HYMER MINE SHAFT
SUBSIDENCE INVESTIGATION
512 ADAMS AVE. SOUTH
RED LODGE, MONTANA

Carbon County, Montana

FINAL REPORT

October 27, 2012

Spectrum Engineering
1413 4th Avenue North
Billings, Montana 59101

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MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
CONTRACT 407040, TASK ORDER 17
HYMER MINE SHAFT SUBSIDENCE INVESTIGATION FINAL REPORT

INTRODUCTION

The purpose of Task Order 17 was for Spectrum Engineering to perform a subsidence investigation at the historic Hymer Shaft located at 512 Adams Avenue South in Red Lodge, Montana. Task 1 of the Task Order called for an exhaustive review of all available site information and area mine maps. This was compiled and submitted to the DEQ on February 29, 2012.

The site is associated with a shaft sinking project that was undertaken in 1904-1906 by the Red Lodge Coal Company. W. E. Hymer was the manager and one-third owner of the Red Lodge Coal Company. Before becoming involved with coal mining, Hymer had developed the Hymer Addition and had acquired the coal rights to the area where the shaft was to be developed. In April of 1904, the Red Lodge Coal Company awarded a contract to have the 8'8" x 16'2" double compartment shaft sunk on the No. 1 coal vein. The shaft was to be 200 feet deep and was to be lined with 10"x10" timbers and 3"x12" lagging. By August 25, 1904, a 24'x 46' hoisting plant had been constructed and the shaft had been sunk to a depth of 50 feet. On June 10, 1905, Clarence Hymer, the 25 years old son of W.E. Hymer, was killed while working on the shaft sinking project. The shaft was about 100 feet deep at the time of the accident.

There are no newspaper or mine accounts of the shaft after 1905. However, we do know that the Northwest Improvement Company (NWI) began mining the No. 5 Bed 800 feet north of the shaft on December 20, 1905. NWI eventually got most of the coal rights in the Hymer Addition and mined this general area during the period from 1908 to 1918. But, all of their workings skirted around the Hymer Shaft. A 1907- fire insurance rating map of Red Lodge indicates that the shaft and hoisting works were not in operation at that time. This map provides the only known documentation of the shaft location. The generally accepted local history of the shaft is that W. E. Hymer immediately abandoned the project when his son was killed.

By 1927, the hoisting plant had been removed, the shaft had been covered, and a small house had been erected on the site. At some point prior to 1927, the shaft was sealed. Based on information from the drilling investigations in 1998 and 2012, it is believed that the shaft was sealed by installing a timber bulkhead over both compartments about 56 feet above the bottom of the shaft. Then the opening above the bulkhead was backfilled to the surface. In conjunction with backfilling, it is also believed that the uppermost shaft timbers were completely removed in order to level the site. Sometime around 1959, the surface over the covered shaft caved, creating a modest subsidence hole. This surface damage was repaired by backfilling. Additional backfill was placed within the subsided area between 1994 and 1998. During this later period, an addition was added to the house. Then a deck, which extends over the shaft subsidence area, was constructed.

In 1998, the Department of Environmental Quality Abandoned Mine Lands Bureau (DEQ AMLB) decided to investigate continued settlement around the shaft. Five boreholes that were 15 to 35 feet in length were drilled to locate the shaft. The drilling roughly located the shaft and indicated that a partially collapsed wood bulkhead was situated about 22 feet below the surface. A total of 21 cubic yards of 6½ sack grout (2000 psi) was pumped into drill hole DH-4 to stabilize the ground. Most of the grout did not remain in the zone where it had been placed and fell further down the shaft. After the grout was allowed to setup, drill hole DH-4 was redrilled. It went through large voids below the depth of 35 feet and hit solid material at a depth of 78 feet below the surface. An additional 30 cubic yards of grout and 11 cubic yards of neat cements were injected into this hole. If the compartments in the shaft confined the grout, most of the grout and neat cement would have been placed into the southern compartment. Drilling and grout injection employed 5" Dex casing. The 1998 drilling site was reclaimed with cover-soil fill that was graded level with the adjacent ground.

Task 2 called for a subsidence investigation. This was to include three investigations as follows:

- Drilling to determine the extent of the failure since the 1998 grouting project.
- Geotechnical investigation to determine if compaction measures would prevent future subsidence.
- Structural investigation to determine if the current structures are stabilized and to develop a structure stabilization plan.

The results of these investigations are addressed within this report.

SUBSIDENCE INVESTIGATION

Initial Structural Investigation

On April 2, 2012, Bill Maehl from Spectrum Engineering, Matt and Wes Krivonen from Krivonen and Associates (licensed structural engineers), and Steve Stokke from Yellowstone Concrete and Structural (helical pier and structural stabilization expert) met with Pebbles Opp from DEQ AMLB and Andy Van Ornum (landowner) at 512 Adams Avenue South. They evaluated the current subsidence, as well as, the subsidence in the adjoining yard of 518 Adams Avenue South (Aimee Romeijn). The purpose of this investigation was to provide an assessment of the current structure, to assess risks to the structure, and to assess structural remedies.

The team inspected the inside and outside of the Van Ornum residence for settlement damage. The exposed portion of the house foundation around the outside of the house was also examined. Because no damage was observed on the outside and no appreciable settlement was found in the interior of the house, the crawlspace, which exposes more of the 4-foot high stem wall foundation of the structure, was not examined. The Krivonen and Associates structural investigation report is presented in Appendix A. Per the structural report, they do not believe the original house structure or the later addition have been affected by the cone of depression around the shaft. Consequently, it appears that only the deck has been affected by the subsidence.

Krivonen and Associates and Yellowstone Concrete and Structural recommended the placement of 32 helical piers (see Appendix B) and a 30-inch thick reinforced concrete pad over the entire subsidence area at a depth of 1-foot under the surface. This would require removal and replacement of the deck.

Follow-up Structural Investigation

On October 22, 2012, Jeffrey Riedel P.E., a geotechnical engineer with Pioneer Technical Services, inspected the stem wall and crawl space of the structure at 512 Adams Avenue South, after Pebbles Opp from DEQ AMLB had obtained permission for the inspection from the landowner, Andy Van Ornum. The inspection found two cracks in the southern stem wall of the structure and a crack in the dirt floor of the crawl space. These features indicate that the subsidence cone associated with mine shaft extends under the southeast corner of the structure. The damage to the stem wall appears to be related to the subsidence around the shaft

Drilling Investigation

On July 8, 2012, Spectrum Engineering sent a formal request for quotations to the following five geotechnical drilling firms:

- Haz Tech Drilling of Billings, MT;
- Terracon Consultants of Billings, MT;
- O'Keefe Drilling of Butte, MT;
- Axis Drilling of Belgrade, MT; and,
- SK Geotechnical of Billings, MT

The bid was opened on July 24, 2012. Only Axis Drilling, which is owned by Lyle Ballenger, submitted a bid. Axis agreed to provide a Davey Kent track-mounted air-rotary drill with a detached compressor. The equipment would have angle drilling capabilities and could employ O-DEX casing to penetrate unstable materials. The equipment would also provide geotechnical capabilities with split spoon sampling and a calibrated hammer for standard penetration testing. This type of drill provides a measure of safety when conducting a subsidence investigation because the drill is fairly light weight.

The purposes of the investigation were to determine current subsurface conditions inside the previously capped and partially caved mine shaft and to provide information for reclamation design of the on-going surface settlement problem. The work included:

1. Obtaining a Red Lodge City Business License - Pay fee to City Treasurer and submit license prior to beginning work.
2. Establishing Site Access - A portion of fence between the garage and the house was removed by the landowner.

3. Minimizing Property Damage - The drill had to cross a lawn and a sidewalk and drill in close proximity to the house. The sidewalk was protected by laying planks and plywood. Plastic tarps were installed on the deck to prevent drill cuttings and debris from coming in contact with any portion of the house or deck.
4. Drilling - One hole was drilled on the northern edge of the shaft to verify the shaft location. One hole was drilled down the center of each of the compartments to a depth reaching solid material at the bottom of the shaft. A fourth hole was drilled at the edge of the deck to collect geotechnical information.
5. Casing - Temporary O-DEX system casing was required for drilling. The driller was able to recover all casing.
6. Drill Hole Plugging – Contractor plugged all drill holes with drill cuttings. Due to unstable conditions, all drill holes caved to some extent as the casing was withdrawn.
7. Site Restoration - The driller removed all construction materials, tarps, plastic sheeting, plywood, and debris from the site as necessary to restore the site to its pre-drilling condition. Drill cuttings were spread on the surface.

On August 13th - August 15th of 2012, Dave Murja from Spectrum Engineering, Jeff Riedel from Pioneer Technical Services, and Lyle Ballenger from Axis Drilling met on the site to conduct the drilling investigation. Lyle Ballenger was accompanied by one helper.   Pebbles Opp from DEQ was on site to observe the investigation. During the investigation 220 feet of O-DEX drilling was completed. The holes were logged by the driller and Jeff Riedel. Table 1 shows the costs incurred for drilling.

Table 1
Axis Drilling Budget

Work Description	Quantity	Units	Unit Rate	Amount
Mobilization, Business License, Access, Repair/Replace Property Damage (Price Increased to Include Geotechnical Sampling and Testing)	1	Lump	$3,565.00	$4,890
Drilling Footage (O-Dex Drilling)	220	Feet	$32.00/Ft	$7040.00
Drill Hole Plugging (Bid Price Decreased)	4	Holes	$250.00/ea	$1,000
Site Restoration and Demobilization (Bid Price Decreased)	1	Lump	$2,450.00	$2,450
				$15,380

<u>Shaft Location Confirmation</u> - The top of drill hole H-1 was located 3 feet north of the north edge of the sidewalk. It was drilled for 39 feet on an angle of 80° toward the north side of the shaft. It was oriented perpendicular to the end of the shaft and was intended to intercept the middle of the north side of the shaft. At the top it went through less than 1 foot of soil. Then it entered and remained in gravel until it ended before reaching the side of the shaft. Although the hole had to be abandoned prematurely because the gravel was collapsing on the casing, this hole had advanced 6.8 feet horizontally, verifying that the entire shaft is located to the south of the sidewalk. It also verifies that the native material in the area is gravel.

Drill Hole H-4 was drilled at the north end of the upper deck on the house and as close to the side of the deck as the drill could get. This puts the location at about 2 feet east of the edge of the lower deck and about 2.5 feet south of the end of the lower deck. This hole was drilled vertically and entered a vertical timber on the west side of the shaft at a depth of 21 feet below the surface. In order to verify that the timbers were vertical instead of part of the cap, the hole was drilled 4 feet into the timber. This hole fixes the location of the western edge of the shaft at a revised location that is about 1.5 feet further to the west and closer to the deck than previously believed.

<u>Groundwater</u> - The groundwater elevation and rate of flow into the shaft are significant planning considerations. All boreholes started encountering water at a depth of 24 feet. At a depth of 30 feet the volume of water became significant. Because the backyard, and in particular shaft location in the backyard of the residence at 512 Adams Avenue South are in a depression, all of the water that was produced by drilling had to be collected in a sump and pumped to a storm water drain using a sump pump. The storm drain is located on the corner of Adams Avenue South and 16th Street. The sustained inflow to the drill casing was measured at over 20 gallons per minute (GPM). Flow rates at over 30 GPM were observed for short durations. Because the amount of water that had to be handled during the investigation had not been anticipated, a sump pump and about 200 feet of 2-inch discharge hose had to be rented from a local contractor to control the water and to prevent ponding beneath the deck.

It is also interesting to note that the groundwater observation well, that was installed 35 feet east of the shaft during the DEQ AMLB 1998 project, is currently dry. The static water level in the well was 19 feet below the surface when it was drilled in 1998. At that time, the bottom of the hole was 34 feet below the surface. The bottom 13 feet of the well is now filled with silt, preventing the well from recharging.

<u>Inspect Shaft Compartment Grouted in 1998</u> - The planned location for drill hole H-3 was the center of the southern compartment of the shaft. It was located 10 feet north of the property line and 7.8 feet east of the upper deck. So, it probably entered the northeast corner of this compartment. The purpose of this hole was to inspect the condition of the grout that had been placed in the shaft in 1998. The upper 10 feet of the hole was composed of loose topsoil with organic content. Then the drill went through several relatively thin layers (1-2 foot thick) of neat cement above the timber cap, which was encountered 22.5 feet below the surface. The cement is part of the grout and cement that was placed above the timber cap in 1998. Because a nearly equal thickness of grout/cement was found in H-2 over 7 feet from this hole, it can be assumed that the material probably spread out in a 10-foot radius when it was injected. With this flow radius, the lenses of material that were found during the current drilling would more than account for the amount of grout/cement that was placed above the timber cap. Since this material was placed under very low pressure conditions, the fill would have been confined to void spaces. But, the technique that was employed would have achieved little compaction of the overall fill area.

The timber cap has partially collapsed. The timbers that are still in place have significantly deteriorated. There is a thin layer of organic material above the rotting timbers that are still in place. It appears as though oil or some type of sealant was pored over the timbers when they were installed prior to 1907. The drill cuttings that came up the hole from this elevation were somewhat gooey and foul smelling. The remains of the timber cap are occasionally below the groundwater elevation and are deteriorating. Those timbers that have fallen into the tangle of debris below the cap and have remained underwater are still solid and give off the odor of pine when they are drilled.

Below the zone where the timbers are located, which extends down to about 33 feet below the surface, the drill went through 30 feet of sand and fine gravel chips. Some or all of this material could be some of the remains of the grout that was placed inside the compartment in 1998. With the large volume of water inside the shaft and method of placement, it is possible that much of the cement in the grout was washed out of the mixture as the grout settled to the bottom. At any rate, the drill did not penetrate any hard grout in this portion of the shaft. On the other hand, this part of the shaft is completely filled with unconsolidated granular material.

Between the depths of 65 feet and 75 feet, the compartment was filled with garbage, wood, and coal waste. The drill brought up cloth and metal. The change in material between the two debris zones would also seem to indicate that sand and fine gravel chips had been an introduced fill that was sandwiched between separated portions of earlier fill materials. The drill found solid material below a depth of 75 feet and was unable to advance. When the casing was pulled, the bottom 35 feet of the hole, which was saturated, collapsed.

<u>Exploration of the Northern Compartment</u> - Drill Hole H-2 was drilled to explore the northern compartment of the shaft, which was not known to exist in 1998. H-2 was located 17 feet north of the property line and 8.7 feet east of the upper deck. It should be situated fairly close to the center of the compartment. The drill went through about 10 feet of loose topsoil at the surface. Below the topsoil, the drill encountered various fill materials that contained general debris and three zones containing grout. This hole went through a collapsed section of the caved timber, hitting a tangle of timbers and a large boulder at the depth of 37 feet. Below this bridged area in the compartment, from a depth of 44 feet to 62 feet, the compartment was filled with extremely loose saturated silt containing some gravel. From 62 feet to 68 feet, the drill encountered loose silt that had settled out of the water. From 68 feet to 75 feet, the fill consisted primarily of carbonaceous materials. The drill had difficulty penetrating the material below 75 feet. It is assumed that the bottom of the shaft was reached at this depth.

Based on these drilling results, the existence of the northern compartment has been confirmed. It also appears that there must be a substantial barrier between the two compartments below a depth of about 35 feet from the current surface as there does not appear to be any communication between the two compartments below this depth. The compartment or perhaps just the timber cap has caved and there is a substantial amount of bridging above a depth of 44 feet. Between 44 feet and 62 feet, the compartment is filled with loose silt with the consistency and strength of mud. The bottom 7 feet of the compartment is filled with waste material that probably fell to the bottom when the cap initially failed. Because a large boulder was encountered in the upper fill, we can probably assume that an upper section of one of the timber walls of the shaft might also have collapsed allowing the boulder to cave into the shaft.

The condition of this compartment represents a deep seated area of instability for the surrounding gravel valley fill and for the nearby surface structures that are supported on the gravel. Most of the upper fill is currently being supported by a loose bridge of tangled timbers and rocks. Because the groundwater level fluctuates in this zone, the timbers will eventually deteriorate, causing the bridge to break apart. This would certainly cause the development of a subsidence depression above the compartment and could result in the failure of an upper wall of the shaft.

Geotechnical Investigation

On June 26, 2012, Pat Redmond of Pioneer Technical Services visited the Red Lodge site. He conducted a brief tour of the site. Following this initial investigation, he provided the following comments in his email account:

> *Seems best to stabilize the hole first and then figure what a cap might consist of. Am thinking that a few helical piles could provide support for the deck beyond the shaft location and beyond the area of settlement. Timbers or steel could span between the piles to support the deck. Pretty low cost and stable so if the ground settles a little in the future near the stabilized shaft it does not affect the house. If you can stabilize the shaft, the settlement adjacent to the shaft will decrease over time.   If helical piles are not used, the only option would be to cap over the area or dig it up and replace the now loose material next to the shaft to prevent settlement. Both would be very intrusive and expensive with some risk to the existing home foundations.*

On August 13th - August 15th of 2012, Jeff Riedel of Pioneer Technical Services and Lyle Ballenger from Axis Drilling conducted the geotechnical investigation simultaneously with the drilling investigation. The purpose of the geotechnical investigation was to characterize the materials and the current stability of those materials that are contained within the shaft and the subsidence zone. Jeff Riedel logged all of the drilling and conducted periodic standard soil penetration tests in the upper 50 feet of all vertical holes.

<u>Drill Hole H-4</u> - This borehole was specifically drilled to gain geotechnical information. Split spoons sampling was conducted along nearly the entire length of this hole. In addition, standard penetration tests were conducted at closely spaced intervals. This hole was located at the north end of the upper deck on the house and as close to the side of the deck as the drill could get, putting it about 2 feet east of the edge of the edge of the lower deck and about 2.5 feet south of the end of the lower deck. Although the hole was positioned to miss the shaft and penetrate through the bottom of the subsidence cone, the drill bit entered a vertical timber on the west side of the shaft at a depth of 21 feet below the surface. Thought was given to redrilling the hole on an angle

to miss the shaft, but interpretation of data on a non-vertical hole would have been difficult. All of the material above the shaft timbers was very loose. An actual void was encountered between the depths of 18 feet and 20 feet.

CONCLUSIONS

Base on the investigations that were conducted, the following conclusions can be reached:

1. The shaft was a 8’8” x 16’2" double compartment shaft that was lined with 10"x10" timbers and 3"x12" lagging.
2. The entire shaft is situated south of the sidewalk. The northwest corner of the shaft is situated less than 2 feet to the east of the north end of the upper deck. The southwest corner of the shaft is on the edge of the southwest corner of the deck.
3. The vertical distance from the current surface to the bottom of the shaft is approximately 80 feet.
4. The timber walls surrounding the shaft and the center partition between the compartments are no longer in place above the depth of 21 feet below the current surface.
5. Portions of the timber cap can still be encountered at a depth of 22.5 below the surface. But, much of the timber cap has deteriorated. There is a layer of organic soil over the top surface of the timber cap. Below the organic soil, there is a layer of rotten wood. A significant portion of the timber cap has failed. Failure over the northern compartment appears to be greater than over the southern compartment.
6. The void space that would have required filling when the shaft timber cap initially failed amounted to approximately 275 cubic yards. That void volume has been reduced to an unknown extent by imported backfill and grout. A portion of the void space has also been distributed into the subsidence cone area.
7. In both compartments, broken timbers created bridged areas. Because these timbers are situated below the groundwater level, they are not rotten.
8. The groundwater level is about 24 feet below the surface. Groundwater flow below 30 feet is significant (between 20 GPM and 30 GPM).
9. The southern compartment, which was filled with grout in 1998, is currently filled with sand and fine gravel. Although the cement appears to have been washed away in the deep fill areas, no voids were encountered in this compartment. Almost 40 vertical feet of near void was found in this compartment before it was filled in 1998. At the currently known dimensions of the compartment, completely filling a void of this size would have required 95 cubic yards.
10. The northern compartment, which was not discovered in 1998, contains a zone that is filled with excessively loose saturated silt. This zone is located directly below a zone in the shaft that has been bridged off by a tangle of rock and timbers. The conditions inside this compartment of the shaft will eventually lead to additional subsidence and should be corrected. An actual 2-foot wide separation in to soil on the west side of this compartment was discovered indicating ongoing settlement.

11. A mostly filled subsidence cone that is not centered on the shaft extends around the shaft. Around the perimeter of the shaft, the bottom of the subsidence cone is believed to extend down 22 feet to 27 feet below the surface to where the timber cap was located and the currently intact walls of the shaft provide a buttress. In the southern compartment, whatever is left of the walls is braced with fill. However, there is little supporting fill in the northern compartment above a depth of 62 feet. In places, the walls of the shaft could still extend above the timber cap. The timber is probably thoroughly rotten, but differences in the distances that the subsidence cone extends out from the sides of the shaft could be partially explained by the lingering buttressing effect of upper walls.
12. The material situated within the subsidence cone is loose and prone to settlement. A 2 foot separation in the soil was noted in H-4, which was drilled next to the deck. This material will not provide adequate support for a structure.
13. The native material surrounding the shaft is sand and gravel with numerous boulders. This material is expected to have a low angle of repose. It would be nearly impossible to drill without casing.
14. The area where the shaft is located at the rear of the dwelling does not have positive drainage. The fill that has been placed in and around the shaft tends to hold rainwater near the surface, while surface water on the surrounding gravel drains readily. Because any material that has been used for fill in this area will be sitting over porous gravel and the partially filled shaft, standing water might tend to wash the clay fine silt fractions out of the fill thereby reducing its strength.
15. The inspection of the crawl space and stem walls of the structure found two cracks in the southern stem wall and a crack in the dirt floor of the crawl space. These features indicate that the subsidence cone associated with mine shaft extends under the southeast corner of the structure.

RECOMMENDATIONS FOR CORRECTIVE ACTON

30-Inch Thick Reinforced Concrete Cap

This proposed solution does not require changing conditions underground if one can assume that the cone of subsidence has reached its ultimate limits and is stable. It would involve spanning the entire shaft area with a concrete cap installed near surface. The proposed cap would be installed sloping away from the house and would prevent any snowmelt or rainfall or sprinkler water from going into the ground immediately over the cap. The concrete structure would be covered with 12-inches of cover soil. The structure would be supported on 32 helical piers. This solution would require removal and replacement of the deck. Prior to selecting this alternative, a geotechnical evaluation for the applicability of helical piers would be required. Test piers would be required to achieve at least 40,000 pounds of bearing capacity.

The total estimated cost of final reclamation is $157,600 for 32 helical piers, excavation and removal of soil, placement of a 30-inch thick reinforced concrete pad, tying the concrete pad into the house foundation, removal and replacement of the deck, removal and replacement of the alley fence for access purposes, removal and replacement of the fence between the two yards, removal and replacement of the greenhouse/shed, and repair of two yards. The geotechnical and structural reports conflict on the efficacy of employing a concrete cap based on differing assessments of the stability of the subsidence cone.

Soil Binder

Spectrum Engineering, in association with Yellowstone Structural considered using HMI Soil Binder, which was developed for sinkhole stabilization. This product is a liquid that can be injected into unstable soils through 1-inch diameter injection pipes. The injection is accomplished using an air hammer to install the injection pipes on 2 to 4 foot centers and a small pump to inject the stabilizer. The stabilizer fills the voids in the soil and cements the soil particles together, forming a soil mass that has a 400 psi compressive strength. The total cost is about $350 per cubic yard of soil treated.

It could be used in difficult to access areas, like beneath the deck, by temporarily removing a few boards on the deck. It could be placed to form underground retaining walls or used to add support under footings. Because it has a strength of only 400 psi, it could be readily excavated and removed in the future.

