REPORT

Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments

Submitted To: Blackbird Mine Site Group

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EXECUTIVE SUMMARY

Background

The Blackbird Mine Site Group (BMSG) has been conducting environmental response actions at the Blackbird Mine Site since 1994 and continuing to the present, pursuant to a June 1995 Administrative Order on Consent (AOC) for non-time critical removal actions and an August 2003 Unilateral Administrative Order (UAO) for remedial actions, both issued by the Environmental Protection Agency (EPA). The BMSG conducted extensive emergency response actions, early actions and remedial actions at the Blackbird Mine Site and constructed permanent facilities for diversion, collection, storage and treatment of impacted waters. In addition, actions have been taken to remove tailings and sediment containing arsenic and cobalt from depositional areas along Blackbird Creek and Panther Creek.

Subsequent to these actions, flooding in Blackbird Creek in early 2003 and in May 2008 and 2009 resulted in erosion and deposition of sediments along the Blackbird Creek channel, and deposition of sediments extending downstream into Panther Creek. In some areas, sediments were deposited in the channel and floodplain, leading to flooding of and damage to the Blackbird Creek Road. The transported sediments containing elevated levels of arsenic and cobalt were deposited in areas along Blackbird Creek, at the Panther Creek Inn (PCI), and in certain areas on Panther Creek downstream of the PCI. Sampling activities following the flood event indicated that the sediments deposited along Blackbird Creek were below the cleanup levels identified by the EPA for those areas. However, there were some locations in residential and recreational areas along Panther Creek that contained sediment deposits *in overbank areas*[1] with levels of arsenic exceeding the EPA-developed cleanup levels and the preliminary remediation goal (PRG) for cobalt for protection of human health. The release of sediments from Blackbird Creek may also contribute to exceedances of sediment cleanup levels for arsenic, cobalt, and copper established *for Panther Creek* by EPA for protection of benthic macroinvertebrates and other aquatic organisms. The erosion of sediments during spring floods in 2008 and 2009 also likely contributed to dissolved copper concentrations that exceeded cleanup levels in Panther Creek established by EPA for protection of aquatic life. Removal actions were conducted in 2009 in several of these Panther Creek overbank areas. Additional removals are planned for 2010.

In response to these events, the EPA requested that BMSG conduct a study to identify and evaluate potential measures to control the potential impacts of future flood flows and releases of sediments from Blackbird Creek so that the associated potential human health risk is significantly reduced and the

[1] The EPA has provided specific editorial and substantive changes to the text of this document. Although the BMSG and Golder Associates do not agree with some of the changes, all of the EPA changes have been incorporated into this final document. The new text provided by EPA is shown in italics. For ease of reading this final document, the text deleted by the EPA changes is not shown; however, an additional electronic sub-file showing a full redline/strikeout version of the text is included in the electronic file of the report.

Blackbird Creek Road is protected. This report presents an evaluation of alternative measures to address the potential for the continued release of sediments and iron oxyhydroxides (floc) with arsenic and cobalt content from Blackbird Creek to areas downstream of the Blackbird Mine Site.

Existing Conditions

Following initiation of this study, the BMSG acquired the PCI and the surrounding properties that had been used for residential and recreational purposes. As the new owner, the BMSG has closed the PCI as a business and the property is no longer used for residential purposes. This change of ownership and land use has significantly reduced the potential human health risk from contaminated sediments. Issues with overbank deposits containing arsenic and cobalt in areas downstream of the PCI, and along Panther Creek, are unchanged by the ownership transition at the PCI.

Within Blackbird Creek, solid phase arsenic is present in both primary and secondary mineral phases. The primary mineral phase (i.e. the original mineral ore) is indicative of a tailings source. Arsenic also occurs in association with iron oxyhydroxides, a secondary mineral phase (i.e. a phase formed from adsorption of arsenic to the iron oxyhydroxides). As seepage containing dissolved iron discharges to surface water below the West Fork Tailings Impoundment, an increase in solution pH occurs due to mixing with Blackbird Creek and West Fork bypass waters, and a change to more oxidizing conditions occurs due to exposure to atmospheric oxygen, promote precipitation of ferrihydrite (iron oxyhydroxide). Floc is the reddish, very fine, fluffy mass formed by the iron oxyhydroxides which partially settle and form coatings on the stream sediments. Throughout this document arsenic that is present predominantly as a primary mineral phase is defined as a sediment source. Arsenic present in association with iron oxyhydroxides is defined as a floc source.

Solid phase cobalt is present mostly as a primary mineral phase (e.g. cobaltite) in the mill tailings. Cobalt does not form secondary phases as readily as arsenic under geochemical conditions occurring in Blackbird and Panther Creeks, but there are also secondary phases in association with iron oxyhydroxides.

Bed load and suspended load sediments with associated arsenic and cobalt are transported down the Blackbird Creek system by natural hydrologic processes. Bed load (coarse-grained sediments) and suspended load (fine-grained sediments) are mixed together and are present along all of Blackbird Creek. The bed load sediments are generally low in arsenic and cobalt content. Arsenic and cobalt are associated with fine-grained sediments which include tailings from historic mining operations. Since sediments are not completely segregated by size at most locations along Blackbird Creek, arsenic and cobalt are present in some portion of most of the sediments. New sediments continue to be added to the Blackbird Creek channel from basin tributaries in response to flood events. These sediments, which do not contain high concentrations of arsenic or cobalt, are mixing with and covering the existing sediments that contain these elements.

