idaho
Stibnite Mine	Idaho
PD\Canyon Resources Seven-Up Pete and McDonald	Montana
Zortman Mine	Montana
ASARCO East Helena Smelter	Montana

ASARCO Tacoma Smelter Landfill	Washington
ASARCO Ray Mine	Arizona
ASARCO Murray Smelter	Utah
BNSF Shirley and Savage Projects	Montana
Crown Butte Power Line Corridor	Wyoming
Westmoreland Absaloka Mine	Montana
Stillwater Mine East Boulder Road	Montana
Cambior Carlota Mine	Arizona
Sonora Mine	California
Columbia Falls Aluminum Landfill	Montana
W.R. Grace Vermiculite Tailings	Montana
Consolidation Coal Ash Creek	Wyoming
Canyon Resources CR Kendall	Montana
Tongue River Railway	Montana
Central Montana Railway	Montana
ASARCO Young Mine Zinc Tailings	Tennessee
Billings Heights Sanitary Sewers	Montana
Red Lodge Sewer Outfall Failure	Montana
Wrongful Death Litigation, Butte	Montana
Rimrock Drilling Litigation, Billings	Montana
Mountain View Subdivision, Billings	Montana
Teton Wilderness Landslide	Wyoming
Bozeman Railway Stability	Montana
McClain Creek Slide	Montana
Buffalo Jump Slide	Montana
Cathedral Mountain Slide	Montana
Michael Keaton Residence, Bridger Bowl	Montana
Leon Hirsch Residence, Lima	Montana
Lee Residence, Cromwell Island, Flathead Lake	Montana
Stayner Residence, Big Sky	Montana
Faubert Residence, Big Sky	Montana
Lyman Creek Water Supply Project, Bozeman	Montana
Aspen Grove Subdivision, Big Sky	Montana
Skywood Preserve Subdivision, Big Sky	Montana
Beehive Subdivision, Big Sky	Montana
Moonlight Basin, Big Sky	Montana
Blue Grouse Development, Big Sky	Montana
Beaver Creek, Gallatin County	Montana
Sunwest Subdivision, Madison County	Montana
Bench Ranch, Sunlight Basin	Wyoming
Roger Altman Residence, Jackson Hole	Wyoming
Jackson Hole Ski Area	Wyoming
Red Lodge Mountain Ski Area	Montana

DAMS AND TAILINGS IMPOUNDMENTS

PROJECT	LOCATION
PPL Montana Saddle Dam	Montana
PPL Montana Main Dam	Montana
Hecla Grouse Creek Tailings	Idaho
Westmoreland Absaloka Mine Dams	Montana
ASARCO Young Mine Zinc Tailings	Tennessee
ASARCO Coy Impoundment Failures (karst)	Tennessee
ASARCO E. Helena Smelter Sludge Repository	Montana
Zortman Mine Dams	Montana
Echo Bay Republic Mine Dams	Washington
ASARCO Blackhawk Tailings	New Mexico
ASARCO Mission Tailings	Arizona
ASARCO Ray Mine Dams	Arizona
W.R. Grace Vermiculite Tailings	Montana
McNeil Slough Reservoir	Montana
Bearpaw Reservoir	Montana
Nilan Reservoir	Montana
Hauser Reservoir FERC Expansion Permit	Montana
Thompson Falls FERC Expansion Permit	Montana
Huntley Irrigation Dam	Montana
Worthen Meadows Reservoir, Lander	Wyoming
Chapek Reservoirs, Sheridan	Wyoming
Chevron Carter Creek Gas Plant Impoundment	Wyoming
Glaston Reservoirs, Big Timber	Montana
Upper and Lower Flagstaff Dams	Montana
BLM Reservoirs	Montana
Billings PUD Impoundment	Montana
Yellowstone Country Club, Billings	Montana
Yates Dam	Montana
Lebowa Dam	South Africa
Sterkspruit Dam, Transkei	South Africa
Transkei Dams(25 sites)	South Africa

FOUNDATIONS

PROJECT	LOCATION
Four Seasons Resort, Teton Village	Wyoming
Crescent Mountain Resort, Teton Village	Wyoming
Snake River Lodge, Teton Village	Wyoming
Teton Club, Teton Village	Wyoming
Teton Lodge, Teton Village	Wyoming
Gondola Restaurant, Teton Village	Wyoming
Bridger Center, Teton Village	Wyoming
Cody Center, Teton Village	Wyoming
Rendezvous Peak Lodge, Teton Village	Wyoming