Deep Shaft Filling

The relatively open zone in the northern compartment should be filled to eliminate the risks associated with having the surface fail with having a deep failure in the shaft wall that could destabilize the current subsidence cone. This would require pumping concrete into the bottom of the shaft under pressure to take care of the unfilled voids in the shaft that are 40’ to 70’ underground. Because this portion of the shaft is filled with water and silt, an injection well and a relief hole will need to be drilled in order to displace the water and silt in the shaft. If we attempt to work on both compartments, two independent sets of drill holes will be required. The injection well should go down to within a few feet of the bottom of the loose area. The casings might need to be left in the ground and cut off unless the work could be done in stages. With some pressure, concrete could be forced at least part of the way up through the bridged zones below the cap. Because flowability would not be of much benefit, using a mix with pea sized gravel and employing a cement pump truck would work. However, investigating grout designs that have been specially formulated for use underwater or in flooded environments would be instructive. Such designs could be adapted to meet the specific requirements of the Hymer Shaft. Because water disposal is problematic at this site, the relief well could be fitted with a large diameter hose that could discharge into a filter bag. Using a large tank to store displaced water and sediment might also be required.

Todd Lorenzen, one of the senior geotechs at Pioneer, who does deep foundations, suggested drilling and casing a hole, running a concrete tremmie down the casing, pumping concrete to the bottom through the tremmie so the concrete is not exposed to free water until the end of the casing.   He thought we could gradually pull the casing as the void fills with concrete.   If we were able to pull the casing, we could get use a stiffer concrete mix of around a 6” slump, to be certain it would not get diluted by the groundwater.

Soil Binder Shaft Cap

After the deep voids in the shafts have been filled with cement, HMI Soil Binder could be used to form a thick cap in the lower portion of the subsidence cone. The binder, which is introduced as a liquid, could also bind the wood and debris together. But, it might be acceptable to just sandwich the debris zone between concrete and the HMI Soil Binder cap. We could install anchors into the soil binder cap or compaction grout above it. In either case, it would partially stabilize a portion of the subsidence cone. The thickness of the zone would be around 8 feet.

Subsidence Cone Stabilization

Compaction grouting could be used to stabilize the portion of the subsidence cone that is above the water table and the collapsed cap. Angle holes would be required to get to as much of the area beneath the deck as possible. Possibly grout with a compressive strength of around 300 psi could be used; so that placement of this material would not restrict future development of the property. The HMI Soil Binder would probably need to be used in conjunction with compaction grouting to build a series of walls along the house foundation and under the deck in those areas that we can't reach without removing the deck. Obviously, construction would be easier if the deck could be removed and then be rebuilt. But this would not be absolutely necessary.

Structure Anchors For Deck Stabilization

If the active zone on the west side of the shaft is narrow and only extends beneath the deck, the deck posts could be supported by grout anchors at a cost of about $17,000. The anchors would be drilled and grouted and would extend to a depth placing them in firm/undisturbed material. Some temporary modification of the deck might be necessary to implement this option. This option has been extracted from the attached Pioneer Technical Services Report.

Structure Anchors For House Stabilization

If it is necessary to support the house, a suite of micropiles could be employed. Micropiles are anchors that can be installed beneath the existing footing to provide support for the structure. The piles are installed by drilling a cased hole beneath the footing, installing a steel high strength anchor and backfilling the hole with grout. The high strength steel is then fixed to the bottom of the footing. The micropile will transfer the load from the house to materials at depth with adequate strength to support the structure. Hence, the load would be moved off the weak settling ground. For engineering design and installation of six 30-foot long micropiles the cost would ber around $45,000. An additional cost of $10,000 would be required to remove the existing deck. A supplementary site investigation would also be required to assure proper design. See the attached Pioneer Technical Services Report from which this option has been extracted.

SUMMARY

The site investigation has confirmed that the shaft is a 8’8” x 16’2" double compartment shaft. The western wall of the shaft runs along the front edge of the deck that is attached to the rear of the house at 512 South Adams Avenue. The bottom of the shaft appears to end in sand and gravel at a depth of 80 feet. The in place material is very stable and hard at this depth. Above this depth, the shaft was sunk through sand and gravel valley fill that contains numerous intermixed boulders. The bottom depth of the shaft coincides with the local verbal history, which indicates that Hymer abandoned the project immediately after his son was killed on the shaft sinking project.

We have also confirmed that the shaft was lined with timbers. The condition of the timbers is relevant with respect to the subsidence cone that has formed or is forming around the shaft as intact timbers stabilize the bottom edge of the cone. Because the areal extent of the cone is much greater to the south than to the north, it would seem to follow that the depth of the subsidence cone is deeper on the south side of the shaft. The reason for this difference is most likely related to the condition of the timbers. Where the timbers have remained intact to a higher elevation, ground movement has been restricted. In areas where the timbers have rotted or buckled at a lower elevation, the ground on that side of the shaft has been affected to a greater depth.

Although this drilling investigation encountered the water table at a depth of 24 feet, it probably fluctuates seasonally and from year to year. Below a depth of 27 feet the flow was significant. At about 22 feet below the surface, the timbers are rotten or have completely rotted away. Eventually, those timbers that are not perpetually covered by water will rot, causing some portion of the subsidence cone to move downward as more ground slumps into the shaft.

The fact that a portion of the shaft is situated below the ground water table is also significant because that portion of the shaft is flooded. When the shaft cap and upper timbers initially collapsed, some of the timbers fell down into the water and floated on the surface. Some of the timbers got pushed below the water surface and became saturated. So they have remained solid for over 100 years. At any rate, there is a rat's nest of timbers, boulders, garbage, sand and gravel that is situated near the water level in both compartments of the shaft. To some degree, the fill that has been dumped into the subsidence depression at the surface has pushed the nested material further down into the water. Although some fine sand and silt gets washed through the blockage each year, there is a zone above the bottom of the shaft in each compartment that is just filled with super-saturated silt and water. Because there was an attempt to fill the southern compartment with grout, that compartment contains much coarser firmer material.

In addition to having a rat's nest of collapsed timbers and debris floating and/or wedged into each compartment 25 feet to 35 feet below the surface, there is a subsidence cone that extends up to the surface on an angle from the top of the intact portion of the shaft. The material inside the cone could be the native sand and gravel that has slumped around shaft. Or, it could be loose fill materials that have been imported and dumped a surface depression. This material is pushing downward on the semi-floating rat's nest of timbers and debris, causing it to gradually move deeper into the shaft. Since the site does not drain, water collecting over the subsidence cone tends to wash fine material out of the fill and down into the shaft.

When we drilled down through the southern compartment of the shaft, we did encounter lenses of the grout that was injected in 1998. Nearly all of the grout was found between no more than 35 feet below the surface. We probably encountered sand and fine gravel that had been associated with the grout at greater depths. But, the cement used in the grout was not evident. Grouting into a flooded space usually requires some special techniques; to prevent separation.

DEEP SHAFT STABILIZATION COST ESTIMATE				
			Unit Cost	Cost
Mobilization			LS	$11,000
Pollution Liability Insurance			LS	$20,000
House Protection			LS	$1,000
Shaft Bridging			LS	$3,000
Drilling	234	Feet	$20.00	$4,680.00
Casing	234	Feet	$25.00	$5,850.00
Casing Fittings			LS	$2,000
Concrete Pump Truck	1.47	days	$1,440.00	$2,117.97
Concrete	147	Cubic Yards	$156.00	$22,944.71
Contractor Extra Labor	80.00	Hours	$45.00	$3,600.00
Filter Bladder			LS	$5,000
Mud Tank			LS	$2,000
Water Disposal			LS	$1,000
Mud Disposal	44	Cubic Yards	$12.00	$529.49
Jack Casings			LS	$5,000
Soil Stabilization	54.5	Cubic Yards	$350.00	$19,081.48
Cleanup			LS	$4,000
Total Cost				**$112,803.66**

The initial reclamation approach should be to stabilize the subsidence cone by filling the bottom 50 feet of the shaft. One option would be to fill the shaft with fine aggregate concrete. Because there does not appear to be any communication between the compartments at this depth, two drill holes for each compartment will be required. One hole will be drilled to the bottom of the shaft. The other hole will be drilled through the bottom of the rat's nest. Concrete would be pumped down the deeper hole while water and sediment are evacuated out the other hole. The injection casing would be gradually raised until the cement is being pumped directly in to the nest of timbers and debris. Due to the tight space and lack of drainage, disposal of wet materials and equipment stationing are expected to be significant problems. Doing further subsidence stabilization should be postponed until the results of the deep shaft filling have been evaluated. After the subsidence cone has been stabilized by filling the intact portion of the shaft, compaction grouting, anchors, or soil binder could be used locally to stabilize critical areas. This option would require a complete pre-construction home inspection focusing on existing structural damage because this stabilization could potentially cause damage to the structure.

A possible alternative would be to treat the bottom 62 feet of the shaft with HMI Soil Binder, which was designed for sinkhole stabilization and can be applied under water. Prior to injecting the fluid, gravel could be placed into the northern shaft. The HMI Soil Binder stabilization is reported to cost $350 per yard of soil stabilized. If the treatment volume in the shaft is around 200 cubic, as estimated for the preceding concrete/ soil concept; then, the cost would be at least $70,000. Although the total construction cost would likely exceed $120,000, there would be no risk of causing damage to the house. The product manufacture will need to be contacted to gain additional information on this product and its approved applications before this usage can be recommended.

Best Regards.

David M. Murja.
Spectrum Engineering, Inc.
1413 4th Avenue North
Billings, MT 59101

Appendix A
Project Photographs

001-Angle Drilling H-1

002-H-1 Hole Location

003-Compressor and Oher Equipment in Alley

004-Hit Water Table In H-1

005-Setting Up on H-3

006-Standard Penetration Test on H-3

007-Split Spoon Sample

008-Drilling H-3

009-Collecting Chip Sample at H-3

010-Pumping Water While Drilling H-3

011-H-2 Over The North Compartment

012-H-2 House Protection and Supervision

013-Dealing With The Water in H-2

014-H-2 Location In Back Yard

015-O-Dex Hammer Bit

016-Moving To H-4 On Timber Bridge

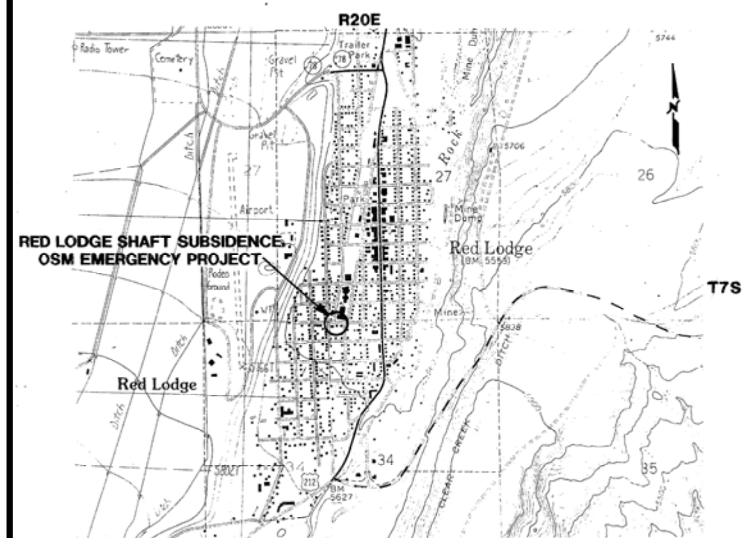
017-H-4 Location

018-Penetration Test on H-4

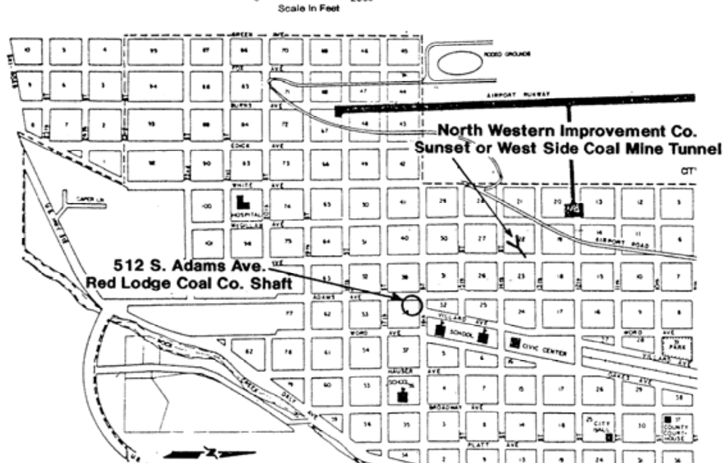

019-Pre-Drilling Back Yard


020-Deck at 512 S. Adams

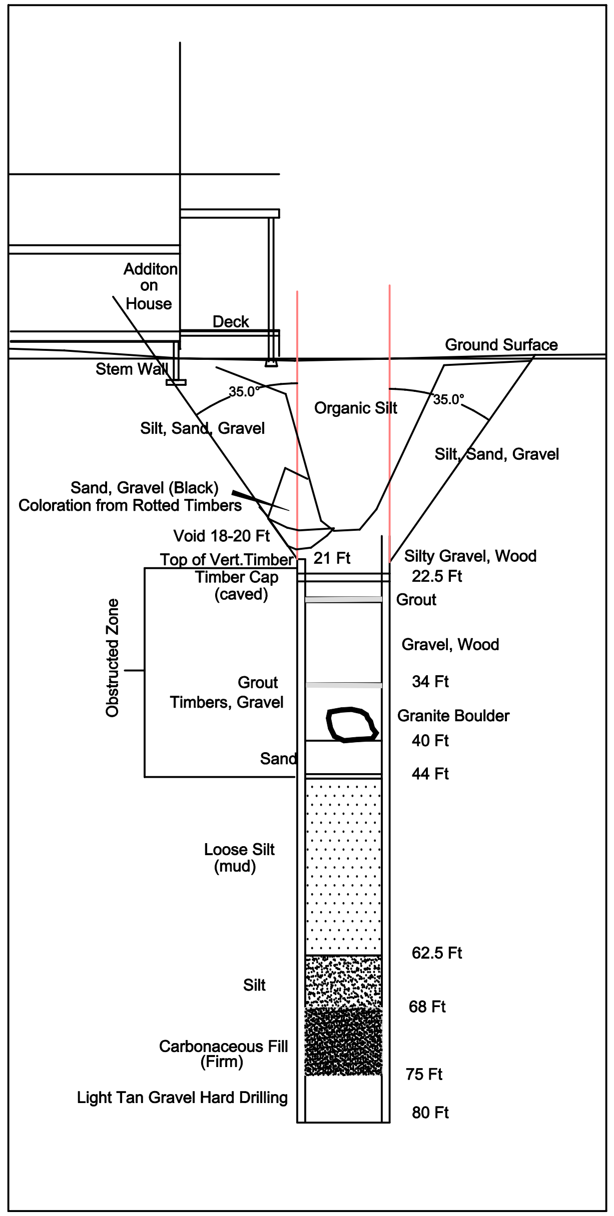
Appendix B
Site Map

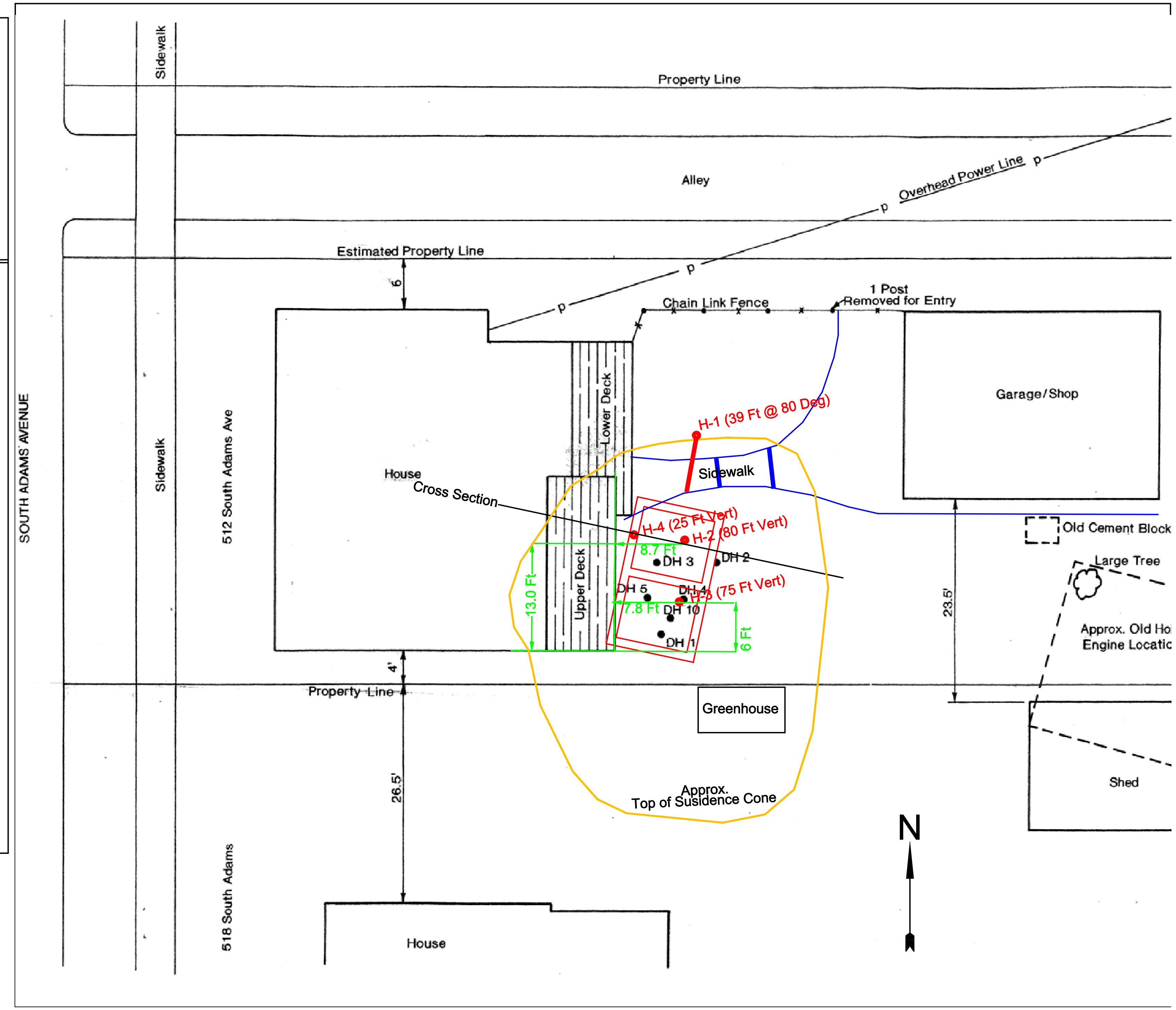


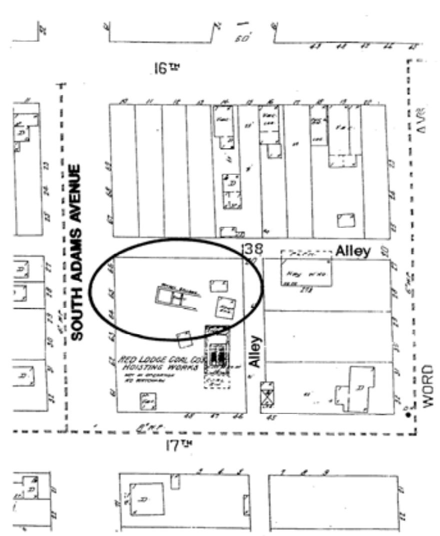
AREA LOCATION MAP



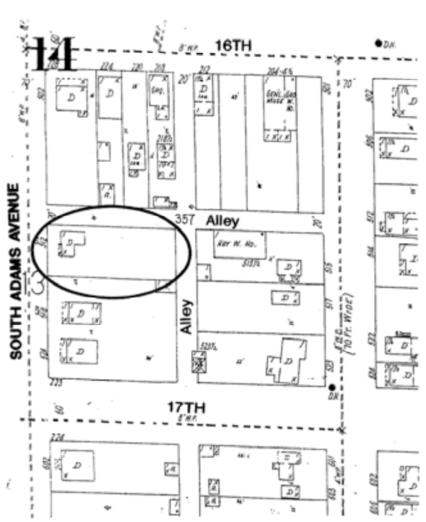
CITY OF RED LODGE MAP







1907 SANBORN FIRE INSURANCE RATING MAP SHOWING SURFACE PLANT AND SHAFT LOCATION OF THE RED LODGE COAL COMPANY.



1927 SANBORN FIRE INSURANCE RATING MAP SHOWING HOUSE CONSTRUCTED ON LOT C. 1917 WITH COAL PLANT & SHAFT GONE.

Note 1 - 62 Cubic Yards of Grout and Neat Cement Were Injected Into DH4 in 1998
DH 1, DH 2, DH 3, DH 4, DH 5 AND DH 10 were drilled in 1998

Note 2 - H-1, H-2, H-3 and H-4 were drilled on August 2012.

HYMER SHAFT

Constructed by the Red Lodge Coal Company 1904-1906
8 Ft-8 In X 16 Ft-2 In Double Compartment Shaft
Lined with 10"x10" timbers and 3"x12" lagging.

SPECTRUM ENGINEERING 1413 4th Ave. North Billings, MT 59101 Phone: (406) 259-2412 October 2012	STATE OF MONTANA Department of Environmental Quality REMEDIATION DIVISION 1100 Last Chance Gulch Helena, MT 59620	N½ Section 34 of T7S, R20E Carbon County, Montana HYMER SHAFT 512 Adams Ave. South, Red Lodge FILE NAME: Red Lodge Subsidence SHEET NO. 1

Appendix C
Borehole/Soil Testing Logs

Drill Hole No. H-01

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/13/12 - 8/13/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 9.5' S8SE of porch	HAMMER TYPE: 140-Auto

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

DEPTH (FT)	SAMPLES: BULK	SAMPLE ID	MATERIAL DESCRIPTION	REMARKS / TESTING
0–6	X	B#1	Dry, Very dark brown [10YR 2/2], ORGANIC SILT, OL, non-plastic, soft.	Driller pushed casing and bit without hammer.
6–8	X	B#1	Dry, Very dark brown [10YR 2/2], SILTY GRAVEL with Sand, GM, non-plastic.	
8–9.5	X	B#1	Moist, Very dark brown [10YR 2/2], SILTY GRAVEL with Sand, SM, non-plastic.	
9.5–14	X	B#2	Dry, Very dark grayish brown [10YR 3/2], SILTY GRAVEL with Sand, GM, non-plastic.	
14–15.5	X	B#2 / B#3	Moist, Very dark grayish brown [10YR 3/2], GRAVEL, GP, non-plastic, Boulder.	
15.5–21.5	X	B#3 / B#4	Moist to Saturated, Very dark grayish brown [10YR 3/2], GRAVEL with Sand, GP, non-plastic.	

Columns also present (no data): WELL LOG, GRAPHIC LOG, DRIVE, UNDISTURBED, RECOVERY (%), LIQUID LIMIT, PLASTIC LIMIT, CORRECTED SPT, DRY DENSITY (pcf), MOISTURE (%).

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

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WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		21–25			X	B#4		Moist to Saturated, Very dark grayish brown [10YR 3/2], GRAVEL with Sand, GP, non-plastic. *(Continued)*						
		25–30			X	B#5								
		32–34			X	B#6		Saturated, Dark yellowish brown [10YR 4/4], GRAVEL with Sand, GP, non-plastic.						Hard drilling ,probably tight boulders and cobbles, cuttings are granitic.
		35						Saturated, Very dark brown [10YR 2/2], SAND with Gravel, SP, non-plastic, dense.						
		36–38.5			X	B#7		Saturated, Light gray [10YR 7/2], non-plastic, Grout.						
		37						Saturated, Very dark brown [10YR 2/2], SAND with Gravel, SP, non-plastic.						
		39												Total Depth 39 ft

Depth scale: 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

Drill Hole No. H-02

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/14/12 - 8/15/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 17' N of S Fence, 9'E of deck fence	HAMMER TYPE: 140-Auto

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WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		0–16.5			5–10 (bulk)	B#1		Moist, Black [10YR 2/1], ORGANIC SILT, OL, soft.						Time: 2:00 PM
		16.5–20.5						Moist, Black [10YR 2/1], GRAVEL, GP, loose.						