Diffusion of oxygen into the West Fork Tailings Impoundment results in weathering of cobaltite and release of arsenic in dissolved form at low concentrations. Cobalt released from weathering of cobaltite remains primarily in the dissolved form. Tailings impoundment seepage, which contains the dissolved arsenic and cobalt also contains iron; therefore, upon discharge to Blackbird Creek, dissolved arsenic is adsorbed/co-precipitated with iron oxyhydroxide as a floc material. This floc is transported downstream by natural hydrologic processes.

Although arsenic can move downstream into Panther Creek in stream sediments and in the floc, the mass loading rates and corresponding potential health risks are very different. Estimates of mass loading rates indicate that the sediments carry approximately 10 times more arsenic than the floc annually. A study conducted in Fall 2009 to characterize the contribution of floc to total arsenic concentrations in Panther Creek overbank materials indicated that the floc contribution to total arsenic levels is insignificant. Efforts to control arsenic should reflect this significant difference in level of contribution between the two sources.

Alternative Actions

This report identifies and evaluates measures to address potential arsenic and cobalt risks to human health and to address potential arsenic, cobalt, and copper risks to aquatic organisms that result from future releases of sediments and floc particles from flooding and erosion in Blackbird Creek, and to protect the Blackbird Creek Road. The technologies evaluated include:

- Measures to collect or control the floc deposits that form in Blackbird Creek downstream of the West Fork Tailings Impoundment. Measures evaluated included both capture (detention facilities) and treatment (both passive and active treatment alternatives).
- Sediment control measures to reduce the volume of sediments released from Blackbird Creek, primarily during high flow events. The primary sediment control measures that were evaluated include in-stream stabilization and removal of potentially contaminated sediments, in-stream dams and reservoirs for settling of suspended sediments and off-channel settling basins.

From the technologies evaluated, five alternatives were developed to control risks from erosion of sediment, risks from floc and to protect the Blackbird Creek Road. These include:

- Alternative A – Baseline Remedy (No Action)
- Alternative B – In-Stream Stabilization & Removal
- Alternative C – In-Stream Stabilization & Removal with PCI Settling Basins
- Alternative D – Single Large In-Stream Dam
- Alternative E – In-Stream Stabilization & Removal with a Single Moderately Sized In-Stream Dam

Chemical characterization of Panther Creek overbank materials indicated that the total arsenic loading from floc is small (approximately 10 percent of the total load) compared to the loading from other sources, including fine-grained sediment. For this reason, treatment of floc is predicted to have only a small effect in removing contaminants of concern (COCs) from the total flux of sediments moving down Blackbird Creek. Therefore active and/or passive systems focused on treatment of floc were not included in the alternative configurations for evaluation.

The five alternatives were evaluated and compared with respect to:

Effectiveness

- Overall Protection of Human Health and the Environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Long Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility and Volume
- Short Term Effectiveness

Implementability

- Ease of Construction
- Suitability of the Proposed Technology
- Ease of Implementation
- Administrative Constraints

Cost

- Capital Costs
- Operations and Maintenance (O&M) Costs
- Net Present Cost (NPC)

The most significant conclusions from the evaluations and comparisons were as follows:

1. All of the action alternatives *(Alternatives B through E)* are effective at reducing the potential for recontamination of overbank areas along Panther Creek. *The level of effectiveness varies among the action alternatives.*
2. Alternative B, which includes in-stream stabilization of Blackbird Creek sediments, coupled with supplemental removal of contaminated sediments, would be effective in controlling movement of existing contaminated fine-grained sediments in Blackbird Creek over the long term. The majority of the sediments would be stabilized by the end of 2010. Some migration of potentially contaminated sediments would occur during the first several years (on the order of approximately six years) as the fines are winnowed (i.e. flushed out) from the channel surface and an armor layer develops.
3. Alternative C would provide the same effectiveness *as* Alternative B's in-stream stabilization and removal, but would allow additional *capture of sediments* through use of the PCI Settling Basins. The basins would be operated so that nearly all of the flow of Blackbird Creek would pass through them *most of the time*. The sediments released during the winnowing process would *be settled out in* the settling basins thus allowing control of COCs *associated* with those sediments. Alternative C *is the most effective among the action alternatives.*
4. *Alternative D would not include in-stream stabilization and removals along Blackbird Creek. Rather, it would include a large dam (approximately 150 feet high) near the*

mouth of Blackbird Creek that would capture Blackbird Creek sediments and store them behind the dam. It would be nearly as effective at sediment capture as Alternative C at smaller runoff events (up to the two year event), but its effectiveness would diminish at larger runoff events. Alternative D would have the greatest environmental impacts and would be the most costly alternative.