Granite Ridge Subdivision, Teton Village	Wyoming
Grouse Creek Mill and Crusher	Idaho
ASARCO E. Helena Storage Tanks	Montana
ASARCO Lead Battery Recycling Plant	North Carolina
Murray Pacific Log Yard, Tacoma	Washington
Zortman Mine Water Treatment Plants	Montana
Zortman Mine Cable Belt Conveyor	Montana
Western Energy Housing Studies, Colstrip	Montana
ASARCO Ray SX-EW Plant	Arizona
Navajo Bridges, BIA	Arizona
Faith Chapel Church, Billings	Montana
Michael Keaton Residence, Bridger Bowl	Montana
Chambless Ranch, Bridger Bowl	Montana
Leon Hirsch Residence, Lima	Montana
Four Corners Ice Palace, Bozeman	Montana
Koch Materials, Laurel	Montana
Moonlight Basin, Big Sky	Montana
Russell and Karen Fagg Residence, Billings	Montana
Stone Crop Subdivision, Jackson Hole	Wyoming
Crescent H Ranch, Jackson Hole	Wyoming
Thurston Residence, Jackson Hole	Wyoming
Roger Altman Residence, Jackson Hole	Wyoming
Teton Springs Development	Idaho
Warbonnet Subdivision, Billings	Montana
Northern Cheyenne Housing	Montana
Sheridan V.A. Hospital	Wyoming
Spring Creek Subdivision, Bozeman	Montana
Safeco Insurance, Great Falls	Montana
State Farm Insurance, Bozeman and Miles City	Montana
Intermountain Foods, Bozeman	Montana
Aldworth Construction, Bozeman	Montana
Briarwood Subdivision, Billings	Montana
Drummond School	Montana
Independent School, Billings	Montana
Malta High School	Montana
Glasgow High School	Montana
Jackson Hole High School	Wyoming
Wilson High School	Wyoming
Homestead Post Office, Billings	Montana
Hysham Water Treatment Plant	Montana
Kandisi River Bridge	Kenya
Moffat College Library	Kenya
Bukaleba Clinic and School	Uganda
Pretoria Hospital	South Africa
Urban Beltway Roads and Bridges, Johannesburg	South Africa
Dwangwa Sugar Mill	Malawi

ENVIRONMENTAL AND MINING PROJECTS

PROJECT	LOCATION
ASARCO Yak Tunnel CERCLA Site, Leadville	Colorado
ASARCO E. Helena Smelter CERCLA site	Montana
ASARCO Tacoma Smelter CERCLA site	Washington
ASARCO Omaha Smelter CERCLA site	Nebraska
Murray Pacific Log Yard, Tacoma	Washington
Murray Smelter, Salt Lake City	Utah
Crown Butte Land Application	Montana
Zortman Waste Repositories	Montana
Stillwater Mine Land Application	Montana
ASARCO Lead Battery Recycling Plant EA	North Carolina
EXXON Refinery Interception Drain, Billings	Montana
PPL Montana Interception Drains, Colstrip	Montana
PPL Montana Fly Ash, Colstrip	Montana
Rosebud Power Fly Ash, Colstrip	Montana
NRCS Animal Waste Projects	Montana
Columbia Falls Aluminum Landfill	Montana
Getter Trucking Facilities EA	Wyoming, North Dakota, Montana
Lander Oil Field	Wyoming
Winkleman Dome Oil Field	Wyoming
Hardscrabble Oil Field	North Dakota
Four Eyes Oil Field	North Dakota
Brush Lake Oil Field	Montana
Landtech Injection Wells	Montana and North Dakota
Balco Injection Well and Pipelines	North Dakota
Pacific Recycling, Billings	Montana
Fremont County Abandoned Mines	Wyoming
Montana Abandoned Mines	Montana
Elkhorn Abandoned Mine/CERCLA	Montana
Alladin Tipple Reclamation	Wyoming
Underground Storage Tanks	Montana
Lewistown Clay Reclamation	Montana
Livingston Gravel Reclamation	Montana
Northern Tier Pipeline	Washington, Montana
Zortman Mine Goslin Gulch	Montana
Phelps-Dodge Seven Up Pete	Montana
Phelps-Dodge McDonald	Montana
Canyon Resources CR Kendall	Montana
Canyon Resources CR Briggs	California
Cambior Carlota	Arizona
Bolnisi Madneuli Mine	Republic of Georgia
Jezkazgan SX-EW	Kazakhstan
Montco Project, Tongue River	Montana
Wesco Cook Mountain	Montana
Meridian Cook Creek projects	Montana
Consolidation Coal Otter Creek	Montana
Westmoreland Absaloka	Montana

Western Energy and Montana Power Colstrip	Montana
Arch Youngs Creek	Montana
Bull Mountains	Montana
Meridian Circle West Project	Montana
Ft. Union mine	Wyoming
Consolidation Ash Creek	Wyoming
Carrizozo	New Mexico

RIVER MECHANICS

PROJECT	LOCATION
Yellowstone River Cumulative Impact Assessment	Montana
BNSF Yellowstone Channel Training Assessment	Montana
Clark Fork Litigation, Missoula	Montana
Yellowstone Litigation, Sidney	Montana
Missouri River Litigation, Culbertson	Montana
Horse Creek Erosion, Forsyth	Montana
Careless Creek Erosion, Musselshell County	Montana
Yellowstone Access Sites	Montana
Sweetgrass Creek Reclamation	Montana
Riverfront Park Litigation, Billings	Montana
Big Horn Litigation, Custer	Montana
Langman Litigation, Yellowstone River	Montana
Clarks Fork Yellowstone Boundary Dispute	Montana
Douglas Creek Erosion, Rangely	Colorado
Rock Creek Erosion, Carbon County	Montana
Two Medicine Canal, Blackfoot Reservation	Montana
Huntley Irrigation Diversion	Montana
Alder and McGinnis Erosion, Blackfoot	Montana
Carter Gulch Channel Reclamation, Zortman	Montana
Ruby Gulch Channel Reclamation, Zortman	Montana
Huntley Flood Dike	Montana
Sun River Boundary Dispute	Montana
Bayeux Channel Stabilization	Haiti