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

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WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
▽ (approx. 24)		21–25			X	B#2		Saturated, Very dark grayish brown [10YR 3/2], SILTY GRAVEL, GM, medium dense. *(Continued)*						
		25–25.5						Moist, Light gray [10YR 7/1], loose, Grout.						
		25.5–34			X (25–30)	B#3		Saturated, Very dark grayish brown [10YR 3/2], GRAVEL, GP, loose to medium dense.						Very slow drilling
		34						Saturated, Light gray [10YR 7/1], loose, Grout.						
		34–37						Saturated, Dark gray [10YR 4/1], GRAVEL, GP, medium dense.						
		37–40						Saturated, Dark gray [10YR 4/1], GP, medium dense, Boulder.						Large boulder (37-40')
		40–43.5			X (40–44)	B#4		Saturated, Dark gray [10YR 4/1], SAND with Gravel, SP, loose.						
		43.5–44						Saturated, Black [10YR 2/1], SAND with Gravel, SP, very loose.						

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WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		44–49						Saturated, Black [10YR 2/1], SAND with Gravel, SP, very loose. *(Continued)*						Return water reduced 2-3 gal/min SS#1 fell entire distance under weight of rods
		45–46.5	X			SS#1	94				0			
		48–49.5	X			SS#2	0				2			
		49–62						Saturated, Black [10YR 2/1], SAND with Gravel, SP, very loose, abundant coal.						
		50–51.5	X			SS#3	61				4			
		55												Advance drill from (50-55') in 5 mins
		60												Advance casing without hammer, took 5 mins
		62–67						Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, loose.						Firmer drilling but still loose materials

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

PROJECT NAME: 512 South Adams

Drill Hole No. H-02

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

DEPTH (FT)	MATERIAL DESCRIPTION	REMARKS / TESTING
67–68	Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, loose. *(Continued)*	
68–75	Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, loose.	
75–80	Saturated, Light brown [7.5YR 6/3], GRAVEL, GP, dense.	Much harder drilling at 75'. Return water at 20-30 gpm
81		Total Depth 80 ft

Columns: WELL LOG, GRAPHIC LOG, DEPTH (FT), SAMPLES (DRIVE, UNDISTURBED, BULK), SAMPLE ID, RECOVERY (%), MATERIAL DESCRIPTION, LIQUID LIMIT, PLASTIC LIMIT, CORRECTED SPT, DRY DENSITY (pcf), MOISTURE (%), REMARKS / TESTING

Depth scale: 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

Drill Hole No. H-03

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/13/12 - 8/14/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 10' from south fence, 7' E of porch	HAMMER TYPE: 140-Auto

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

DEPTH (FT)	SAMPLES (DRIVE / UNDISTURBED / BULK)	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
0–10.5				Moist, Very dark brown [10YR 2/2], ORGANIC SILT, OL, no to low plasticity, soft.						Easy drilling
10.5–12.5	Drive (10–11.5)	SS#1 SS#2		Dry to moist, Light gray [10YR 7/1], non-plastic, hard, Grout.						Cuttings smell like cement
12.5–14				Moist, Black [10YR 2/1], SILTY GRAVEL, GM, no to low plasticity, loose.						Silt stuck to cuttings
14–16	Bulk (15–20)			Dry to moist, Light gray [10YR 7/1], non-plastic, hard, Grout.						Cuttings have granitic origin
16–17.75	Bulk	B#1		Moist, Black [10YR 2/1], ORGANIC SILT with GRAVEL, OL, firm.						
17.75–21	Bulk (20–21)	B#2		Moist, Very dark brown [10YR 2/2], ORGANIC SILT with GRAVEL, OL, organic odor, firm.						Rotten timbers at 21, smells like sewage

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PROJECT NAME: 512 South Adams

Drill Hole No. H-03

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Column headings: WELL LOG | GRAPHIC LOG | DEPTH (FT) | SAMPLES: DRIVE, UNDISTURBED, BULK | SAMPLE ID | RECOVERY (%) | MATERIAL DESCRIPTION | LIQUID LIMIT | PLASTIC LIMIT | CORRECTED SPT | DRY DENSITY (pcf) | MOISTURE (%) | REMARKS / TESTING

Depth scale (ft): 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

Sample (type)	Sample ID	Material Description	Remarks / Testing
		Dry, Light gray [10YR 7/1], hard, Grout.	Cuttings are dust
Bulk	B#2	Moist to wet, Very dark brown [10YR 2/2].	
		Moist, Light gray [10YR 7/1], hard, Grout.	Cuttings smell like cement
		Saturated, Very dark brown [10YR 2/2], wood debris.	
		Saturated, Black [10YR 2/1], ORGANIC SILT, OL, organic odor, soft.	Hole returns high volume of water
Drive	SS#3	Saturated, Dark grayish brown [10Y 4/2], SAND with Gravel, SP, soft, wood debris.	
		Saturated, Light gray [10YR 7/1], Grout.	Cuttings are a mixture of wood debris and grout
		Saturated, Very dark grayish brown [10YR 3/2], SAND with Gravel, SP, loose, wood debris.	
Bulk	B#3	Saturated, Very dark grayish brown [10YR 3/2], SAND with Gravel, SP, loose, wood debris.	
		Saturated, Black [10YR 2/1], SAND with Gravel, SP, loose, wood debris.	

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PHONE NUMBER:

PROJECT NAME: 512 South Adams

Drill Hole No. H-03

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DEPTH (FT)	SAMPLES (BULK)	SAMPLE ID	MATERIAL DESCRIPTION
44–49	Bulk (to 45)	B#3	Saturated, Black [10YR 2/1], SAND with Gravel, SP, loose, wood debris. *(Continued)*
49–56.5	Bulk (from 55)		Saturated, Black [10YR 2/1], SAND with Gravel, SP, loose, trace wood debris.
56.5–67	Bulk (55–60)	B#4	Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, medium dense, trace wood debris, abundant coal.
	Bulk (60–65)	B#5	

Columns: WELL LOG | GRAPHIC LOG | DEPTH (FT) | SAMPLES: DRIVE, UNDISTURBED, BULK | SAMPLE ID | RECOVERY (%) | MATERIAL DESCRIPTION | LIQUID LIMIT | PLASTIC LIMIT | CORRECTED SPT | DRY DENSITY (pcf) | MOISTURE (%) | REMARKS / TESTING

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WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		67–75			X (70–75)	B#6		Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, medium dense, trace wood debris, abundant coal. *(Continued)*						
		75–90												Total Depth 75 ft

Depth scale: 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

Drill Hole No. H-04

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/15/12 - 8/15/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 17'N of S Fence, 2' E of deck face	HAMMER TYPE: 140-Auto

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		0–8						Moist, Black [10YR 2/1], ORGANIC SANDY SILT, OL, firm.						
		0–5			X	B#1								
		5–6.5	X			SS#1	67				7			
		8–18						Wet, Very dark gray [10YR 3/1], SILTY GRAVEL, GM, firm.						
		10–11.5	X			SS#2	28				9			
		15–16.5	X			SS#3	6				7			Small amount of wood debris in cuttings
		16.5–18			X	B#2								
		18–20						Void.						Driller notes a void between (18-20')
▼		20–21.5	X			SS#4	11	Saturated, Very dark gray [10YR 3/1], SILTY GRAVEL with Sand, GM, very loose.			2			

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PHONE NUMBER:

PROJECT NAME: 512 South Adams

Drill Hole No. H-04

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		21–25	X			SS#4	11	Saturated, Very dark gray [10YR 3/1], Abundant Wood Debris.			2			Primarily of wood debris in cuttings (20-25')
		26												Total Depth 25 ft

Depth scale: 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

,

PHONE NUMBER:

DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

Appendix D
Geotechnical Report
Pioneer Technical Services, Inc.
Jeffrey J. Riedel, PE
Pat Redman, PE

PIONEER TECHNICAL SERVICES, INC.

September 17, 2012

Mr. Dave Murja
1413 4th Ave North
Billings, MT 59101

MONTANA
JEFFREY J. RIEDEL
No. 17359 PE
LICENSED
PROFESSIONAL ENGINEER
9-17-12

RE: Hymer Mine Shaft Subsidence Geotechnical Report

Dear Dave,

This letter summarizes our observations of the geotechnical subsurface conditions and presents recommendations for stabilizing the existing residential structure located at 512 South Adams Ave, in Red Lodge, Montana.

SCOPE OF SERVICE

Pioneer Technical Services, Inc was contracted by Spectrum Engineering to participate in field investigations that included: characterization of the conditions within the existing mine shaft, providing geotechnical and engineering interpretation of the data, and preparing potential remedies to support the existing porch structure. Recommendations are based on observations made from four boreholes that were drilled in the general location of the Hymer Mine Shaft as shown on the site plan in Figure 1.

SITE INVESTIGATION

Field Data Collection: Drilling Investigation

Four boreholes were drilled between August 13th, 2012 and August 15th, 2012 by Axis Drilling using a track-mounted Davey Kent drill and employing a STATEX drilling methodology. The first three boreholes (H-1, H-2, and H-3) were drilled to determine the existing condition of the two suspected shaft compartments. The fourth borehole was drilled to evaluate the geotechnical properties beneath the existing porch and geotechnical samples were collected. Borehole locations are shown in Figure 1. Mr. Jeffrey Riedel, P.E., a geotechnical engineer with Pioneer Technical, logged the boreholes and field logs were prepared that recorded the observation of the geotechnical engineer. Each sample was carefully observed as it was recovered and soil classification, moisture condition, and the presence of organic and other notable features were recorded in the field logs. Disturbed samples were sealed in thick plastic bags and/or 5-gallon buckets and transported to the Pioneer Soils Laboratory in Belgrade, Montana for testing and additional classification. Field observations are presented on the borehole logs in Attachment 1.

All soils were classified in accordance with the United Soils Classification System and texturally in accordance with ASTM Test Method D-2487/2488. The stratification lines shown on the borehole logs represent the approximate boundary between soil types as observed in the boreholes. The actual *in-situ* transition may be either gradual or abrupt and typically changes within the limits of the house footprint. Due to the depositional characteristics of natural soils, care should be taken in interpolating subsurface conditions beyond the location of the boreholes. The following is a summary of the findings in each of the boreholes.

Borehole H-1 was drilled slightly north of the suspected mine shaft location, approximately 3-feet north of the sidewalk and 17-feet south of the existing northern fence line and 9.5-feet east of the lower deck face. It was drilled 39-feet at an angle of 80° from the horizontal and at an azimuth of S2°E. The borehole was intended to verify the integrity of the material in the area of the mine shaft to allow for safe drilling operations and to locate the north side of the shaft. Relatively dense apparently void free material was encountered through the bottom of the borehole, at a vertical depth of 38.5 feet. The upper 0-6 feet is a soft organic silt (ML). From 6 feet to 35 feet, the materials were Silty Gravels (GM) with an 18-inch boulder at 14-feet. Near the bottom of the hole, at 35 feet, Poorly Graded Sand with Gravel (SP) was encountered along with a thin layer of soft, grout-colored sand, indicating potential grout from previous stabilization attempts. This hole had advanced 6.8 feet horizontally from the surface location of the borehole. The hole was terminated at a depth of 38.5-feet, the gravels were binding the casing and casing advancement was getting too difficult.

H-2 was located 17-feet north of the property line and 8.7-feet east of the upper deck. The hole location was anticipated to be situated within the northern compartment. The borehole was drilled to a total depth of 75 feet. The upper 16.5 feet of the material was soft to medium stiff organic silt (ML) with easy drilling. From a depth of 16.5 to 25 feet, the cuttings suggested zones of wood and loose silty gravel (GM), again with relatively easy drilling. Water was encountered at a depth of 24 feet. At a depth of 25 feet, return water changed to the color of grout for approximately 0.5 feet. At a depth of 25.5 feet, drilling rates slowed significantly and cuttings changed to olive green. Cuttings appeared to be produced from a granitic host, chips of quartz and alkali feldspars that originated from granitic rock in the alluvium. Slow advancement rate and granitic cuttings in alluvium continued to a depth of 34 feet. In this zone the borehole was producing approximately 5-10 gpm of water. At a depth of 34 feet a 3-inch layer of grout was interpreted from the color of the cuttings. At an approximate depth of 34 feet, significant wood debris were observed in the cuttings along with granite host cuttings, slow advancement rate continued with 5-10 gpm of water production. At a depth of 37 feet, the advancement rate slowed even further for a distance of 3 feet, this interval was interpreted to be a granitic boulder. At a depth of 40 feet, the drill was through the boulder and the production of water reduced to 2-3 gpm and cuttings indicated a very loose sand mixed with gravel. The lower water production is interpreted to be caused by an increase in fine grained materials at this depth.

At a depth of 45 feet a split spoon sample was taken, the sampler fell under its own weight, as if it was resting on the edge of something then slipped off. The sampler rods were caught by the lower hydraulic clamps and did not appear to stop on firm material. An additional 5 feet of rod was attached and the sampler was lowered to 48 feet, three feet past end of casing. This zone is interpreted as a possible void. Each of the three 6-inch intervals took 1 blow for an uncorrected N value of 2 and the material is described as very loose. The casing was then advanced to a depth of 50 feet and a split spoon sampler was lowered. The uncorrected N value was 4 and the material was still described as very loose. The driller was then able to advance to 55 feet in 5 minutes by only spinning the casing and again to 60 feet in 5 minutes by only spinning casing, implying the very loose material continued. Cuttings observed between 50 to 62.5 feet consisted only of 1/4 inch chips of coal, similar to H-3 near the same depth. This suggests potentially coal infill within the north shaft at this elevation. Between 62.5 to 75-feet the materials became relatively more firm, though still loose. At a depth of 75 feet, the color of the cuttings changed to light tan and the cuttings were ¼ to ½" chips (granitic) and the production of water greatly increased to 20-30 gpm. The depth of 75 feet was interpreted as native ground and the hole was ended at 80 feet in depth.

Borehole H-3 was drilled to inspect the condition of the southern shaft compartment. The hole was drilled 10-feet north of the southern fence line and 7.8-feet east of the upper deck-face. The upper 10.5 feet was soft to medium stiff organic silt (ML) and the drilling was very easy. From a depth of 10.5 to 36 feet cuttings showed interbedded layers of grout (1-2 feet in thickness), rotten wood fibers and organic silt. A 1.5-foot thick layer of grout first appeared at a depth of 10.5 feet. A split spoon sampler identified the top of this grout layer. The grout was very dense, and the spoon could not penetrate the grout without significant effort. Apart from this grout layer, drilling was relatively easy to 36-feet. Water was initially encountered around 20 feet of depth. From 36 to 40 feet significant quantities of loose, medium-grained sand was observed and wood debris. The production of water decrease in these sands. From 40 to 57 feet cuttings were a mixture of wood debris, gravels and soft grout. In this interval, the hole produced approximately 10 – 20 gpm of water and the material was very loose and drilling easy. At 57 feet, materials were more firm, but still loose. Material at depths of 57 to 77 feet were black coal chips and wood debris. The chips are interpreted to be mine waste rock. At 70 feet water production from the casing increased from 10-20 gpm to 30-40 gpm. The borehole was ended at 75-feet in depth, where the gravels were binding the casing. Native materials were not located in this hole. Although, the increase in water production implies the native materials may be near 75-feet.

The intention of borehole H-4 was to obtain geotechnical data for the *in-situ* alluvial material between the northern compartment and the deck face. The borehole was located where a vertical geotechnical hole would give information about the materials beneath the deck, without dismantling a portion of the deck. The hole was located 17-feet north of the southern fence line and 2-feet east of the deck face. The upper 8-feet of material was soft to medium stiff organic silt (ML). Drilling through this interval was very easy with uncorrected blow counts at a depth of 5 feet of N=7, equivalent to medium consistency. At a depth of 8-feet, the materials transition from organic silt to loose silty gravel (GM) and then to a poorly graded gravel with sand (GP) at a depth of 15 feet. The interval between 10 to 15 feet showed silty gravels (GM) and wood debris. At a depth of 18- 20 feet the driller noted a void. At a depth of 20-feet the uncorrected blow counts were 2 and the materials described as very loose silty gravel with sand and wood. At depths between 21.5 and 25 feet the cuttings were predominantly wood debris. The wood debris was interpreted to be the shoring for the west side of the chamber, the borehole was abandoned since it was believed the hole was above the shoring or collapsed timbers mixed with alluvium.

The subsurface conditions were interpreted from the field observations, observation of cuttings, and the performance of the drill. The soil properties inferred from the field analyses, supported by our experience, formed a basis for developing our conclusions and recommendations.

Field Data Collection: Surface Observations

As shown in survey data presented in Attachment 11 of Spectrum Engineering's letter to the Montana DEQ dated February 29, 2012, and included in Attachment 2 of this document, the ground surface above the suspected location of the buried mine compartments indicates a depression. Based on site observations, the eastern boundary of the depression is defined by a notable lip that exists approximately 25 feet from the estimated center of the shaft. To the northeast, the boundary of the depression is a series of cracks observed in a concrete sidewalk approximately 20 feet from the shaft. The arch-shaped boundary of the depression appears to wrap south beneath the southern fence line, to the west of the shaft; notable surface features are difficult to see because the upper and lower deck and the home obscure the ground surface. However, surface displacement beneath the deck posts were noted by the home owner.

Groundwater Observations

Ground water levels were inferred from drilling and are shown on the borehole logs. The groundwater conditions were also loosely inferred from the volume of return water from the casing. In general, return water fluctuated with respect to the grain size and the depth. Smaller particles surrounding the bit typically lower the return water flow and greater depth increases the head above the end of the open casing. The greatest volume of water was produced in the native gravels in H-1 and H-2. The high water volumes suggest the native a gravels have high permeability while the shafts have lower permeability due to the abundance of fine-grained material, grout and timbers, mixed into the in-filled shafts.

GEOTECHNICAL ENGINEERING ANALYSIS AND RECOMMENDATIONS

Interpretation of Subsurface Conditions

The location of borehole H-3 was assumed to be in the southern shaft compartment. The purpose of this hole was to inspect the condition of the grout that had been placed in the shaft in 1998. As discussed above, the upper 10.5 feet of the material was soft to medium stiff organic silt. From a depth of 10.5 to 36 feet cuttings showed layers of grout (1-2 feet in thickness), rotten wood fibers and organic silt.

The first layer of grout was encountered at 10.5 feet in depth. Immediately beneath the grout was a mixture of fill materials consisting of alluvial gravels and organic silt that was likely placed above the shaft. The first appearance of wood debris occurred at a depth of 18 feet, and is assumed to be where the remaining shaft begins. Then the drill went through several relatively thin layers (1-foot thick) grout (depths of 21.5 – 22.5 feet, and 26 - 27 feet), and a thicker layer (33 – 36 feet). A potential timber cap was sandwiched between two thin grout layers at depths of 22.5 - 26 feet below the surface.

Grout was also found in H-2, at similar depths to hole H-3, suggesting the grout material spread out when it was injected. This would indicated a connection or collapse between the two shafts. The timbers encountered between 18 to 30 feet in depth appear to be significantly deteriorated. The cuttings within this interval also smelled organic and appeared rotten. The deteriorated timbers are possibly within the range of seasonal groundwater fluctuation where the timbers are cyclically saturated and exposed to air as the groundwater elevation fluctuates. This would accelerate decomposition of the timbers. Timbers below 30-feet gave off the odor of pine. These timbers likely remained underwater and are much less decayed.

From 30 to 40 feet, the drill went through a mixture of wood and sand, the cuttings were the color of cement but drilling was not hard. Some or all of this material could be remnant grout that was placed inside the compartment in 1998. The hole did not penetrate any significantly hard grout layers in this interval.

Below 40 feet, the materials were a very loose to loose mixture of silty gravels and minor amounts of wood debris to a depth of 65 feet. Between the depths of 65 to 75 feet, cuttings consisted of wood and coal chips. The cuttings also had a small amount of cloth and metal. The material in this interval was medium dense and native gravels were not encountered.

Borehole H-2 was drilled to explore the northern compartment of the shaft. As described previously, the upper 16.5 feet of the material was soft to medium stiff organic silt. This was interpreted to be fill that had been placed over the collapsed shaft location. From a depth of 16.5 to 25 feet, the cuttings suggested zones of wood and silty gravel (GM) of granitic origin, with a thin (0.5 feet) zone of cement colored sand at 25 feet. From 25 to 37 feet the material became medium dense and the drilling rate slowed. At a depth of 34 feet a 3-inch layer of grout was interpreted from cuttings color, but was not hard. At a depth of 34.25, significant wood debris was observed in the cuttings along with granite host cuttings. At a depth of 37 feet, the advance rate slowed significantly for a distance of 3 feet to a depth of 40 feet, this interval was interpreted to be a granitic boulder. The materials between 40 feet and 62.5 feet were very loose and were followed by loose materials to a depth of 75 feet, where native alluvial gravels were encountered.

Depths from 16.5 through 40 feet appear to be a collapsed section of the compartment. A large boulder was encountered at a depth of 37 – 40 feet, it appears a section of one of the timber walls of the shaft or the timber cap might have collapsed allowing the boulder to cave into the shaft. Above the boulder the materials transition from loose to medium dense and below the boulder the materials were very loose and transitioned to loose. It appears that the boulder and collapsed timbers are likely supporting the materials above.

As noted above in geotechnical borehole summary, the driller noted a void in borehole H-4 between the interval of 18-20 feet. Immediately beneath the void was a thin layer of loose gravel followed by significant amounts of wood. The void is interpreted to represent settlement of the wood and failure in some fashion of the materials beneath or adjacent to this wood.

Surface Displacement

The observed surface depression may be a consequence of two or three contributing factors. Displacement may be partially caused by settlement of the loose organic silt above a depth of 10 to 16 feet. The organic silt materials were observed to be loose and yielded low Standard Penetration blow counts. Material of this consistency and thickness would have significant settlement potential. However, the lateral extent of these materials appears to be limited, as observations from H-1 and H-4 suggest it quickly gets thinner with distance from the shaft. H-1 shows a thickness of 1 foot and H-4 shows a thickness of 8 feet as opposed to 10.5 feet thick in H-3 and 16.5 feet thick in H-2.

The second, and likely more significant, contributing factor causing the observed surface displacements is the loss/readjustment of material in the existing mine shaft. As discussed above, the materials within both compartments at depths of 20 - 40 feet appeared loose to medium dense. Materials above 36 feet in the southern compartment appear to be partially supported by the grout that was installed in 1998 and also possibly timbers. The materials in the northern compartment appear to be supported by a combination of timbers and collapsed alluvial gravels wedged at 40-feet. In both the compartments the materials below 40 feet are a loose to very loose mixture of debris and appeared to have little competency for supporting the overlying materials. The loose to very loose nature of the lower materials (40 – 60 feet) suggests the timber cribbing is still supporting the adjacent alluvial gravels at this depth and the grout/timbers and boulder/timbers are supporting the materials above 36 and 40 feet respectively.

A collapse above a depth of 40 feet appears to have caused the observed surface displacements and the void observed in H-4. Approximate calculations suggest failure at a depth of 40 feet would result in active wedge failure of materials within approximately a 20-foot radius of the shaft at the surface, shown in Attachment 2. The active zone would likely be a cone of loosened material and will continue to consolidate over time.

A future collapse of the timber cribbing between depths of 40 to 60 feet could cause the formation of a larger active zone. A catastrophic collapse of the shaft at a depth of 60 feet may initiate an active zone with a surface expression up to 28 to 34 feet from the shaft. Based on location of the shaft compartments, the observed surface displacements beneath the porch and the estimated potential radius of the active zone, there is a possibility the materials beneath the house foundation could be adversely affected by continued failure within the shaft.

RECOMMENDATIONS FOR CORRECTIVE ACTON

The materials within the two compartments at depths below 36 and 40 feet are very loose to loose which suggests the cribbing within the shaft is supporting the surrounding alluvial gravels adjacent to the shaft below approximately 40-feet. Above 40-feet the shafts have apparently collapsed. The surface silts directly above the south shaft appear to be loosely supported by thin layers of grout collapsed alluvium and timbers, in the southern compartment, and by timbers and collapsed alluvial gravels in the northern compartment. Continued settlement and displacement of the materials at depth may adversely affect the materials beneath the deck and house by slowly increasing the size of the surface expression. Materials currently within the surface depression may continue to settle since they have been disturbed. This could continue to affect the deck and potentially the house unless stabilized. In addition continued consolidation of the uncompacted organic silt above the shaft may continue to affect the deck.

It is our understanding that Spectrum Engineering is providing a plan to stabilize the mine shaft to limit continued displacement of the materials at that depth. Therefore, the following remediation options assume the shaft is backfilled and further movement of the materials within the shaft is prevented. With successful backfill of the existing shaft compartment; settlement of the existing materials in the active zone will likely decrease with time as the loosened materials are reorganized and settled. Therefore, installation of anchors or foundation support systems into this material should consider potential settlement of these materials.

Potential Solutions

Depending on the extent of the active zone and the amount of the potential settlement remaining in the soils within the collapsed zone around the shaft several options are available for supporting the porch. Each of these options assumes the shaft has been successfully filled and that the remaining subsidence is not deep seated and will gradually decrease with time.

One option to remedy the porch settlement is to fit the porch supports with adjustable post and pad footing supports. Settlement of the active zone will likely continue to occur, even after the shaft compartments are filled, however the magnitude should decrease with time. The porch can be supported with adjustable column brackets, be monitored and re-leveled as needed until the materials cease to settle. The estimated cost to install adjustable post supports is estimated to $5,000 to $8,000.

At the present time, the western extent of the active settlement zone is not explicitly understood and ground anchors will only be affective if they are tied into soils which are not settling. The simplest way to estimate the lateral extent of the active zone of settlement would be to determine if settlement has affected the house foundation. This can be accomplished with a thorough inspection of the foundation walls for cracks and displacements. A lack of observed cracks within the house foundation will not necessarily mean the active zone does not extend beneath the house or that the house will not settle. However, the existence of particular types of cracks may be indicative of settlement effects from the active zone. A thorough visual inspection of the foundation and a report detailing the results and recommendations would cost approximately $4,000.

The western extent of the active zone can be further evaluated with inclinometers. Inclinometers are devices used to measure subsurface displacement through time. The inclinometer casing is a slender tube (about 3 inches in diameter) that is installed into a borehole. If material adjacent to the borehole moves laterally, the movement will be reflected in the inclinometer casing. Movement of the casing is measured with a sensitive electronic device that is inserted into the casing to measure angular deviations in the hole. In this application, the inclinometer would be installed adjacent to the porch and potentially angled beneath the porch. One inclinometer to a depth of 40 feet and monitored once per two months for a period of 12 months including a summary report would cost an estimated $12,000.

Another method to track the surface movements might be to install a series of fixed survey markers around the house and beneath the porch. The markers would be surveyed repeatedly over time. Movement of the survey markers would provide insight into the extent and continued movement of the active zone and provide information on soil movement. Installation and monitoring (4 times over 12 months) and a engineering summary report and recommendations would cost an estimated $10,000.

Depending on the extent and continued displacement of the active zone the following anchoring options may be pursued,

If there is:

1) Little or no continued displacement:

   Do nothing if continued displacement is not observed.

2) Continued displacement that only extends beneath the porch. If the active zone is narrow on the west side of the shaft and only extends beneath the porch, an anchor system would be a feasible system to support the porch posts. The anchors would need to extend into the firm/undisturbed materials at depth. For the design and installation of 2 anchors, oversite and as-built drawings the estimated cost is $17,000. Drilled and grouted anchors would be necessary since helical piers may be affected by large alluvial boulders.

3) If observations of the house foundation, inclinometers and/or survey markers suggest the materials beneath the house are settling, a system of anchors could be considered to limit future movement of the structure. One potential system that would provide this support is a suite of micropiles. Micropiles are anchors that can be installed beneath the existing footing to provide support to the structure. The piles are installed by drilling a cased hole beneath the footing, installing a steel high strength anchor and

backfilling the hole with grout. The high strength steel is then fixed to the bottom of the footing. The micropile will transfer the load from the house to materials at depth with adequate strength to support the structure and the structure will no longer rest on the weak and settling materials. For engineering design and installation of 6, 30 foot micropiles the estimated cost is $45,000. Installation of the micropiles would require the removal of the porch which is estimated at an $10,000 dollars.

The risk involved in installing micro-piles beneath the house may come from limited information regarding the lateral extent of the active zone. If the active zone extends beneath the house too far and micropiles are installed through this active zone, lateral diplacements of the active zone may cause lateral deflection of the piles and in-turn the piles apply lateral forces to the house foundation. Installation of the inclinometers on the on the west side of the shaft should provide the necessary information to target the active zone. However an additional site investigation beneath or adjacent to the home may be required to adequately design the micropiles.

Closure

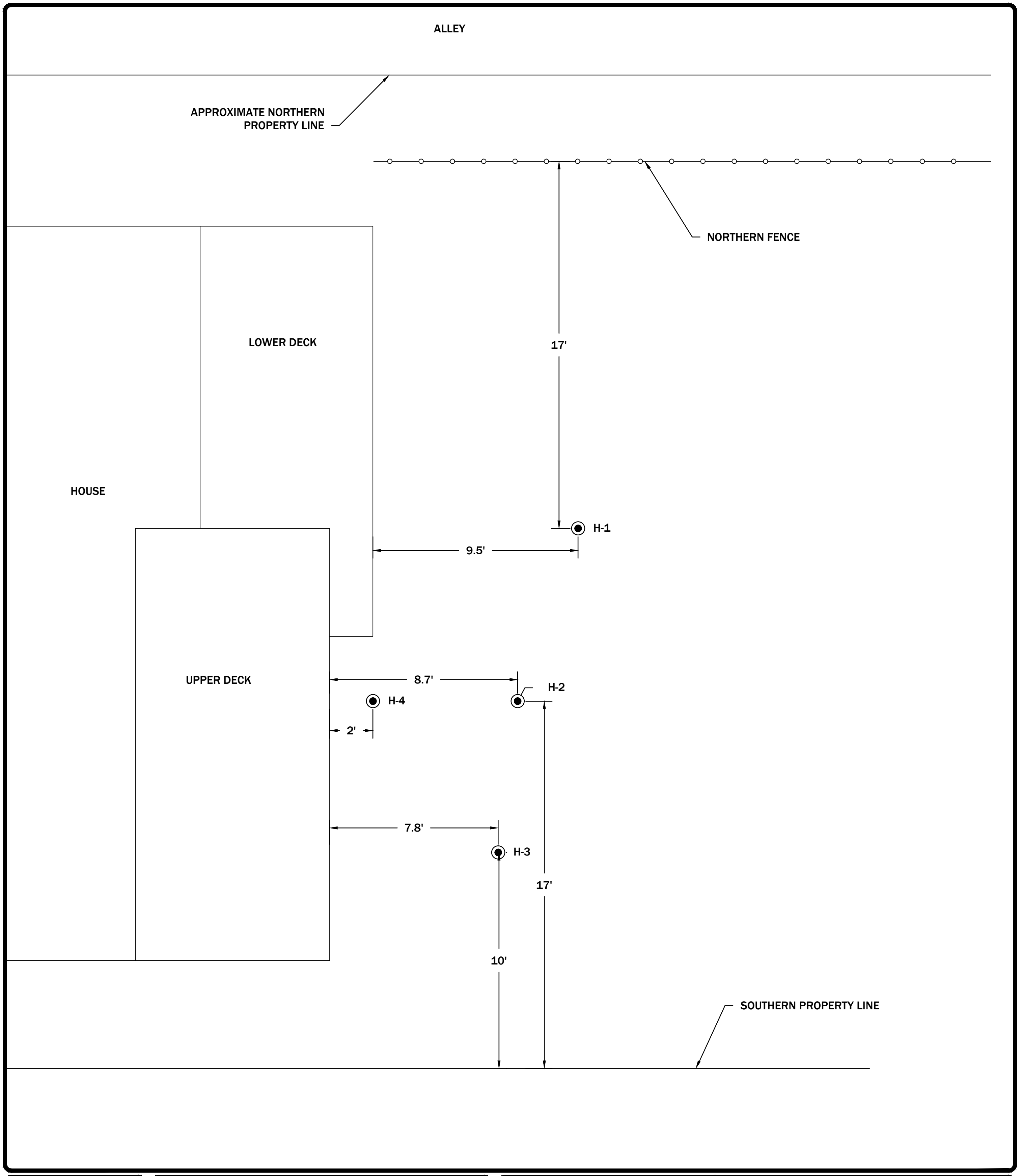
This report assumes the twin shafts are completely remediated and no additional collapse of the existing shafts will occur. We have not provided any design concepts for stabilizing the mine shafts. If this information is desired please feel free to call our office.

It has been our pleasure to assist you on this project. If you have questions, please contact this office at 406-388-8578.

Sincerely,

Jeffrey J. Riedel, PE
Project Geotechnical Engineer

Figures



DISPLAYED AS:	
COORD SYS/ZONE:	NA
DATUM:	NA
UNITS:	FEET
SOURCE:	PIONEER

SCALE IN FEET: 0 3 6

FIGURE 1

HYMER SHAFT GEOTECH INVESTIGATION
512 S. ADAMS
RED LODGE, MT

PIONEER TECHNICAL SERVICES, INC.
1215 APPLES WAY
BELGRADE, MT 59714
(406) 388-8578

DATE: 9-6-12

Attachment 1

Drill Hole No. H-01

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/13/12 - 8/13/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 9.5' S8SE of porch	HAMMER TYPE: 140-Auto

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		0–6			X	B#1		Dry, Very dark brown [10YR 2/2], ORGANIC SILT, OL, non-plastic, soft.						Driller pushed casing and bit without hammer.
		6–8						Dry, Very dark brown [10YR 2/2], SILTY GRAVEL with Sand, GM, non-plastic.						
		8–9.5						Moist, Very dark brown [10YR 2/2], SILTY GRAVEL with Sand, SM, non-plastic.						
		9.5–14			X	B#2		Dry, Very dark grayish brown [10YR 3/2], SILTY GRAVEL with Sand, GM, non-plastic.						
		14–15.5						Moist, Very dark grayish brown [10YR 3/2], GRAVEL, GP, non-plastic, Boulder.						
		15.5–21.3			X	B#3, B#4		Moist to Saturated, Very dark grayish brown [10YR 3/2], GRAVEL with Sand, GP, non-plastic.						

PIONEER TECHNICAL SERVICES, INC.	CLIENT: Spectrum Engineering
	ADDRESS: ,
	PHONE NUMBER:

DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

PROJECT NAME: 512 South Adams

Drill Hole No. H-01

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DEPTH (FT)	SAMPLE ID	MATERIAL DESCRIPTION	REMARKS / TESTING
21–32	B#4, B#5	Moist to Saturated, Very dark grayish brown [10YR 3/2], GRAVEL with Sand, GP, non-plastic. *(Continued)*	
32–35	B#6	Saturated, Dark yellowish brown [10YR 4/4], GRAVEL with Sand, GP, non-plastic.	Hard drilling ,probably tight boulders and cobbles, cuttings are granitic.
35–36		Saturated, Very dark brown [10YR 2/2], SAND with Gravel, SP, non-plastic, dense.	
36–37	B#7	Saturated, Light gray [10YR 7/2], non-plastic, Grout.	
37–39		Saturated, Very dark brown [10YR 2/2], SAND with Gravel, SP, non-plastic.	
39			Total Depth 39 ft

Column headings: WELL LOG, GRAPHIC LOG, DEPTH (FT), SAMPLES (DRIVE, UNDISTURBED, BULK), SAMPLE ID, RECOVERY (%), MATERIAL DESCRIPTION, LIQUID LIMIT, PLASTIC LIMIT, CORRECTED SPT, DRY DENSITY (pcf), MOISTURE (%), REMARKS / TESTING

Depth scale: 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

,

PHONE NUMBER:

Drill Hole No. H-02

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/14/12 - 8/15/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 17' N of S Fence, 9'E of deck fence	HAMMER TYPE: 140-Auto

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	OL	0–16.5			Bulk 5–10	B#1		Moist, Black [10YR 2/1], ORGANIC SILT, OL, soft.						Time: 2:00 PM
	GP	16.5–20.5						Moist, Black [10YR 2/1], GRAVEL, GP, loose.						

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

,

PHONE NUMBER:

DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

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DEPTH (FT)	SAMPLES (BULK)	SAMPLE ID	MATERIAL DESCRIPTION	REMARKS / TESTING
21–25	Bulk	B#2	Saturated, Very dark grayish brown [10YR 3/2], SILTY GRAVEL, GM, medium dense. *(Continued)*	
25–25.5			Moist, Light gray [10YR 7/1], loose, Grout.	
25.5–34	Bulk (25–30)	B#3	Saturated, Very dark grayish brown [10YR 3/2], GRAVEL, GP, loose to medium dense.	Very slow drilling
34			Saturated, Light gray [10YR 7/1], loose, Grout.	
34–37			Saturated, Dark gray [10YR 4/1], GRAVEL, GP, medium dense.	
37–40			Saturated, Dark gray [10YR 4/1], GP, medium dense, Boulder.	Large boulder (37-40')
40–43.5	Bulk (40–44)	B#4	Saturated, Dark gray [10YR 4/1], SAND with Gravel, SP, loose.	
43.5–44			Saturated, Black [10YR 2/1], SAND with Gravel, SP, very loose.	

Columns WELL LOG, GRAPHIC LOG, DRIVE, UNDISTURBED, RECOVERY (%), LIQUID LIMIT, PLASTIC LIMIT, CORRECTED SPT, DRY DENSITY (pcf), MOISTURE (%): no entries. Water level symbol at approx. 24 ft.

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

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PHONE NUMBER:

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

DEPTH (FT)	SAMPLES (DRIVE / UNDISTURBED / BULK)	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
44–49				Saturated, Black [10YR 2/1], SAND with Gravel, SP, very loose. *(Continued)*						Return water reduced 2-3 gal/min
45–46.5	DRIVE	SS#1	94				0			SS#1 fell entire distance under weight of rods
48–49.5	DRIVE	SS#2	0				2			
49–62.5				Saturated, Black [10YR 2/1], SAND with Gravel, SP, very loose, abundant coal.						
50–51.5	DRIVE	SS#3	61				4			
55										Advance drill from (50-55') in 5 mins
60										Advance casing without hammer, took 5 mins
62.5–67+				Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, loose.						Firmer drilling but still loose materials

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DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

DEPTH (FT)	MATERIAL DESCRIPTION	REMARKS / TESTING
67–68	Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, loose. *(Continued)*	
68–75	Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, loose.	
75–80	Saturated, Light brown [7.5YR 6/3], GRAVEL, GP, dense.	Much harder drilling at 75'. Return water at 20-30 gpm
80–90		Total Depth 80 ft

Column headings: WELL LOG; GRAPHIC LOG; DEPTH (FT); SAMPLES: DRIVE, UNDISTURBED, BULK; SAMPLE ID; RECOVERY (%); MATERIAL DESCRIPTION; LIQUID LIMIT; PLASTIC LIMIT; CORRECTED SPT; DRY DENSITY (pcf); MOISTURE (%); REMARKS / TESTING

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

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PHONE NUMBER:

Drill Hole No. H-03

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/13/12 - 8/14/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 10' from south fence, 7' E of porch	HAMMER TYPE: 140-Auto

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

DEPTH (FT)	SAMPLES (DRIVE / UNDISTURBED / BULK)	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
0 – 10.5				Moist, Very dark brown [10YR 2/2], ORGANIC SILT, OL, no to low plasticity, soft.						Easy drilling
10.5 – 12.5	Drive (10 – 11.5)	SS#1 SS#2		Dry to moist, Light gray [10YR 7/1], non-plastic, hard, Grout.						Cuttings smell like cement
12.5 – 14				Moist, Black [10YR 2/1], SILTY GRAVEL, GM, no to low plasticity, loose.						Silt stuck to cuttings
14 – 16	Bulk (15 – 20)			Dry to moist, Light gray [10YR 7/1], non-plastic, hard, Grout.						Cuttings have granitic origin
16 – 17.75		B#1		Moist, Black [10YR 2/1], ORGANIC SILT with GRAVEL, OL, firm.						
17.75 – 21	Bulk (20 – 21)	B#2		Moist, Very dark brown [10YR 2/2], ORGANIC SILT with GRAVEL, OL, organic odor, firm.						Rotten timbers at 21, smells like sewage

Groundwater symbol at approx. 20 ft.

PIONEER TECHNICAL SERVICES, INC.	CLIENT: Spectrum Engineering
	ADDRESS: ,
	PHONE NUMBER:

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DEPTH (FT)	SAMPLES	SAMPLE ID	MATERIAL DESCRIPTION	REMARKS / TESTING
21–22.5	BULK	B#2	Dry, Light gray [10YR 7/1], hard, Grout.	Cuttings are dust
22.5–26	BULK (to 25)	B#2	Moist to wet, Very dark brown [10YR 2/2].	
26–27			Moist, Light gray [10YR 7/1], hard, Grout.	Cuttings smell like cement
27–28			Saturated, Very dark brown [10YR 2/2], wood debris.	
28–29.5			Saturated, Black [10YR 2/1], ORGANIC SILT, OL, organic odor, soft.	Hole returns high volume of water
29.5–33	DRIVE (31–32.5)	SS#3	Saturated, Dark grayish brown [10Y 4/2], SAND with Gravel, SP, soft, wood debris.	
33–36			Saturated, Light gray [10YR 7/1], Grout.	Cuttings are a mixture of wood debris and grout
36–40			Saturated, Very dark grayish brown [10YR 3/2], SAND with Gravel, SP, loose, wood debris.	
40–42.5	BULK	B#3	Saturated, Very dark grayish brown [10YR 3/2], SAND with Gravel, SP, loose, wood debris.	
42.5–44	BULK	B#3	Saturated, Black [10YR 2/1], SAND with Gravel, SP, loose, wood debris.	

Columns also present (no data): WELL LOG, GRAPHIC LOG, RECOVERY (%), LIQUID LIMIT, PLASTIC LIMIT, CORRECTED SPT, DRY DENSITY (pcf), MOISTURE (%).

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

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PHONE NUMBER:

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DEPTH (FT)	SAMPLES (BULK)	SAMPLE ID	MATERIAL DESCRIPTION
44–49	Bulk (to 45)	B#3	Saturated, Black [10YR 2/1], SAND with Gravel, SP, loose, wood debris. *(Continued)*
49–56.5	Bulk (55–60)		Saturated, Black [10YR 2/1], SAND with Gravel, SP, loose, trace wood debris.
56.5–67		B#4	Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, medium dense, trace wood debris, abundant coal.
	Bulk (60–65)	B#5	

Columns WELL LOG, GRAPHIC LOG, DRIVE, UNDISTURBED, RECOVERY (%), LIQUID LIMIT, PLASTIC LIMIT, CORRECTED SPT, DRY DENSITY (pcf), MOISTURE (%), REMARKS / TESTING: no entries.

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:
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PHONE NUMBER:

DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		67–75			X (70–75)	B#6		Saturated, Black [10YR 2/1], GRAVEL with Sand, GP, medium dense, trace wood debris, abundant coal. *(Continued)*						
		75–90												Total Depth 75 ft

CLIENT: Spectrum Engineering

ADDRESS:

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PHONE NUMBER:

PIONEER TECHNICAL SERVICES, INC.

DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

Drill Hole No. H-04

PROJECT NAME: 512 South Adams	
DATE STARTED / FINISHED: 8/15/12 - 8/15/12	DRILLER: Axis Drilling
LOGGED BY: JR	DRILL TYPE: Davey-Kent
GROUND SURFACE ELEVATION:	HOLE DIAMETER: 4.5" ODEX
BOREHOLE LOCATION: 17'N of S Fence, 2' E of deck face	HAMMER TYPE: 140-Auto

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		0–8			X (0–5)	B#1		Moist, Black [10YR 2/1], ORGANIC SANDY SILT, OL, firm.						
		5–6.5	X			SS#1	67				7			
		8–18						Wet, Very dark gray [10YR 3/1], SILTY GRAVEL, GM, firm.						
		10–11.5	X			SS#2	28				9			
		15–16.5	X			SS#3	6				7			Small amount of wood debris in cuttings
		16.5–18			X	B#2								
		18–20						Void.						Driller notes a void between (18-20')
▼ (20)		20–21.5	X			SS#4	11	Saturated, Very dark gray [10YR 3/1], SILTY GRAVEL with Sand, GM, very loose.			2			

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

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PHONE NUMBER:

PROJECT NAME: 512 South Adams

Drill Hole No. H-04

This log is part of a report prepared by Pioneer Technical, Inc. for this project and should be read with the report. This summary applies only at the location of the boring and at the time of the drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplication of actual conditions encountered.

WELL LOG	GRAPHIC LOG	DEPTH (FT)	SAMPLES: DRIVE	SAMPLES: UNDISTURBED	SAMPLES: BULK	SAMPLE ID	RECOVERY (%)	MATERIAL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	CORRECTED SPT	DRY DENSITY (pcf)	MOISTURE (%)	REMARKS / TESTING
		21–25	X			SS#4	11	Saturated, Very dark gray [10YR 3/1], Abundant Wood Debris.			2			Primarily of wood debris in cuttings (20-25')
		26												Total Depth 25 ft

Depth scale: 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

PIONEER TECHNICAL SERVICES, INC.

CLIENT: Spectrum Engineering

ADDRESS:

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PHONE NUMBER:

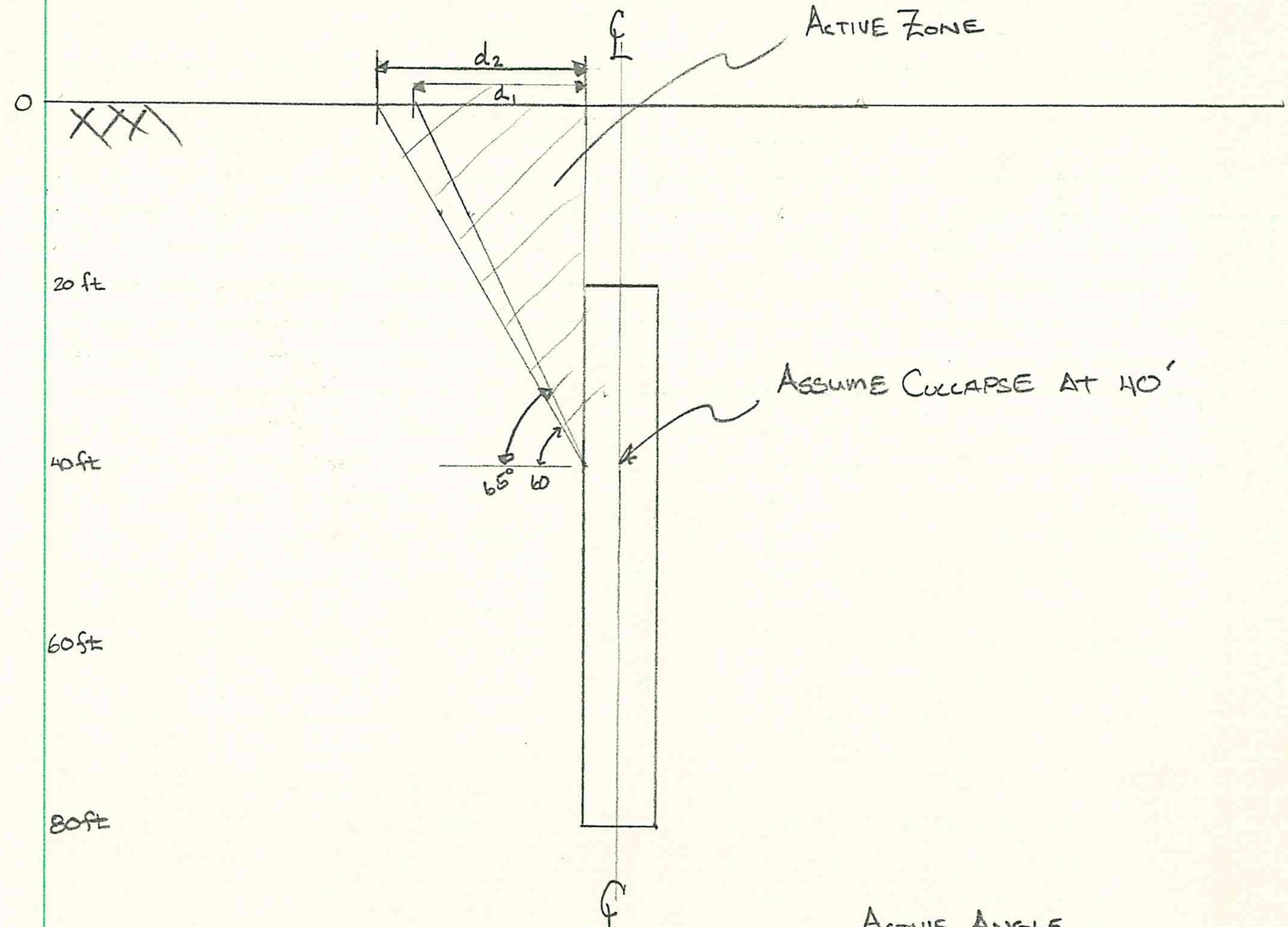
DRILL HOLE LOG 512 S ADAMS.GPJ 9/17/12

Attachment 2

HYMER SHAFT 8-27-12 JR

P.T.S.

ESTIMATE LATERAL EXTENT OF ACTIVE FAILURE WEDGE IF SHAFT COLLAPSES AT 40'



$d_1 = 40/\tan 65$

$d_1 = 18.7'$

$d_2 = 40/\tan 60$

$d_2 = 23.1'$

ACTIVE ANGLE

$\theta = 45° + \phi/2$

ϕ = FRICTION ANGLE

$\phi = (30 \rightarrow 40°)$

$\theta_{40} = 65° = \theta_1$

$\theta_{30} = 60° = \theta_2$

9-4-12
JR
P.T.S.

ESTIMATE LATERAL EXTENT OF ACTIVE FAILURE WEDGE IF SHAFT COLLAPSES AT 60' for ϕ = 30 → 40°

(SEE ANALYSIS OF 40 ft FAILURE DEPTH)

$\theta_{40} = 65° = \theta_3$

$\theta_{30} = 60° = \theta_4$

$d_3 = 60/\tan 65$

$d_3 = 28$ ft

$d_4 = 60/\tan 60$

$d_4 = 34$ ft'

Appendix E
Structural Investigation Report
Krivonen Associates
Matt Krivonen, PE

Krivonen Associates
♦♦♦
725 Grand Ave ♦ Billings, MT 59101
Phone (406) 259-1184 ♦ Fax (406) 256-1659
krivonen@bresnan.net
www.krivonen.com

Date: 5/14/2012
Job#8538

Spectrum Engineering
1413 4th Ave N
Billings, MT 59101
Attn: Bill Maehl

RE: 512 Adams St Red Lodge Subsidence Investigation and Structural Recommendations

Dear Bill,

At your request, this is a short letter summarizing our structural investigation relating to subsidence at 512 Adams Street in Red Lodge, MT. The objective of our investigation was to analyze the effects of subsidence on the structures on site and to provide recommendations for the stabilization of those structures. Our efforts involved two site visits, producing a partial level-survey on the existing main floor of the home, and providing calculations and details which illustrate our proposed stabilization solution. Our analysis was limited to what we could see on-site without the use of destructive testing or over-excavation. Our scope was limited to addressing issues related to subsidence.

According to research done by Spectrum, there is an abandoned mine shaft off the southeast corner of the back deck. The shaft was drilled by the Red Lodge Coal Company and abandoned in 1905. In 1917 the original home was built on the lot. In 1959 a major soils collapse event occurred over the shaft area resulting in settlement several feet deep (HKM memorandum November 3, 2011). This hole was filled with loose material and re-graded. In the 1980's Andy VanOrnum, the current owner, built an addition to the original house on its south and east sides. The addition included a deck off the east side. Spectrum Engineering was contacted in 1998 by the DEQ in response to apparent settlement of the deck due to subsidence. In order to solve the problem Spectrum partially filled the mine shaft with 62.2 cubic yards of concrete. Since that time subsidence has appeared to continue at the rate of approximately 1" per year. A letter from Spectrum dated February 29, 2012 states that a likely cause of this settlement may be related to a "modest subsidence hole" developing in the shaft wall approximately 30'-0" below the surface.

On 4/2/12, I visited 512 Adams St with you, the owner Andy VanOrnum, Pebbles Clark with the Montana DEQ, Steve Stokke with Yellowstone Concrete and Structural Systems, and Wes Krivonen from our office. The purpose of the meeting was to determine the effects of subsidence on the structure and to discuss possible solutions. Based on our observations it appears that the grade over the shaft has dropped significantly due to ongoing subsidence. You stated that the grade was approximately level after the grouting of the shaft in 1998. Our levels taken on the neighbor's porch slab suggest that the magnitude of subsidence is approximately 14". It is difficult to determine the amount of subsidence beneath the existing back deck of the home due to ongoing leveling with shim pieces. Since its last "shimming" the deck has dropped off 1.7" nearest the shaft footprint (see attached level survey). The house itself does not appear to have been effected by the subsidence. We took level readings on the floor of the addition which show that the southeast corner of the home is down approximately 0.6" from the southwest corner of the home. We believe that this differential is related to settlement caused by negative drainage along the south side of the home, and is not related to the subsidence issue in the back *yard. Please see the attached sheet "S1" for level readings. It does not appear that the detached garage to the east of the house has been affected by the subsidence in the shaft. The structure appears to be well outside the cone of influence.*

After discussing several possible solutions to stabilize the foundation we believe that a structural slab spanning over the cone of influence of the shaft to be the most appropriate. This slab would bear on helical piers spaced at approximately 4'-0" on center along the west and east sides of the building. These piers would be screwed into the ground to a depth at which they reached their required load rating by a licensed installer. This solution is depicted on the attached sheet S1.

By utilizing the slab and pier solution proposed we do not believe that further drilling or geotechnical study is necessary. The piers bearing value can be determined by the installer without input from a geotechnical engineer. The strength of the soil beneath the slab is not relevant because the slab does not depend on it for bearing. Furthermore, additional drilling and study will draw this repair process out further and create more of a mess in the back yard.

This solution is contingent upon the helical pier installer being able to develop the required allowable bearing capacity of 40,000 pounds in his piers. This solution is also contingent upon the helical piers maintaining their bearing capacity over time. It assumes that the material into which the piers are drilled is stable and not prone to movement caused by further subsidence.

If the helical pier installer cannot develop the required capacity in the piers, then we will pursue a bearing slab option. This approach is shown on the attached sheet "S2". This solution would require having a geotechnical engineer perform an analysis on the site soils at the perimeter of the cone of subsidence to determine their allowable bearing capacity. Using this bearing value we could determine how much bearing the slab requires beyond the perimeter of the cone of subsidence. The design shown in "S2" assumes an allowable bearing pressure of 3000 pounds per square foot.

In order to determine the approximate size of the slab I re-visited the site on 4/7/2012. The cone of influence that I measured was very approximate and is shown on the attached "S1" sheet. I would recommend verifying these measurements prior to construction. While on-site I discussed our proposed solution with the owner and asked whether he would prefer to have an exposed slab on grade or if he would prefer burying the structural slab underground. He expressed to me that he would prefer having the slab buried. We would recommend burying the slab approximately 12" below grade. This shallow depth limits overburden pressure from soils above while providing enough depth to re-grow grass.

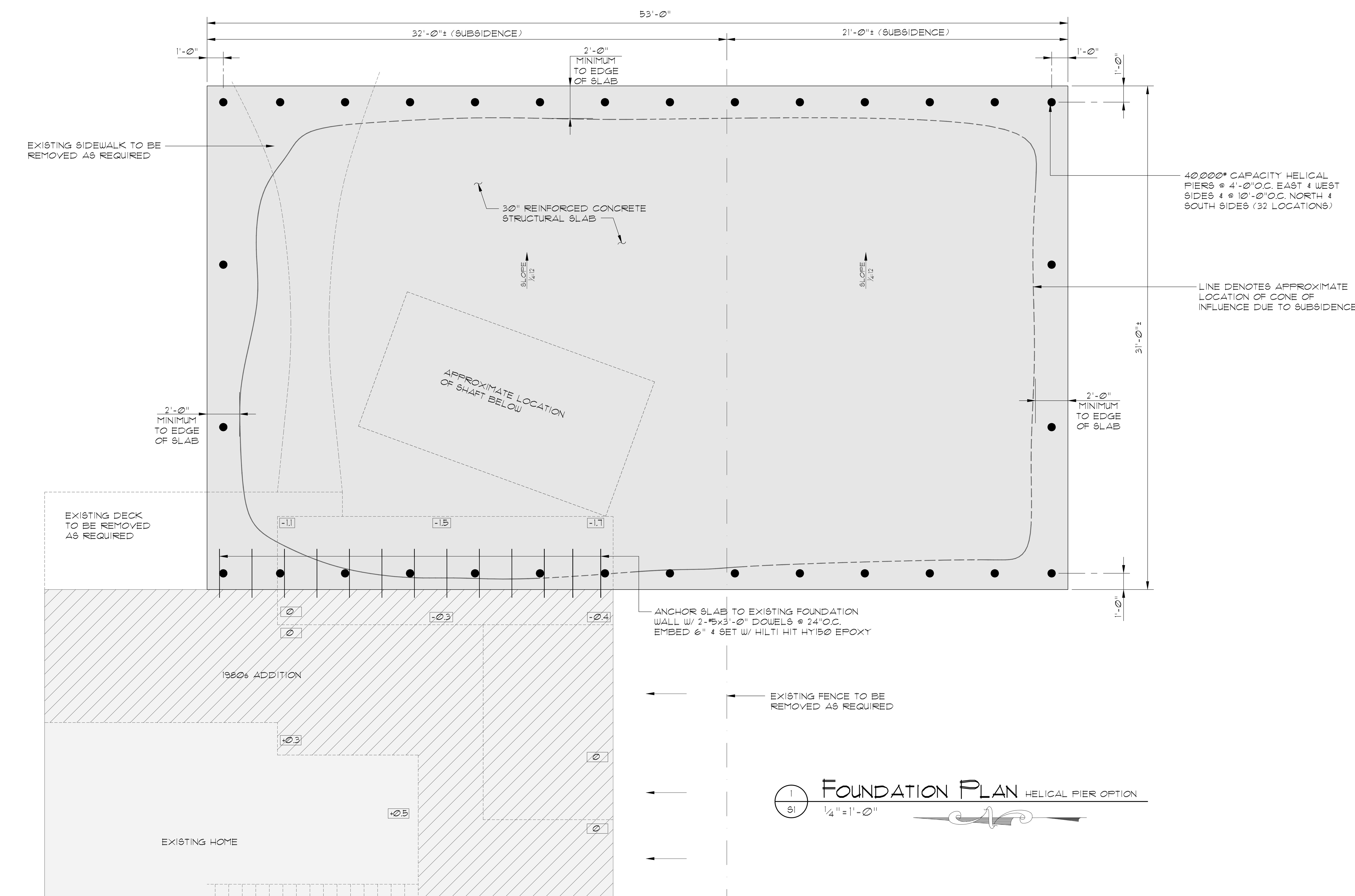
Please let me know if you have any further questions or concerns.

Respectfully,

Matt Krivonen, P.E.

MONTANA MATT KRIVONEN 18076 REGISTERED PROFESSIONAL ENGINEER

725 Grand Ave * Billings, MT 59101 * Phone - (406) 259-1184 * Fax - (406) 256-1659



STRUCTURAL NOTES

1. GOVERNING CODES:

INTERNATIONAL BUILDING CODE, 2009 EDITION
AMERICAN INSTITUTE OF STEEL CONSTRUCTION, 9TH EDITION
AMERICAN CONCRETE INSTITUTE, 318-05
AMERICAN SOCIETY OF CIVIL ENGINEERS, 7-05
AMERICAN WELDING SOCIETY D1.1 (U.O.N.)

2. DESIGN CRITERIA:

OCCUPANCY:........CATEGORY II
SNOW LOAD:........105 PSF + GROUND SNOW
FOUNDATION:........BEARING ON 40,000 # CAPACITY HELICAL PIERS PER MANUFACTURER'S SPECIFICATIONS

3. MATERIALS:

REINFORCING STEEL BARS :
#4 THRU #10 BARS........ASTM A615 - GRADE 60

4. FOUNDATION NOTES:

1. PROVIDE 4" LAYER OF 3/4" MINUS ROADMIX BELOW SLABS ON GRADE. COMPACTION OF FILL BENEATH SLABS ON GRADE SHALL SATISFY 95% MAXIMUM DRY DENSITY PER ASTM D698.
2. SOILS BENEATH FOUNDATIONS SHALL BE PROTECTED FROM FREEZING DURNING CONSTRUCTION.
3. POSITIVE DRAINAGE AND/OR THE EXCAVATION SHALL BE PUMPED TO PREVENT SURFACE WATER BUILD-UP DURING ALL PHASES OF CONSTRUCTION.
4. PRIOR TO FILL PLACEMENT, REMOVE ALL TOPSOILS, ORGANICS, DEBRIS AND OLD CONCRETE AND MASONRY. EXISTING SLABS IN EXCESS OF 48" BELOW BOTTOM OF EXISTING FOOTINGS MAY REMAIN.

5. CONCRETE:

1. ALL CONCRETE SHALL BE READY MIXED AND SUPPLIED IN ACCORDANCE WITH SPECIFICATION REQUIREMENTS. NO WATER SHALL BE ADDED TO MIX AT JOB SITE.
2. MINIMUM COVER REQUIREMENTS:
   CAST AGAINST EARTH = 3"
   FORMED WALLS = 1½"
   TOP OF SLAB = 1"
3. COLD WEATHER CONCRETING GUIDELINES TO BE FOLLOWED IN COLD TEMPERATURES.
4. FLYASH TYPE "F" OR TYPE "C" MAY BE USED TO REPLACE NO MORE THAN 10% OF THE CEMENT CONTENT.
5. 4" SLUMP MAX. 5-7% AIR ENTRAINED FOR ALL FOUNDATIONS & EXTERIOR SLABS.

6. REINFORCING STEEL:

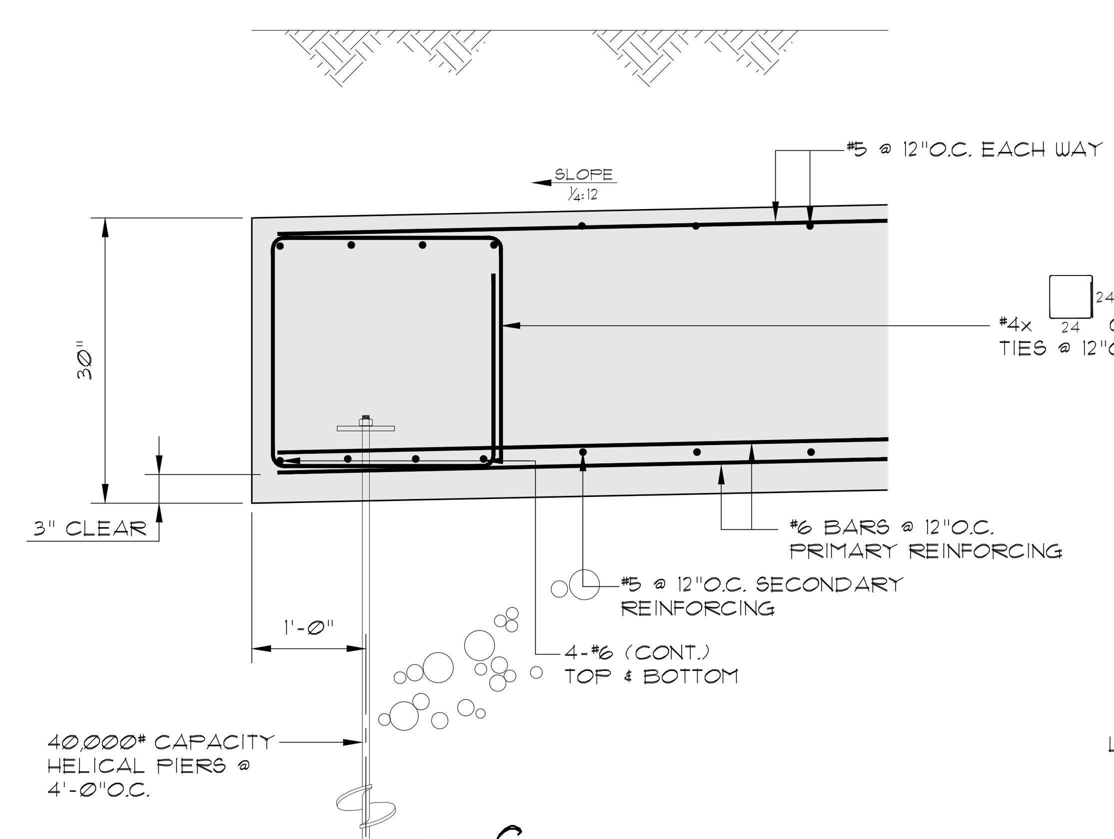
1. LAP REQUIREMENTS: 30 BAR DIAMETERS (CONCRETE) 40 BAR DIAMETERS (MASONRY)
2. CORNER BARS REQUIRED AT FOUNDATION WALL LOCATIONS OF SIZE AND NUMBER OF HORIZONTAL WALL STEEL AT ALL CORNERS AND INTERSECTIONS.
3. REBAR SHALL BE SECURELY TIED IN-PLACE WITH #16 ANNEALED IRON WIRE.
4. CHAIRS SHALL BE USED IN SLABS FOR PROPER PLACEMENT.

7. MISCELLANEOUS:

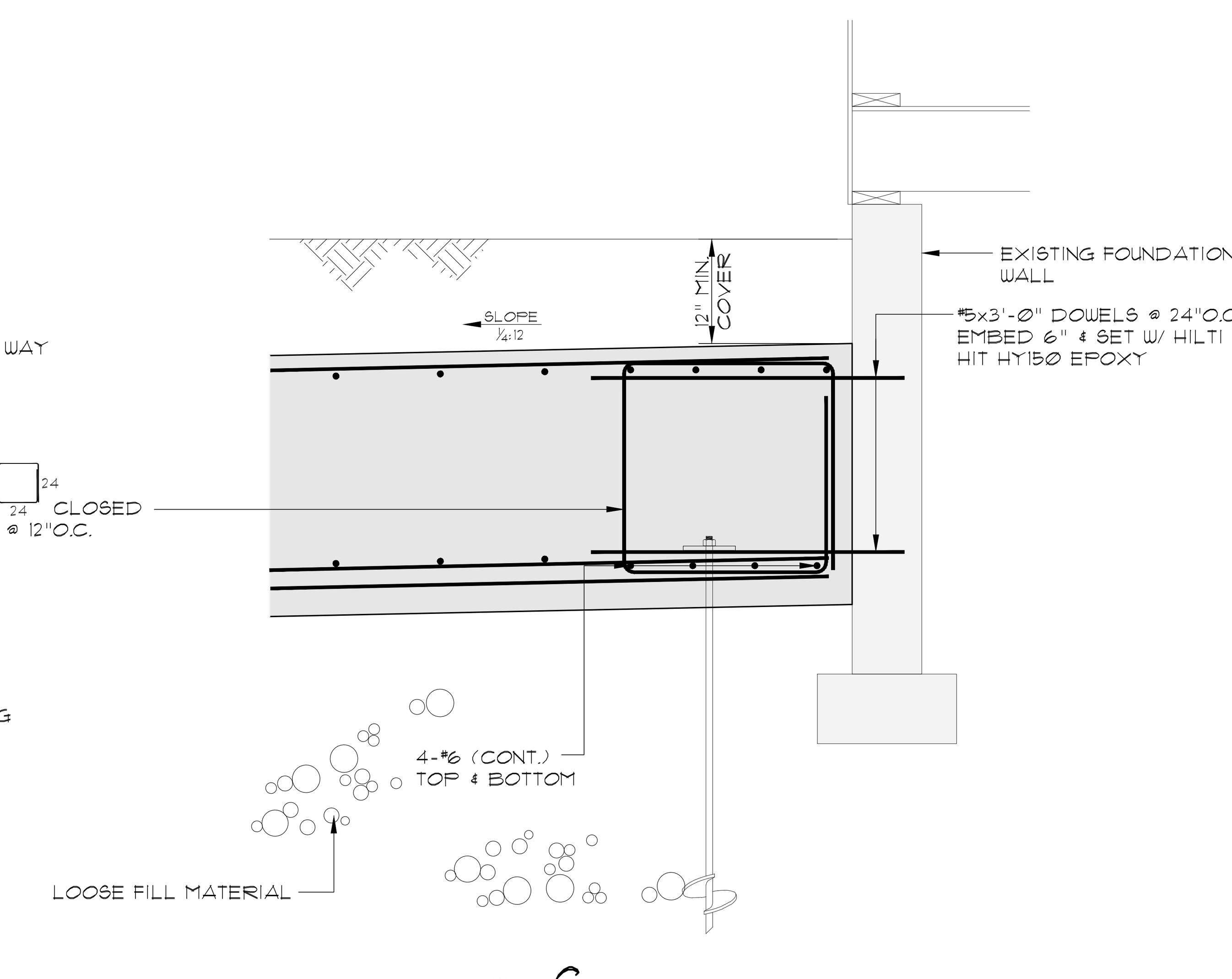
4. SPECIAL INSPECTION OF CONCRETE FOUNDATION WILL BE REQUIRED PER IBC REQUIREMENTS AND/OR LOCAL LOAD REQUIREMENTS

8. SPECIAL INSPECTION:

CONCRETE TESTING:
TAKE 1 STRENGTH TEST ON EACH DAY OF CONCRETE POUR OR A MINIMUM OF 3 STRENGTH TESTS FOR ENTIRE PROJECT SEQUENCE. TAKE 3 CYLINDERS PER STRENGTH TEST OF WHICH ONE IS TO BE BROKEN AT 7 DAYS & TWO AT 28 DAYS. THE TESTING SHALL BE CONSISTENT WITH IBC RECOMMENDATIONS & CONDUCTED BY AN EXPERIENCED INDIVIDUAL FROM A QUALIFIED LAB OF CONTRACTORS CHOICE.



2 / S1 SECTION
3/4"=1'-0"



3 / S1 SECTION
3/4"=1'-0"

KRIVONEN ASSOCIATES, P.C.
STRUCTURAL CONSULTANTS
725 GRAND AVE
BILLINGS, MT 59101
(406) 259-1184
(406) 256-1654 FAX
krivonen@bresnan.net

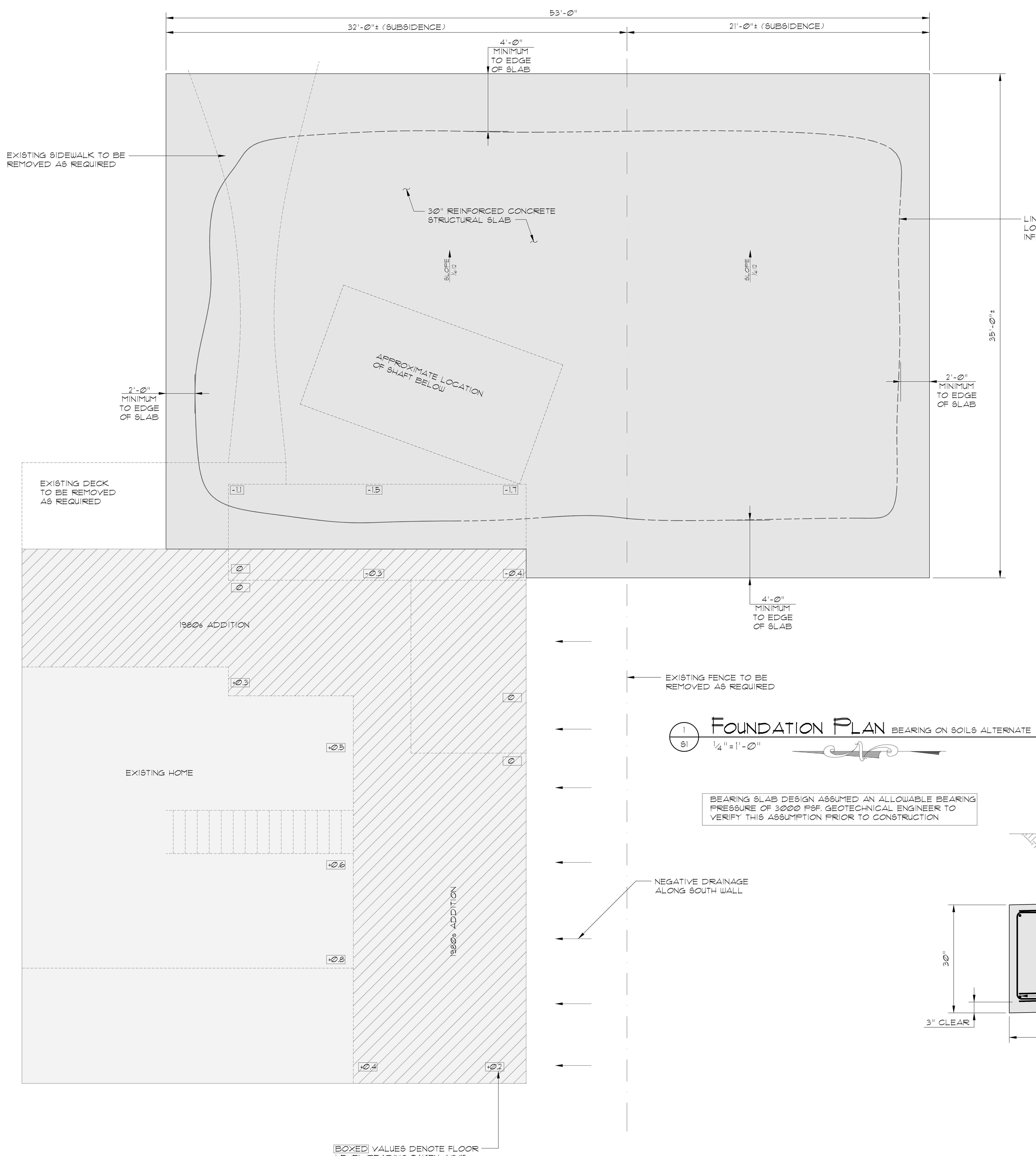
IN ASSOCIATION WITH:
Spectrum Engineering
1413 4th Ave N
Billings, MT 59101
259-2412
Attn: Bill Mashl

512 Adams Ave
Red Lodge, Montana

MONTANA MATT KRIVONEN 18076 5/12/12 PROFESSIONAL ENGINEER

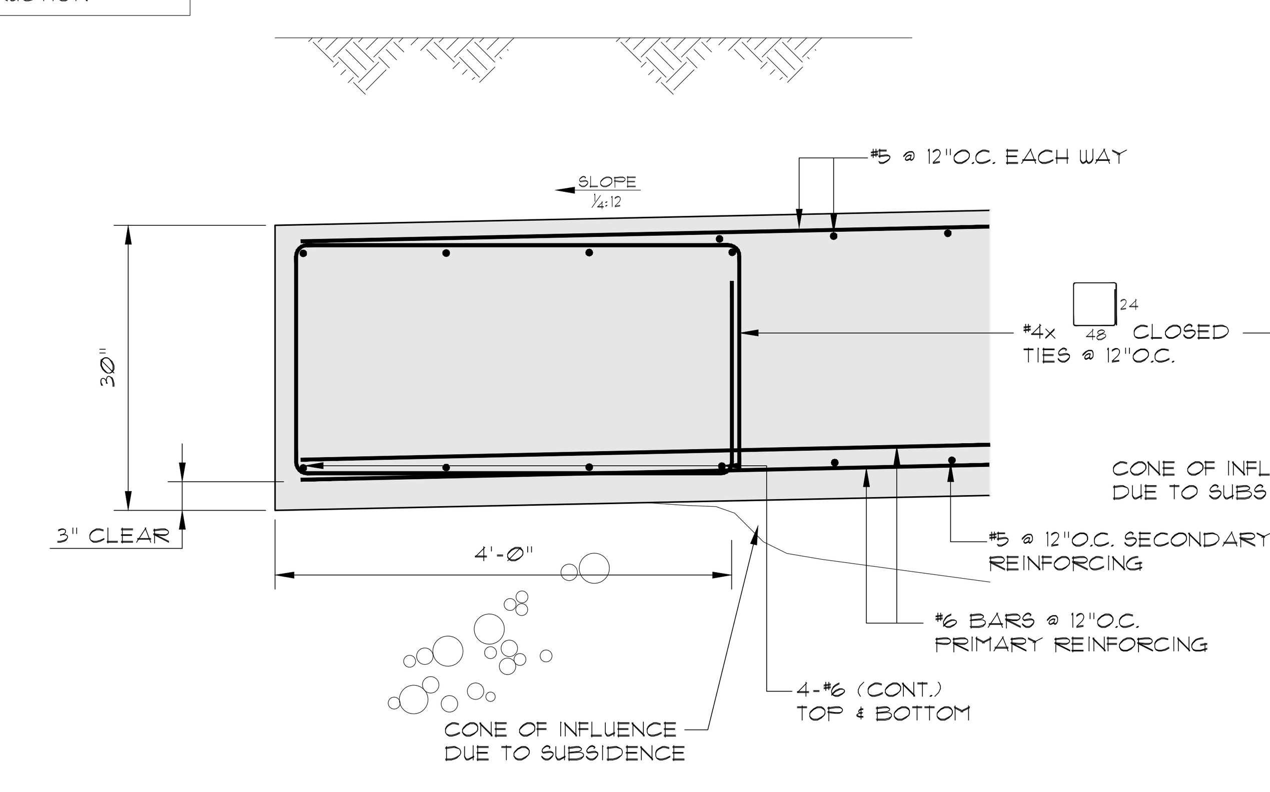
SHEET DESCRIPTION: Pier Plan & Sections
CADD DRAFTER: TB
ENGINEER: MK
SCALE: As Shown
DATE: 5/14/12
JOB NUMBER: 8538
SHEET: S1
1 OF 2

8538s1.dwg 5/14/12

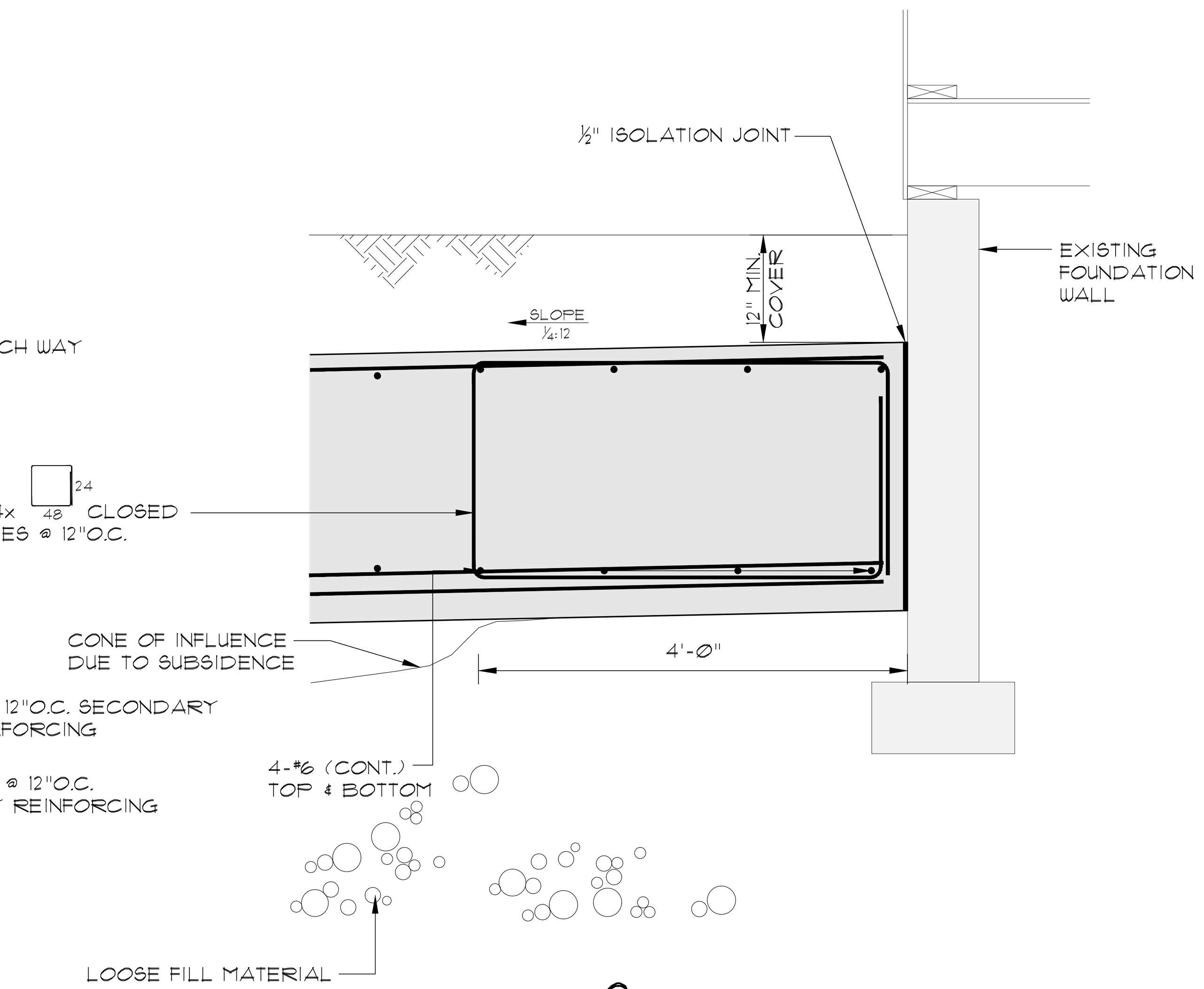


1 S1 FOUNDATION PLAN BEARING ON SOILS ALTERNATE
1/4"=1'-0"

BEARING SLAB DESIGN ASSUMED AN ALLOWABLE BEARING PRESSURE OF 3000 PSF. GEOTECHNICAL ENGINEER TO VERIFY THIS ASSUMPTION PRIOR TO CONSTRUCTION



2 S1 SECTION
3/4"=1'-0"



3 S1 SECTION
3/4"=1'-0"

STRUCTURAL NOTES

1. GOVERNING CODES:

INTERNATIONAL BUILDING CODE, 2009 EDITION
AMERICAN INSTITUTE OF STEEL CONSTRUCTION, 9TH EDITION
AMERICAN CONCRETE INSTITUTE, 318-05
AMERICAN SOCIETY OF CIVIL ENGINEERS, 7-05
AMERICAN WELDING SOCIETY D1.1 (U.O.N.)

2. DESIGN CRITERIA:

OCCUPANCY:........CATEGORY II
SNOW LOAD:........105 PSF + GROUND SNOW
FOUNDATION:........ASSUMES AN ALLOWABLE BEARING PRESSURE OF 3000 PSF. GEOTECH ENGINEER TO VERIFY

3. MATERIALS:

REINFORCING STEEL BARS :
#4 THRU #10 BARS........ASTM A615 - GRADE 60

4. FOUNDATION NOTES:

1. PROVIDE 4" LAYER OF 3/4" MINUS ROADMIX BELOW SLABS ON GRADE. COMPACTION OF FILL BENEATH SLABS ON GRADE SHALL SATISFY 95% MAXIMUM DRY DENSITY PER ASTM D698.
2. SOILS BENEATH FOUNDATIONS SHALL BE PROTECTED FROM FREEZING DURNING CONSTRUCTION.
3. POSITIVE DRAINAGE AND/OR THE EXCAVATION SHALL BE PUMPED TO PREVENT SURFACE WATER BUILD-UP DURING ALL PHASES OF CONSTRUCTION.
4. PRIOR TO FILL PLACEMENT, REMOVE ALL TOPSOILS, ORGANICS, DEBRIS AND OLD CONCRETE AND MASONRY. EXISTING SLABS IN EXCESS OF 48" BELOW BOTTOM OF EXISTING FOOTINGS MAY REMAIN.

5. CONCRETE:

1. ALL CONCRETE SHALL BE READY MIXED AND SUPPLIED IN ACCORDANCE WITH SPECIFICATION REQUIREMENTS. NO WATER SHALL BE ADDED TO MIX AT JOB SITE.
2. MINIMUM COVER REQUIREMENTS:
   CAST AGAINST EARTH = 3"
   FORMED WALLS = 1 1/2"
   TOP OF SLAB = 1"
3. COLD WEATHER CONCRETING GUIDELINES TO BE FOLLOWED IN COLD TEMPERATURES.
4. FLYASH TYPE "F" OR TYPE "C" MAY BE USED TO REPLACE NO MORE THAN 10% OF THE CEMENT CONTENT.
5. 4" SLUMP MAX. 5-7% AIR ENTRAINED FOR ALL FOUNDATIONS & EXTERIOR SLABS.

6. REINFORCING STEEL:

1. LAP REQUIREMENTS: 30 BAR DIAMETERS (CONCRETE) 40 BAR DIAMETERS (MASONRY)
2. CORNER BARS REQUIRED AT FOUNDATION WALL LOCATIONS OF SIZE AND NUMBER OF HORIZONTAL WALL STEEL AT ALL CORNERS AND INTERSECTIONS.
3. REBAR SHALL BE SECURELY TIED IN-PLACE WITH #16 ANNEALED IRON WIRE.
4. CHAIRS SHALL BE USED IN SLABS FOR PROPER PLACEMENT.

7. MISCELLANEOUS:

4. SPECIAL INSPECTION OF CONCRETE FOUNDATION WILL BE REQUIRED PER IBC REQUIREMENTS AND/OR LOCAL LOAD REQUIREMENTS

8. SPECIAL INSPECTION:

CONCRETE TESTING:
TAKE 1 STRENGTH TEST ON EACH DAY OF CONCRETE POUR OR A MINIMUM OF 3 STRENGTH TESTS FOR ENTIRE PROJECT SEQUENCE. TAKE 3 CYLINDERS PER STRENGTH TEST OF WHICH ONE IS TO BE BROKEN AT 7 DAYS & TWO AT 28 DAYS. THE TESTING SHALL BE CONSISTENT WITH IBC RECOMMENDATIONS & CONDUCTED BY AN EXPERIENCED INDIVIDUAL FROM A QUALIFIED LAB OF CONTRACTORS CHOICE.

KRIVONEN ASSOCIATES, P.C.
STRUCTURAL CONSULTANTS
725 GRAND AVE
BILLINGS, MT 59101
(406) 259-1184
(406) 256-1659 FAX
krivonen@bresnan.net

IN ASSOCIATION WITH:
Spectrum Engineering
1413 4th Ave N
Billings, MT 59101
259-2412
Attn: Bill Maehl

512 Adams Ave
Red Lodge, Montana

MONTANA MATT KRIVONEN 18076 5/12/12 REGISTERED PROFESSIONAL ENGINEER

SHEET DESCRIPTION: Foundation Plan & Sections
CADD DRAFTER: TB
ENGINEER: MK
SCALE: As Shown
DATE: 5/14/12
JOB NUMBER: 8538
SHEET: S2
2 OF 2

8538s2.dwg
5/14/12

Helical Piles

Helical piles are a factory-manufactured steel foundation system consisting of a central shaft with one or more helix-shaped bearing plates and a bracket that allows attachment to a structure. The helix plates are commonly referred to as blades or flights and are welded to the lead section.

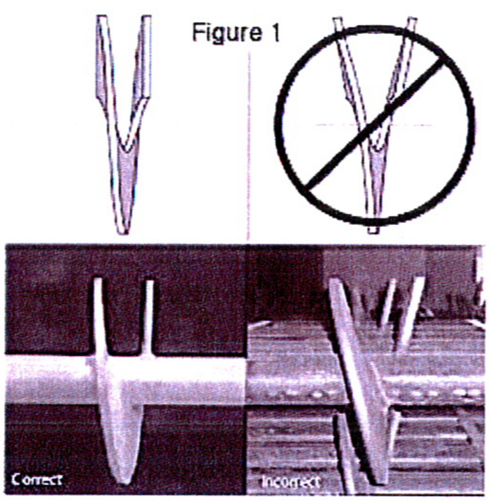
Extension shafts, with or without additional helix plates, are used to extend the pile to competent load bearing soil and to achieve design depth and capacity. Brackets are used at the tops of the piles for attachment to structures, either for new construction or retrofit applications. Helical piles are advanced (screwed) into the ground with the application of torque.

The terms helical piles, screw piles, helical piers, helical anchors, helix piers, and helix anchors are often used interchangeably by specifiers. However, the term "pier" more often refers to a helical pile loaded in axial compression, while the term "anchor" more often refers to a helical pile loaded in axial tension. The term "pile" traditionally describes a deep foundation that can resist both tension and compression loads.

Helical Foundation Systems – General Information

Design Information

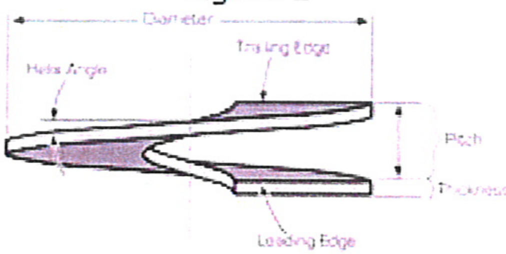
Figure 1



Helical piles are designed such that most of the axial capacity of the pile is generated through bearing of the helix plates against the soil. The helix plates are typically spaced three diameters apart along the pile shaft to prevent one plate from contributing significant stress to the bearing soil of the adjacent plate. Significant stress influence is limited to a "bulb" of soil within about two helix diameters from the bearing surface in the axial direction and one helix diameter from the center of the pile shaft in the lateral direction. Each helix plate therefore acts independently in bearing along the pile shaft.

Multiple piles shall have a center to center spacing at the helix depth of at least four (4) times the diameter of the largest helix plate (ICC-ES AC358). The tops of the piles may be closer at the ground surface but installed at a batter away from each other in order to meet the spacing criteria at the helix depth.

Figure 2



Helix Plate Geometry

For tension applications, the uppermost helix plate shall be installed to a depth at least twelve (12) diameters below the ground surface (ICC-ES AC358). The actual depth will vary depending upon soil conditions and capacity requirements, but should not be less than 12 diameters.

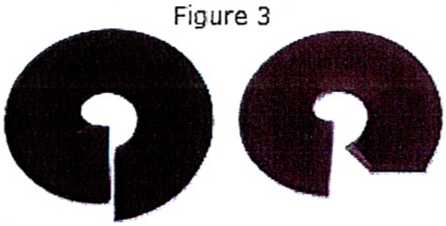
The uppermost helix plate shall be embedded in the ground to a depth of at least five (5) diameters to create a deep foundation bearing condition.

The upper helix plate shall also be located below the depth of seasonal frost penetration and below the "active zone"; i.e., the depth of soil that undergoes seasonal volume changes with changes in moisture content. The depth of the helix plates should therefore be determined from the greatest of these values.

Helical Foundation Systems – Components

Helix Plates

Figure 3



Standard and V-style cut plates

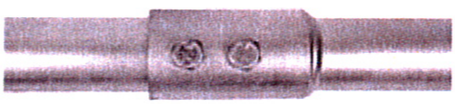
The initial installation of a helical pile is performed by applying a downward force (crowd) and rotating the pile into the earth via the helix plates. Once the helix plates penetrate to a depth of about 2 to 3 feet, the piles generally require less crowd and installation is accomplished mostly by the downward force generated from the helix plates, similar to the effect of turning a screw into a block of wood. Therefore, the helix plate performs a vital role in providing the downward force or thrust needed to advance the pile to the bearing depth. The helix plate geometry further affects the rate of penetration, soil disturbance and torque to capacity correlation.

The consequences of a poorly-formed helix are twofold; (1) the helix plate severely disturbs the soil with an augering effect which (2) directly results in more movement upon loading than a pile with well-formed helices. The differences between a well-formed helix and poorly-formed helix are visually obvious and are shown in the figure above.

ICC-ES AC358 establishes design and testing criteria for helical piles evaluated in accordance with the International Building Code. AC358 further provides criteria for helix plates in order to be considered as a "conforming system". Foundation Supportworks (FSI) helical piles feature plates manufactured with a helix shape conforming to the geometry criteria of ICC-ES AC358. Conversely, blades that are not a helix shape are often formed to a "duckbill" appearance. These plates create a great deal of soil disturbance, do not conform to the helix geometry requirements of ICC-ES AC358, and their torque to capacity relationships are not well documented.

Coupler Detail

Figure 4



FSI external welded coupler

Figure 5

FSI external detached coupler

The coupler detail for a helical foundation system is yet another extremely important feature when considering helical piles and when selecting or specifying a product manufacturer. Manufacturers may advertise that they carry the same or equivalent helical shaft. However, shaft and coupler details are not consistent between manufacturers and these differences may not be readily apparent by simply reviewing product capacity tables.

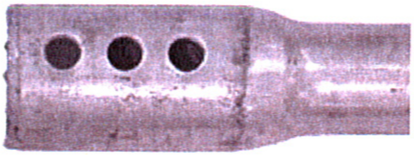
Some manufacturers rate their products based upon the capacities of the gross section of the shaft, thereby ignoring any limitations caused by the coupled connections. For these "equivalent" products, there can be dramatic differences in material properties, tolerances, spacing of bolt holes, oversize of bolt holes, general fit-up, weld quality, etc.

Some of the more common coupler details for round shaft include external welded, external detached, internal detached, and forged and upset. External couplers utilize tube or pipe sections with an internal diameter slightly larger than the outside diameter of the central shaft material (See Figure 4 and Figure 5). These couplers can be sized to provide tight connections that reduce angular deformation and variances from straightness. Such displacements at the couplers introduce eccentricities to the system which can significantly reduce the allowable compressive capacity of the pile, especially considering the slenderness of the more widely used shaft material (typically 3.5-inch outside diameter and smaller).

Internal detached couplers are made from solid round stock or tube or pipe material but with an outside diameter smaller than the inside diameter of the central shaft material. Internal coupler diameters may be significantly undersized to prevent interferences with internal weld beads of the central shaft or due to the variations that are typical in wall thicknesses and inside diameters of pipe sections. Larger gaps between the inside diameter of the shaft and the outside diameter of the coupler can result in a connection with more potential for angular displacements.

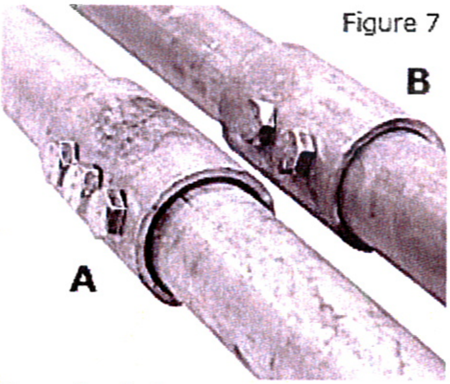
Forged and upset couplers are formed by heating one end of the shaft, placing this end in a form and then enlarging the end with a hammer-like tool or press (See Figure 6).

Figure 6



With this method of manufacturing, it is difficult to create tight connections to strict tolerances.

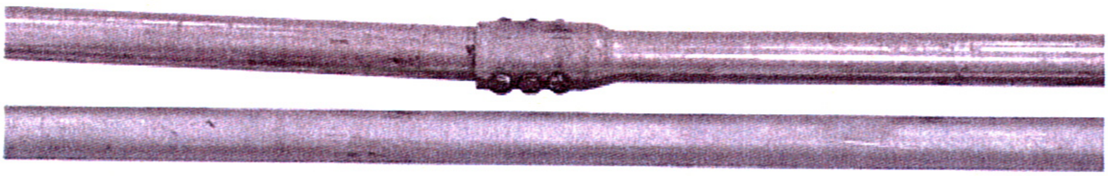
It is not uncommon to have 1/8-inch or more difference between the outside diameter of the shaft and the inside diameter of the upset coupler of the round shaft (See Figure 7).



Coupler tolerances:
(A) Competitor upset coupler
(B) FSI External Welded Coupler

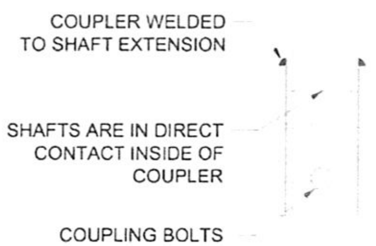
Again, the greater the freedom allowed in the connection, the greater the potential variance from straightness and the higher the potential for bending or buckling of the pile under high compressive loads (See Figure 8).

Figure 8



The risk of pile buckling further increases with unsupported lengths above the ground surface, or if the pile extends through soil strata consisting of soft clays or very loose sand. FSI round shaft helical piles are manufactured with external welded or detached couplers. These systems are manufactured to strict tolerances to allow the pile shafts to be in direct contact inside the coupling, similar to Figure 9.

Figure 9

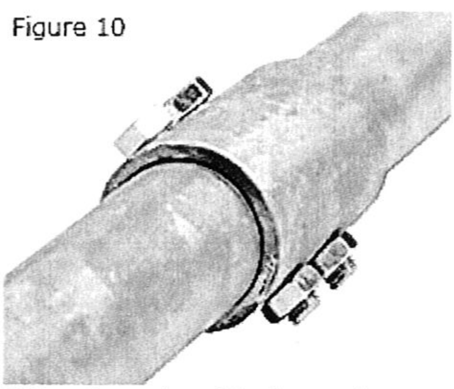


Coupler detail showing shaft contact within coupler

Why is this important? The load path for piles under compression is then directly through the shafts of the extensions and lead section without having to pass through welds and bolts at each connection.

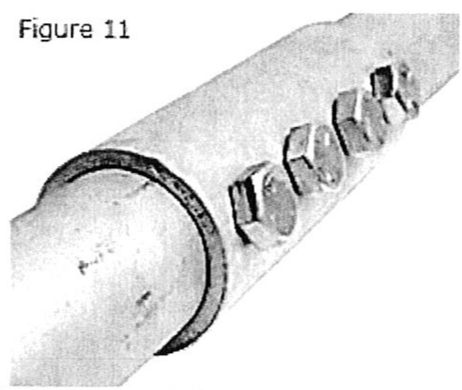
The annular space between the pile shaft and coupler is also kept as tight as practical to maintain pile rigidity while also providing connections that are easily joined in the field (See Figure 10 and Figure 11).

Figure 10



FSI external welded coupler

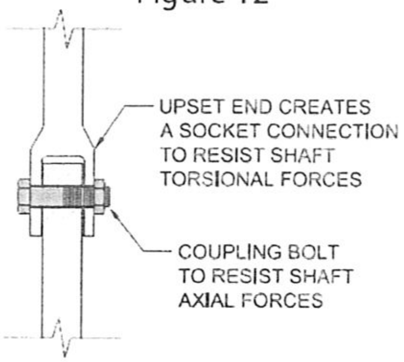
Figure 11



FSI external detached coupler

The most common coupler detail for solid square shaft utilizes a forged and upset end. Cast detached couplers have also been used in lieu of the upsetting process.
The upset end of square shaft is created in a similar manner as for the round shaft, except for forming a square socket connection (See Figure 12).

Figure 12



Schematic of square shaft forged and upset coupler

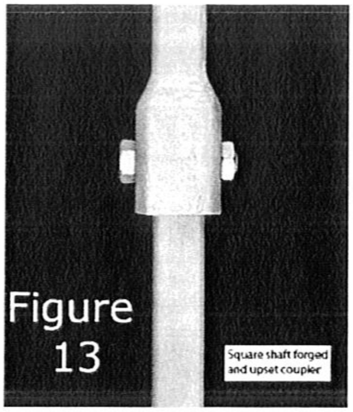


Figure 13 clearly shows a comparison of coupling rigidity between an FSI external welder coupler for round shaft and a typical upset coupler for square shaft.

A similar draping effect is typical for round shaft helical piles with upset couplers.

(taken from Helical Piles - Foundation Supportworks Products
commercial.foundationsupportworks.com/.../11-helical-piles)

Estimate

Structural Slab – Mine Shaft Cap

512 Adams St

Red Lodge, MT

This estimate prepared for:

Mr. Bill Maehl

Spectrum Engineering

YSS

WWW.YELLOWSTONESTRUCTURAL.COM

Yellowstone Structural Systems, LLC
PO Box 22993 • Billings, MT 59101 • (406) 534-9282

01 December, 2011

Bill Maehl
Spectrum Engineering
Billings, MT
maehl@spectrum-eng.com

Re: 512 Adams St – Red Lodge, MT: Structural Slab Mine Shaft Cap

Mr. Maehl,

Per your request we are submitting this estimate to provide all labor, materials, and equipment necessary to perform the work as outlined in the plans produced by Matt Krivonen of Krivonen Associates, Structural Engineers.

A generalized scope of work consists of the following:

- Site prep including required removal of objects in the area of work.
- Excavation and grading.
- Installation of 32 end-bearing 60 kip helical piers.
- Placing and grading gravel base.
- Assembling reinforcing steel per the details within the project drawings.
- Pouring and finishing the structural slab per the design requirements.
- Replacement of soils above slab and finish grading.
- Remediating site.
- Replacement of objects that were previously removed.

Our estimated cost to perform this work is: **$157,600.00 USD**

Kind regards,

Jesse Scott
Yellowstone Structural Systems, LLC
Billings, MT
(406) 534-9282
jesse@yellowstonestructural.com

Appendix F
Follow-Up Structural Investigation Report
Pioneer Technical Services, Inc.
Jeffrey J. Riedel, PE

PIONEER TECHNICAL SERVICES, INC.
1215 Apple's Way, Belgrade, MT 59714
PH(406) 388-8578 FX(406) 388-8579
www.pioneer-technical.com

MONTANA
JEFFREY J. RIEDEL
No. 17359 PE
LICENSED
PROFESSIONAL ENGINEER

10-30-12

Memo

To: Dave Murja

From: Jeffrey Riedel

CC: Pebbles Opp

Date: 10/30/2012

Re: 512 South Adams, Hymer Shaft

Dave,

Per your request, Pioneer Technical Services performed a follow-up site investigation at 512 South Adams Street, Red Lodge, Montana. The objective of this investigation was to determine if surface displacements observed to the north and east of the abandoned Hymer Mine shaft are also observable to the west of the shaft. The surface displacements to the north and east were discussed in a memo to you dated September 17th.

To view the area west of the mine shaft I obtained access to the house crawl space from the home owner Mr. Andy Van Ornum. The following observations were made:

Observations:

Three features were observed which suggest displacements within the mine shaft may have affected soil materials to the west of the shaft and beneath the eastern side of the house. These features include two fractures, labeled Crack No 1 and Crack No 2, within the southern stem-wall of the house and crack (No. 3) within the dirt floor of the crawl space. The approximate location of each feature is presented on the attached plan view sketch in Attachment 1.

Crack No. 1:

This crack is located in the southern stem wall approximately 12 feet west of the eastern stem wall. The crack is visible along exposed face of the stem wall; the footing is not visible. The crack is wider at the top than the bottom suggesting loss of support to the east. Photographs of the crack are shown in Attachment 1.

Crack No. 2

This crack is located along the south wall approximately 8.5 feet west of the eastern stem wall. The crack is visible along the exposed face of the stem wall, but the footing is not visible. As with Crack 1, the crack is wider at the top than the bottom. Photographs of the crack are shown in Attachment 1.

Crack No. 3

This crack was observed in the dirt floor of the crawl space. The trace of the feature is an arc shape that begins approximately 2 feet west of the intersection between the southern and eastern stem wall, extends to a maximum distance of 4.5 feet west of the eastern stem wall and then curves back towards the eastern stem wall in a northeasterly direction. The trace of the feature is shown in the plan-view sketch. The crack has a maximum width of 1-inch (horizontal) and there was no vertical displacement. Photographs of the crack are shown in Attachment 1.

No other obvious cracks were observed within the southern or eastern stem walls. The area of observation is shown in the plan-view. Observations of the northern and northeastern stem walls were not made because access was restricted by an electrical line.

Conclusions:

The location and geometry of the crack in the dirt floor suggests it is potentially related to the deformation that is occurring within the Hymer Mine Shaft. The crack trace curves around the location of the mine shaft. The trace of this crack is approximately 18-20 feet from the anticipated center of the shaft. Similarly, the surface displacement to the east and north of the mine shaft are also on the order of 20 feet from the estimated center of the shaft.

It has been our pleasure to assist you with this project. If you have any questions, please feel free to contact this office at 406-388-8578.

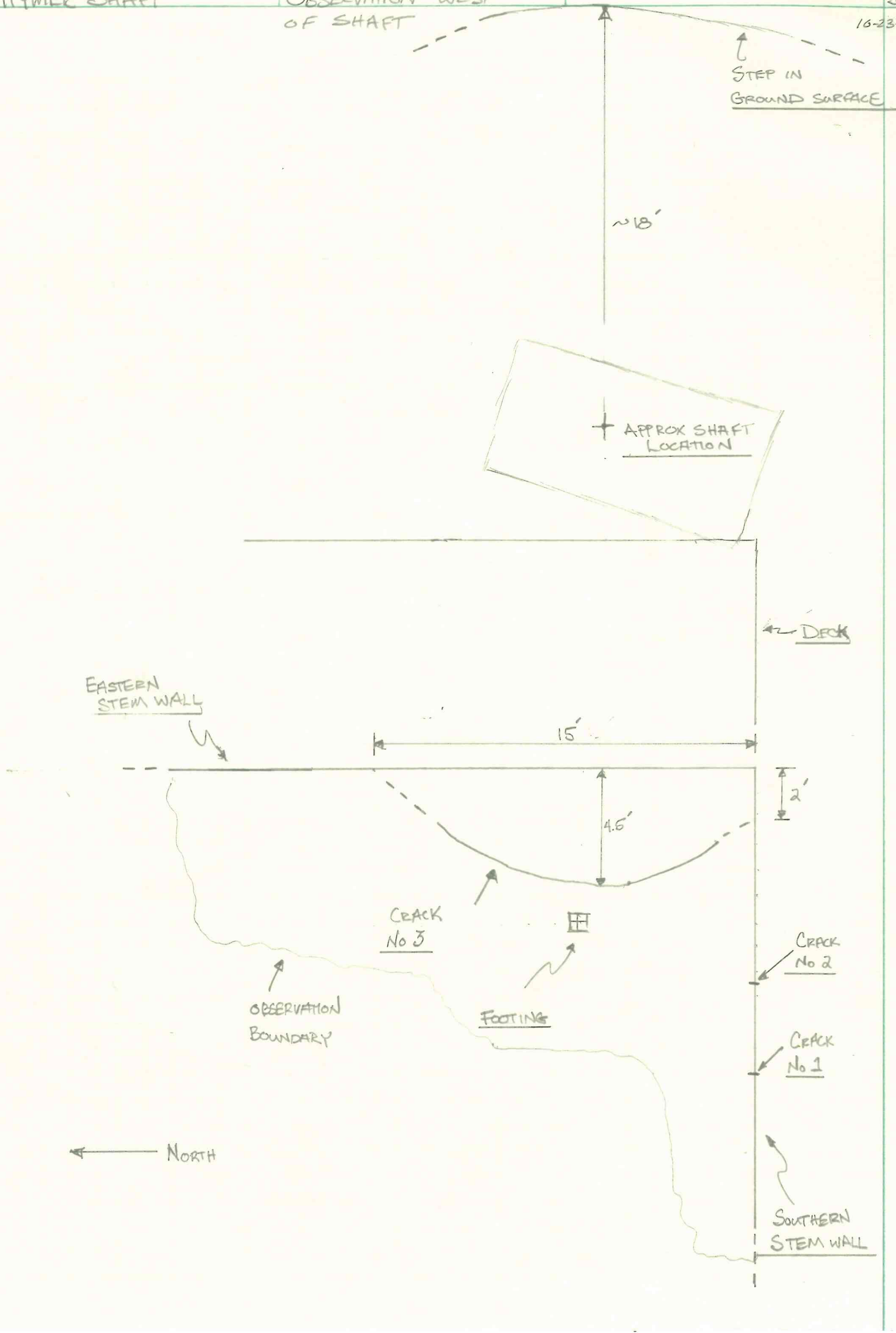
Sincerely,

Jeffrey J. Riedel, P.E.

Project Geotechnical Engineer.

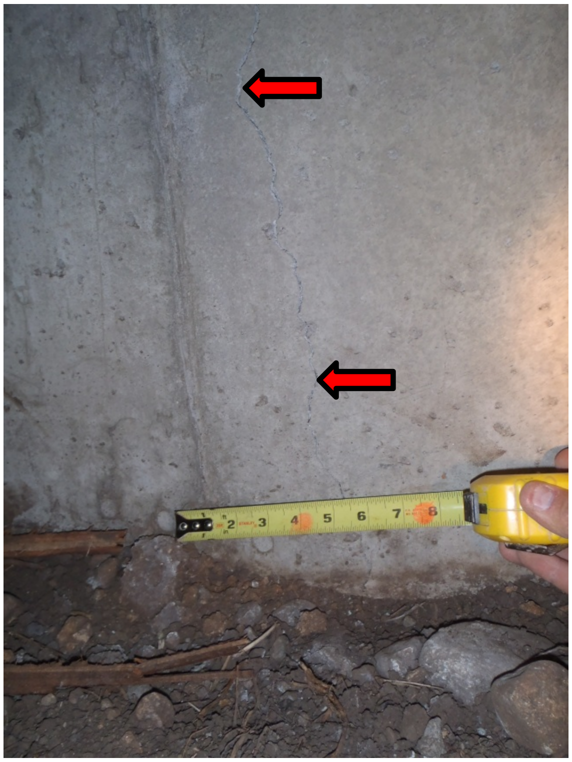
Attachment 1

HYMER SHAFT | OBSERVATION WEST OF SHAFT | JR 10-23-12



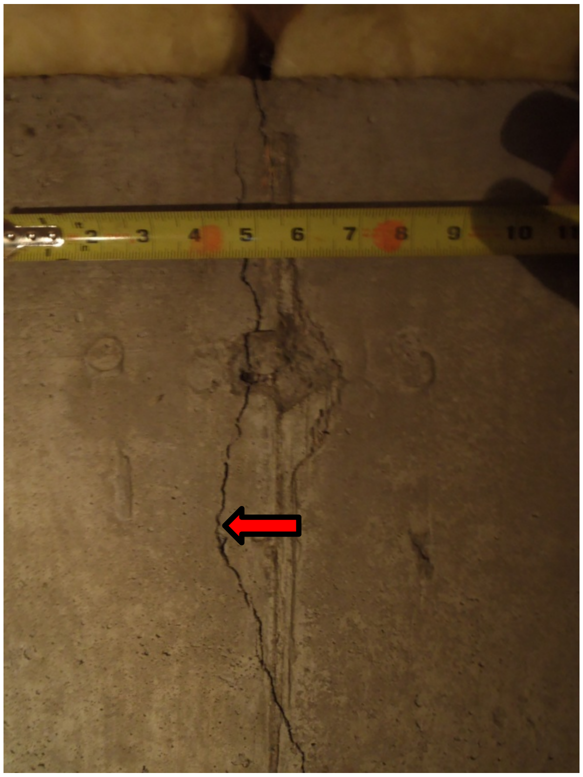
DATE: 10/22/12
DESCRIPTION: Crack No 1: Observe crack width is larger at top than at bottom, looking south.

DATE: 10/22/12
DESCRIPTION: Crack No 1: Close-up of top of upper portion of crack, looking south.



DATE: 10/22/12
DESCRIPTION: Crack No 1: Close-up of bottom portion of crack, looking south.

DATE: 10/22/12
DESCRIPTION: Crack No 2. Observe the crack is wider at the top than the bottom, looking south.



DATE: 10/22/12
DESCRIPTION: Crack No 2. Close up view of top of the crack, looking south.

DATE: 10/22/12
DESCRIPTION: Crack No 2. Close up view of bottom of crack, looking south.

DATE: 10/22/12
DESCRIPTION: Ground Crack: Crack is approximately 1 inch in width at the widest point, looking North.

DATE: 10/22/12
DESCRIPTION: Ground Crack: Looking north at trace of ground crack. Crack location is highlighted in photo.

Appendix G
Subcontractor Solicitations
&
Bids

INVITATION FOR BID
HYMER MINE SHAFT SUBSIDENCE
SUBSURFACE DRILLING INVESTIGATION
RED LODGE, CARBON COUNTY, MONTANA

CALL FOR BIDS

On behalf of the Montana Department of Environmental Quality, Abandoned Mine Lands Bureau (DEQ AMLB), Spectrum Engineering, Inc. (Spectrum) is soliciting bids for a drilling contractor (Contractor) to provide an estimated 200 feet to 300 feet of investigative drilling using an air rotary type drilling at 512 S. Adams Avenue in Red Lodge, Carbon County, Montana.

PROJECT PURPOSE

The Hymer Mine Shaft Subsidence site, located at 512 S. Adams Street in Red Lodge, Montana, will be drilled to determine current subsurface conditions inside the shaft. The information collected will be used to determine cement grouting or compaction grouting requirements for remediation design of an on-going surface settlement problem associated with this partially caved shaft.

A caved mine shaft, which will be investigated by the contracted drilling, is located in the back yard near a deck that is attached to the back of the house. The site can be accessed from the alley by removing a section of chain link fence. There are no buried utilities in the drilling area that will interfere with the project. In 1998, the shaft was probed with five drill holes and injected with grout. The current drilling investigation requires the completion of three drill holes. A 30-foot deep hole will be drilled outside the shaft to verify the shaft location. Then two holes will be drilled to at least a deep of 85-feet inside the shaft. Due to uncertain drilling conditions inside the caved shaft, the scope of work includes a contingency for abandoning and redrilling holes.

SITE HISTORY

The site is associated a shaft sinking project that was undertaken in 1904 -1906 by the Red Lodge Coal Company. W. E. Hymer was the manager and one-third owner of the Red Lodge Coal Company. Before becoming involved with coal mining, Hymer had developed the Hymer Addition and had acquired the coal rights to the area where the shaft was to be developed. In April of 1904, the Red Lodge Coal Company awarded a contract to have the 8’8” x 16’2" double compartment shaft sunk on the No. 1 coal vein. The shaft was to be 200 feet deep and was to be lined with 10"x10" timbers and 3"x12" lagging. By August 25, 1904, a 24'x 46' hoisting plant had been constructed and the shaft had been sunk to a depth of 50 feet. On June 10, 1905, Clarence Hymer, the 25 years old son of W.E. Hymer, was killed while working on the shaft sinking project. The shaft was about 100 feet deep at the time of the accident.

There are no newspaper or mine accounts of the shaft after 1905. However, we do know that the Northwest Improvement Company (NWI) began mining the No. 5 Bed 800 feet north of the shaft on December 20, 1905. NWI eventually got most of the coal rights in the Hymer Addition and mined this general area during the period from 1908 to 1918. But, all of their workings skirted around the Hymer Shaft. A 1907- fire insurance rating map of Red Lodge indicates that the shaft and hoisting works were not in operation at that time. This map provides the only know documentation of the shaft location.

By 1927, the hoisting plant had been removed, the shaft had been covered, and a small house had been erected on the site. The surface over the covered shaft caved sometime around 1959, allowing a modest subsidence hole to develop. The surface damage was repaired by backfilling. Additional backfill was placed within the subsided area between 1994 and 1998. During this later period, an addition was added to the house. Then a deck, which extends over the shaft subsidence area, was constructed.

In 1998, DEQ AMLB decided to investigate continued settlement around the shaft. Five boreholes that were 15 to 35 feet in length were initially drilled to locate the shaft. These holes either encountered loose fill or shaft timbers. The drilling roughly located the shaft and indicated that a partially collapsed wood bulkhead was situated about 22 feet below the surface. A total of 21 cubic yards of 6½ sack grout (2000 psi) was pumped into drill hole DH-4 to stabilize the ground. Most of the grout did not remain in the zone where it had been placed and fell further down the shaft. After the grout was allowed to setup, drill hole DH-4 was redrilled. It went through large voids below the depth of 35 feet and hit solid material at a depth of 78 feet below the surface. There was water in the hole between 45 feet and 55 feet, but the water seemed to be confined to this zone. An additional 30 cubic yards of grout and 11 cubic yards of neat cements were injected up this hole. If the compartments in the shaft confined the grout, most of the grout and neat cement would have been placed into the southern compartment. Drilling and grout injection employed 5" Dex casing. The 1998 drilling site was reclaimed with a cover soil fill that was graded level with the adjacent ground.

SCOPE OF WORK

Subsequent to the grout injection project in 1998, the posts supporting the southeast corner of the upper deck attached to the house have settled over 12 inches. And, there is currently a 1-foot deep depression over the northern compartment. In order to investigate this settlement problem, one hole will be drilled down the center of each of the two compartments. Based on the previous drilling, it is anticipated that each hole will be approximately 85 feet long. The hole drilled into the southern compartment of the shaft should penetrate grout-stabilized fill and grout. The hole drilled into the northern compartment should penetrate 22 feet of loose fill before hitting the remains of a wood bulkhead. Below the bulkhead, large voids, collapsed timbers, gravel, loose rocks and water could be encountered. Prior to drilling the holes in the shaft, a 30-foot deep hole will be drilled near the suspected northern edge of the shaft to confirm the location of the shaft. For shaft location, drilling the hole on an angle would be beneficial

It is expected that completing one borehole to the bottom of the shaft in each compartment will provide adequate information for this investigation. However, conditions inside the shaft could necessitate abandoning a drill hole prior to completion and moving to another location within the compartment in order to complete the borehole to an adequate depth. Therefore, the drilling plan, budget and allotted time will include a contingency for drilling an additional 100 feet. After the drilling has been completed, all metal casing will be removed and the drill holes will be plugged in accordance with the governing rules and regulations. However, in order to preserve our future stabilization options and to avoid excessive abandonment costs, we will want to avoid using backfill to plug holes that have encountered large voids.

The contract will be between Spectrum and Contractor. This work is being performed for DEQ AMLB. As dictated by Spectrum's contract with DEQ AMLB, Spectrum is required to solicit three bids for any subcontracted or outside services.

The Contractor shall supply all equipment, operators, and materials necessary to complete the described scope of work. Spectrum will supply one engineer to oversee the work and to record data. Spectrum will rely on the Contractor's expertise in making appropriate changes in the field.

DESCRIPTION OF INDIVIDUAL BID ITEMS

Bid Item No. 1: Mobilization, Business License, Access, Repair/Replace Property Damage

General: This work includes mobilizing all equipment and materials necessary to complete the work, obtaining a Red Lodge City Business License, paying fee to City Treasurer, submitting a copy of the license to Spectrum prior to beginning work, establishing site access, and repairing/replacing all damage to property caused by drilling equipment.

Contractor shall establish site access by removing a portion of chain link fence located between the garage and house and by removing all other items required for site access.

Contractor shall take appropriate actions to avoid damaging the property including but not limited to the lawn and structures. Drilling equipment will be required to cross a lawn and a sidewalk. The lawn has clumps of grass, and the sidewalk has two cracks. Drilling will occur in close proximity to the deck.

Contractor shall protect the lawn and sidewalk by taking such measures as laying planks and plywood. Contractor shall protect the structures by installing plastic sheeting, plywood, or tarps on the structure to prevent drill cuttings and debris from coming in contact with and damaging any portion of the structure. Contractor shall replace and repair all damage, caused by drilling equipment, to the lawn and structures at no cost to the landowner, Spectrum or DEQ AMLB.

Measurement: There will be no direct measurement of this item.

Payment: Payment will be made at the lump sum price bid for “Bid Item 1 Mobilization, Business License, Access, Repair/Replace Property Damage” which payment will constitute full compensation for all labor, equipment, tools, materials, and incidentals necessary to accomplish the work as specified.

Bid Item No. 2: Drilling Footage (Temporary Casing and Logging)

General: This work includes drilling to investigate a 8’8” x 16’2 double compartment shaft as shown on Sheet No. 1, abandoning and redrilling holes, and installing temporary casing.

Contractor shall use an air rotary drill to investigate an 8’8” x 16’2 double compartment shaft that has partially collapsed. A previous drilling investigation indicates that the shaft was capped with a wooden bulkhead located 22 feet below the surface. Below this depth, there could be a solid wall between the two compartments. The first hole will be drilled on the northern edge of the shaft. This hole will be approximately 30 feet deep and will be used to verify the shaft location. It will be beneficial to drill the location hole on an angle toward the shaft. After verifying the shaft location, one vertical hole will be drilled down the center of each compartment. Each hole will be drilled to a depth that reaches solid material at the bottom of the shaft. Previous drilling indicates that completed drill holes will need to be at least 85 feet in length. The hole drilled into the southern compartment of the shaft should penetrate grout-stabilized fill and grout. The success of a 1998 grout injection project will be assessed by drilling this hole. The hole drilled into the northern compartment is expected to penetrate 22 feet of loose fill before hitting a partially wood bulkhead. Below the bulkhead, large voids, collapsed timbers, gravel, loose rocks and water could be encountered. The loss of circulation should be anticipated.

Each drill hole will be accurately logged indicating all changes in drilling conditions and changes in materials encountered. Depths at which shaft timbers, air circulation and/or voids are encountered will be recorded. Contractor shall identify the size of void spaces and the degree of consolidation of any materials filling the shaft. The information collected will be used to determine cement grouting or compaction grouting requirements for designing remediation of the settlement problem. If circulation is lost, Contractor shall concentrate on identifying the size of void spaces and the degree of consolidation of any materials filling the shaft. Identifying materials by collecting drill cuttings is of secondary importance. Contractor shall provide a separate well log presenting all observations and depths for each hole drilled.

If a hole cannot be completed to the planned depth because structural debris or a large rock has been encountered, Contractor shall redrill the hole in a location as directed by Spectrum. Compensation for additional footage will be paid at the bid unit rate as shown on the Bid Sheet. A contingency drilling footage of 100 feet is included in the quantity as shown on the Bid Sheet.

Contactor shall install temporary casing as directed by Spectrum. Spectrum will determine requirements during drilling activiites. Contractor shall select casing that is appropriate and cost-effective. Because the southern compartment has been filled and stabilized with grout, it should be possible to drill it without casing. It is possible that some grout also flowed into the northern compartment and has stabilized the surface fill in this compartment. Leaving metal casing in the ground shall be avoided. If used, it will be recovered. Contractor shall submit a description of his intended casing procedures with the Bid Sheet.

Measurement: Measurement shall be by the actual number of feet of drilling completed as measured by Spectrum.

Payment: Payment will be made at the unit price bid for "Bid Item No. 2 Drilling Footage (Temporary Casing and Logging)" which payment will constitute full compensation for all labor, equipment, tools, materials, and incidentals necessary to accomplish the work as specified.

Bid Item No. 3: Drill Hole Plugging

General: This work includes plugging all drill holes. Contractor shall plug all drill holes. In order to preserve future stabilization options and to avoid excessive abandonment costs, holes that encounter significant voids shall not be plugged by backfilling alone. Using a packer or 20-foot long piece of PVC casing with a cap to confine plugging materials to the upper portion of the hole would be acceptable as a temporary plug. Contractor shall submit a description of his intended drill hole plugging procedures with the Bid Sheet. A contingency of plugging two additional drill holes is included in the quantity as shown on the Bid Sheet.

Measurement: Measurement shall be by the actual number of drill holes plugged as measured by Spectrum.

Payment: Payment will be made at the unit price bid for "Bid Item No. 3 Drill Hole Plugging" which payment will constitute full compensation for all labor, equipment, tools, materials, and incidentals necessary to accomplish the work as specified.

Bid Item No. 4: Site Restoration and Demobilization

General: This work includes restoring the site and demobilization. Contractor shall remove all construction materials including but not limited to tarps, plastic sheeting, plywood, and debris from the site as necessary to restore the site to its pre-drilling condition. Any ruts that have been created by drilling equipment shall be filled with topsoil and graded. The fence and all other items removed to gain site access shall be reconnected and restored to its original condition.

Measurement: There will be no direct measurement of this item.

Payment: Payment will be made at the lump sum price bid for "Bid Item 4 Site Restoration and Demobilization" which payment will constitute full compensation for all labor, equipment, tools, materials, and incidentals necessary to accomplish the work as specified.

BID SUBMITTAL

Bids will be received at the office of Spectrum Engineering, Inc. until 2:00 p.m. on Tuesday, July 24, 2012 at which time they will be opened. ALL BIDS SHALL BE ADDRESSED TO DEQ AMLB as indicated on the BID SHEET. A complete bid will include 1) addressing the bid to the attention of DEQ AMLB, and 2) completion of pages Bid-1, Bid-2, Bid-3, and Bid-4 of this Invitation for Bid. All bids not containing these pages will be disregarded.

Bids may be emailed, faxed, mailed, or hand delivered to Spectrum Engineering, Inc., 1413 4th Avenue North, Billings, Montana 59101, at telephone 406-259-2412, fax at 406-259-1456 or email at murja@spectrum-eng.com.

The combination of prices bid will be the total compensation for all specified work. No additional compensation will be paid for demobilization, labor, equipment, materials, drilling time, standby time, overhead, profit, insurance and all incidentals including travel, board and room required to finish the work. Spectrum Engineering will not pay any compensation for damage to or loss of equipment. Total compensation and all other forms of reimbursement for this work must be included in the unit and lump sum prices bid.

The intent of the bid structure is for the contractor to supply all labor, equipment, material and supplies required and to assume all risks. Spectrum will supply one engineer with oversight responsibilities to identify the drilling locations, to help log the drill holes, and to function as an inspector. Because the intent of the project is to collect and record data, drilling must be conducted at a rate that will allow all useful information to be accurately recorded.

Driller will be solely responsible for selecting the equipment and techniques required to perform the Work, which shall include providing Spectrum with reliable information concerning down-hole conditions. The ground over and adjacent to the partially caved and backfilled shaft is subsiding and should be considered unstable. Selection of equipment and procedures to minimize settlement and/or collapse risks to equipment, personnel, and the adjacent structures is BIDDER's responsibility but may be included in the evaluation of the bid.

Spectrum Engineering reserves the right to terminate the work at any time and pay only for the actual work completed at the unit rates bid.

Return the Bid Sheet with a brief description of the proposed equipment (drill, angle drilling capability, bit, casing, water truck), the proposed casing procedures, the proposed plan to minimize property damage, the proposed drill hole plugging plan, and the proposed work schedule for starting and completing the work. Your proposed schedule, equipment selection, plans and bid prices will be included in the evaluation to provide DEQ AMLB with the best value. Spectrum Engineering and DEQ AMLB reserve the right to reject any and all bids. A contract might not be issued if all bids exceed the budget allowance. If all bids exceed the budget allowance, Spectrum may elect to negotiate with one or more of the bidders.

PRE-BID CONFERENCE

No pre-bid conference will be held.

QUESTIONS

Questions about this bid solicitation should be directed to Dave Murja, Spectrum Engineering, Inc., 406-259-2412, 406-855-8070 (Cell) or Murja@spectrum-eng.com no later than 2:00 p.m. on Thursday, July 19, 2012.

SCHEDULE

The work will be scheduled at a mutually agreeable time between the Contractor, Spectrum, and DEQ AMLB. A drilling date in late July or early August is preferred by Spectrum. All of Spectrum's task order with DEQ AMLB expires in September 2012.

HEALTH AND SAFETY PLAN

The drilling contractor shall have a site specific health and safety plan that addresses the safety hazards associated with operating drilling equipment in a residential neighborhood.

BID SHEET

ADDRESS BIDS TO:
DEQ AMLB

SUBMIT BIDS TO:
David Murja
Project Engineer
Spectrum Engineering, Inc.
1413 4th Avenue North
Billings, MT 59101
Fax: 406-259-1456
Email: murja@spectrum-eng.com

DEQ AMLB:

The undersigned agrees to furnish all labor, materials, equipment and services necessary to complete all drilling, casing, logging, plugging and restoration work, as bid herein, for the project entitled **"HYMER MINE SHAFT SUBSIDENCE SUBSURFACE DRILLING INVESTIGATION"** in accordance with the attached Invitation for Bid.

The undersigned Bidder understands that the quantities stated herein are approximate and offers to do the work for the quoted unit prices whether the quantities are increased or decreased. Contingency quantities are included in the bid quantities as described in the Invitation for Bid. The Bidder agrees that the unit and lump sum prices quoted include all costs. The Bidder acknowledges his understanding that no additional form of compensation or reimbursement will be made for any loss of or damage to equipment.

The undersigned Bidder agrees to provide or perform the specified work for the following unit prices:

Bid Item	Estimated Quantity	Unit	Description	Unit Price	Total Price
1	1	Lump Sum	Mobilization, Business License, Access, Repair/Replace Property Damage	XXXX	
2	300	Feet of drilling completed	Drilling Footage (Temporary Casing and Logging are included)		
3	4	Each hole	Drill Hole Plugging		
4	1	Lump Sum	Site Restoration and Demobilization	XXXX	
			TOTAL PRICE		

(PRICE IN WORDS) ____ .

Bidder understands that Spectrum Engineering, Inc. reserves the right to reject any or all bids and to waive any informality in the bidding.

The Bidder agrees that this Bid shall be good and may not be withdrawn for a period of 30 calendar days after the scheduled opening time.

The Contractor shall be solely responsible for information required to bid the project. By signing this Proposal, the Contractor acknowledges that he has adequate information, independently verified by the Contractor, to prepare and offer this bid.

Firm Name: ____

By: ____

Title: ____

Business Address: ____

____

____

Telephone No.: ____

Fax No.: ____

Proposed Equipment (Drill, Bit, Casing, Water Truck)

Proposed Casing Procedures

Proposed Plan To Minimize Property Damage

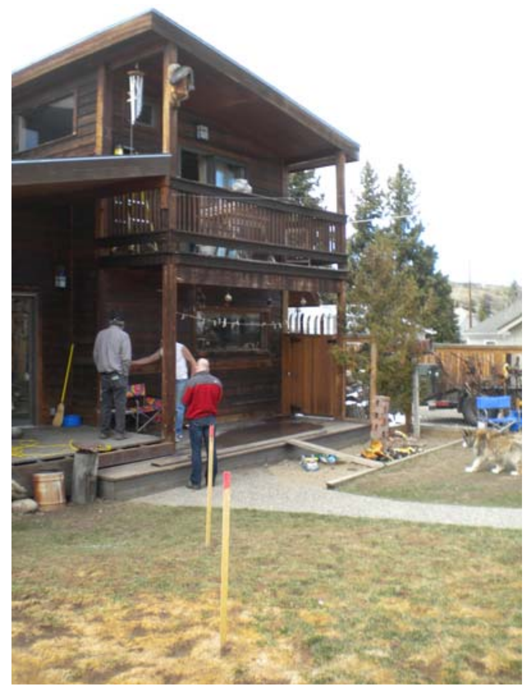
Proposed Drill Hole Plugging Plan

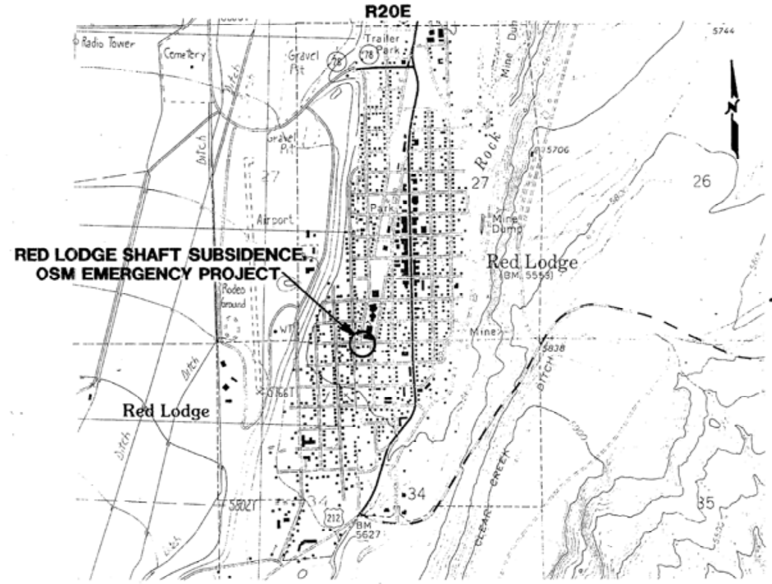
Proposed Work Schedule


512 Adams-1.JPG


512 Adams-2.JPG

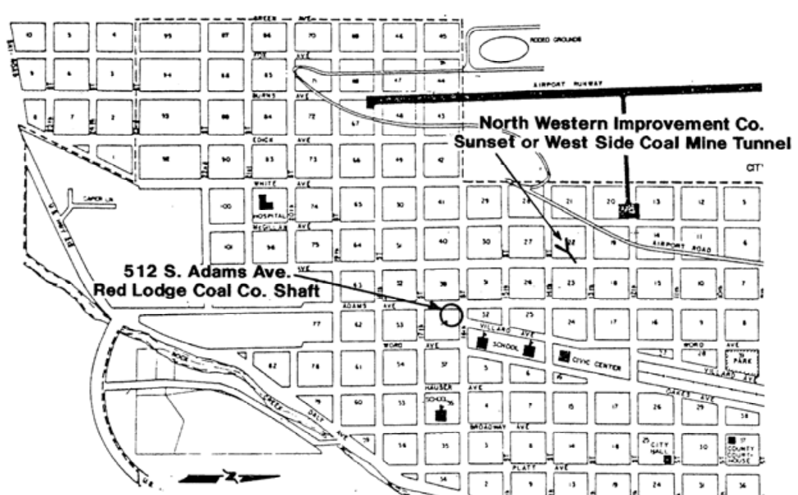

512 Adams-3.JPG


512 Adams-5.JPG



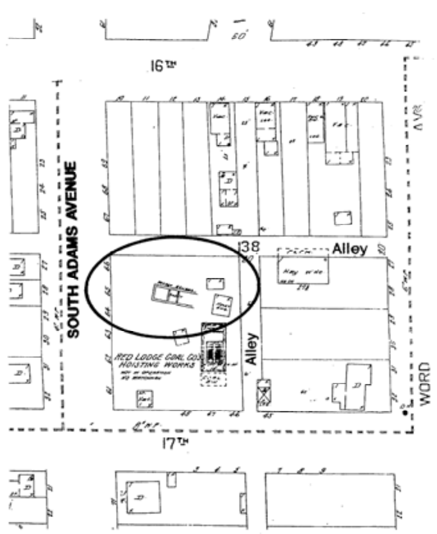
AREA LOCATION MAP

0 1000 2000 Scale In Feet

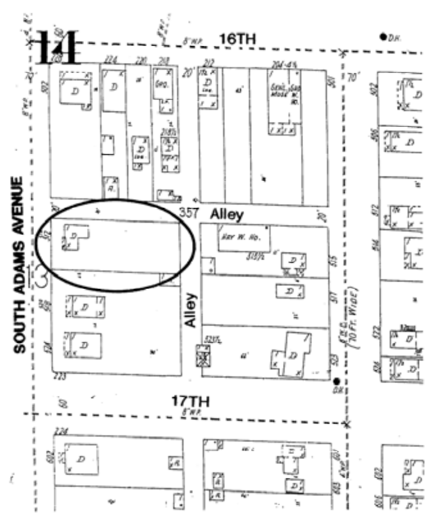


CITY OF RED LODGE MAP

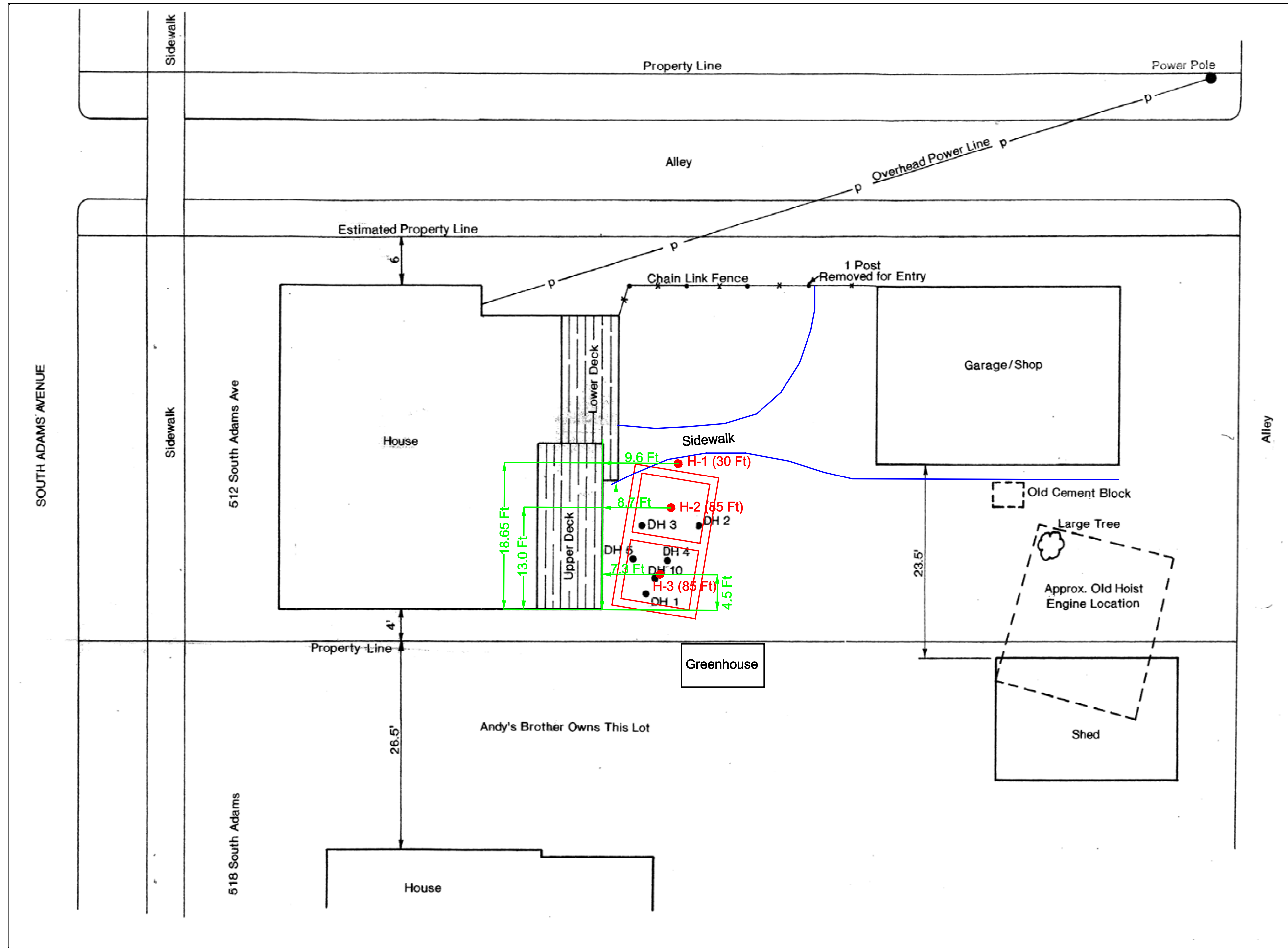
0 500 1000 Scale In Feet



1907 SANBORN FIRE INSURANCE RATING MAP SHOWING SURFACE PLANT AND SHAFT LOCATION OF THE RED LODGE COAL COMPANY.



1927 SANBORN FIRE INSURANCE RATING MAP SHOWING HOUSE CONSTRUCTED ON LOT C. 1917 WITH COAL PLANT & SHAFT GONE.



Note 1 - 62 Cubic Yards of Grout and Neat Cement Were Injected Into DH4 in 1998
DH 1, DH 2, DH 3, DH 4, DH 5 AND DH 10 were drilled in 1998

Note 2 - Only H-1, H-2, H-3 are planned for the current project.

HYMER SHAFT

Constructed by the Red Lodge Coal Company 1904-1906
8 Ft-8 In X 16 Ft-2 In Double Compartment Shaft
Lined with 10"x10" timbers and 3"x12" lagging.

SPECTRUM ENGINEERING 1413 4th Ave. North Billings, MT 59101 Phone: (406) 259-2412 June 2012	STATE OF MONTANA Department of Environmental Quality REMEDIATION DIVISION 1100 Last Chance Gulch Helena, MT 59620	N½ Section 34 of T7S, R20E Carbon County, Montana HYMER SHAFT 512 Adams Ave. South, Red Lodge FILE NAME: Red Lodge Subsidence SHEET NO. 1

BID SHEET

ADDRESS BIDS TO:
DEQ AMLB

SUBMIT BIDS TO:
David Murja
Project Engineer
Spectrum Engineering, Inc.
1413 4th Avenue North
Billings, MT 59101
Fax: 406-259-1456
Email: murja@spectrum-eng.com

DEQ AMLB:

The undersigned agrees to furnish all labor, materials, equipment and services necessary to complete all drilling, casing, logging, plugging and restoration work, as bid herein, for the project entitled **"HYMER MINE SHAFT SUBSIDENCE SUBSURFACE DRILLING INVESTIGATION"** in accordance with the attached Invitation for Bid.

The undersigned Bidder understands that the quantities stated herein are approximate and offers to do the work for the quoted unit prices whether the quantities are increased or decreased. Contingency quantities are included in the bid quantities as described in the Invitation for Bid. The Bidder agrees that the unit and lump sum prices quoted include all costs. The Bidder acknowledges his understanding that no additional form of compensation or reimbursement will be made for any loss of or damage to equipment.

The undersigned Bidder agrees to provide or perform the specified work for the following unit prices:

Bid Item	Estimated Quantity	Unit	Description	Unit Price	Total Price
1	1	Lump Sum	Mobilization, Business License, Access, Repair/Replace Property Damage	XXXX	3,565
2	300	Feet of drilling completed	Drilling Footage (Temporary Casing and Logging are included)	a. open hole vertical open hole angle b. O-Dex	$14.50/ft = 4350.00 $16.00/ft = 4800.00 $32.00/ft = 9600.00
3	4	Each hole	Drill Hole Plugging		2,750
4	1	Lump Sum	Site Restoration and Demobilization	XXXX	2,725
			TOTAL PRICE	$13,390 – $18,640 dependant on drilling method required.	

(PRICE IN WORDS) Price dependant on drilling method required - to be determined on-site. Thirteen thousand, three hundred ninety to Eighteen thousand, six hundred forty

Bidder understands that Spectrum Engineering, Inc. reserves the right to reject any or all bids and to waive any informality in the bidding.

The Bidder agrees that this Bid shall be good and may not be withdrawn for a period of 30 calendar days after the scheduled opening time.

The Contractor shall be solely responsible for information required to bid the project. By signing this Proposal, the Contractor acknowledges that he has adequate information, independently verified by the Contractor, to prepare and offer this bid.

Firm Name: Lyle Ballenger / Axis Drilling, Inc.

By: [signature]

Title: President

Business Address: Axis Drilling, Inc.
204 Cantryside Ln.
Belgrade, MT 59714

Telephone No.: 406.388.2267

Fax No.: 855.570.2947

Proposed Equipment (Drill, Bit, Casing, Water Truck)

Davey Kent Track Rig with articulated angle mast capable of horizontal and angle drilling. Propose DTH open hole @ 3.65 diameter bit. If conditions warrant, a 5.25 O.D. O-Dex System will be employed.

Proposed Casing Procedures

Steel casing is threaded and in 5' pieces. Will pull all steel casing from holes after completion.

Proposed Plan To Minimize Property Damage

Will use planks and plywood to cross lawn and sidewalk. Will tarp everything in vacinity of cuttings on contact. ie: house, lawn, sidewalk, etc.

Proposed Drill Hole Plugging Plan

Will push a shale packer to proper depth and fill hole with cutting or other suitable material.

Proposed Work Schedule

Prior to August 16, 2012