5. *Alternative E would include in-stream stabilization and removals along Blackbird Creek similar to Alternatives B and C. This alternative would also include a moderately-sized dam (approximately 36 feet high) near the mouth of Blackbird Creek to capture sediments released during the winnowing process following the in-stream stabilization. Alternative E would have similar effectiveness to Alternative C during smaller runoff events, but its effectiveness would decrease as flows increase and its effectiveness would be mid-way between Alternatives C and D during larger runoff events.*
6. Alternative B, C and E would be fully effective in protecting the Blackbird Creek Road from erosion.
7. The sensitivities of the effectiveness, implementability and cost of the alternatives to changes in key uncertain parameters were evaluated. The effects of changes in key parameters were then examined to determine if uncertainties could significantly influence the relative comparison of the alternatives. The evaluation of sensitivity concluded that variations of key parameters would not have a significant influence on the selection of a preferred alternative. Although variations in key parameters can increase or decrease effectiveness, implementability and cost, these increases or decreases tend to be similar among all the alternatives, with only small and insignificant variations.

Recommended Alternative

The recommended alternative is Alternative C, in-stream stabilization of sediment and overbank removal, combined with PCI Settling Basins. This action would stabilize fine-grained sediments potentially containing arsenic and cobalt in Blackbird Creek, while also providing erosion protection for the Blackbird Creek Road. The diversion system and settling basins near the PCI would *capture* most of the fine-grained sediments containing potentially contaminated sediments that would be winnowed from the stabilized areas of Blackbird Creek during the first several years (on the order of approximately six years) following construction. With the Alternative C measures in place, the risk of future *deposition* of COCs *at overbank areas* along Panther Creek *at concentrations above the cleanup levels would be* small. *Alternative C would also reduce the potential risks to the aquatic environment along Panther Creek during large runoff events in Blackbird Creek.*

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1.0 INTRODUCTION

This report presents an evaluation of alternative measures to address the continued release of sediments and iron oxyhydroxides (floc) with potential arsenic and cobalt content from Blackbird Creek to areas downstream of the Blackbird Mine Site. The evaluation was completed by Golder Associates Inc. (Golder) on behalf of the Blackbird Mine Site Group (BMSG), based on a request from the Environmental Protection Agency (EPA).

High flow events in Blackbird Creek have caused migration of sediments and floc that forms downstream of the West Fork Tailings Impoundment. Sediment transport is a natural process and not generally a concern; Blackbird Creek sediments are a concern only because these sediments and floc contain arsenic and cobalt at concentrations that exceed the cleanup level established in the Record of Decision (ROD - USEPA, 2003) and cobalt at concentrations that exceed the Preliminary Remediation Goal (PRG) for in-stream and downstream overbank areas along Panther Creek. Once mobilized, these materials are transported by flow and may be deposited in the downstream reaches of Blackbird Creek, or continue into Panther Creek where they are sometimes deposited on recreational or residential properties. Arsenic concentrations in the sediments deposited along Blackbird Creek were measured to be below the arsenic cleanup levels in Blackbird Creek during 2008; however, the accumulation of these sediments in depositional areas of the creek impedes channel function and may cause creek water to flow on to the Blackbird Creek Road. In places, the road subgrade materials contain arsenic and cobalt; therefore, erosion of the roadbed can also contribute to the sediments containing arsenic and cobalt in Blackbird Creek. Blackbird Creek sediments carried to Panther Creek and deposited on residential and recreational properties can contain arsenic levels that exceed the residential and recreational arsenic cleanup levels established in the ROD. Sediments can also contain cobalt exceeding EPA's residential or recreational PRG when deposited in overbank areas with these uses. The release of sediments from Blackbird Creek may also contribute to exceedances of sediment cleanup levels for arsenic, cobalt, and copper established by EPA for protection of benthic macroinvertebrates and other aquatic organisms. The erosion of sediments during spring floods in 2008 and 2009 also likely contributed to dissolved copper concentrations that exceeded cleanup levels in Panther Creek established by EPA for protection of aquatic life.

The objective of this report is to identify and evaluate potential measures to control 1) release of sediment and/or floc from Blackbird Creek that result in exceedances of arsenic cleanup levels or cobalt PRGs in overbank areas along Panther Creek, 2) releases from Blackbird Creek of arsenic, cobalt, and copper to in-stream sediments and floc particles that may affect the natural recovery of the in-stream sediments in Panther Creek, and 3) releases to surface water that may cause copper water quality exceedances in Panther Creek. The evaluation includes:

- Sediment control measures to reduce the volume of sediments released from Blackbird Creek during high flow events. The sediment control measures may also minimize the potential for erosion of the channel bed and banks and reduce the potential for erosion of the existing Blackbird Creek Road. The primary sediment control measures that will be evaluated include in-stream stabilization and in-stream settling dams.
- Measures to collect or control the floc deposits that form in Blackbird Creek downstream of the West Fork Tailings Impoundment. Measures evaluated include both capture (settling and detention facilities) and treatment (both passive and active treatment alternatives).

Potential measures, or control technologies, were classified according to their primary objective: sediment control or floc control technologies. Some technologies address both sources of contaminants of concern (COC).

The evaluation and comparison of alternatives includes discussions of the sensitivity of the comparisons to changes in the estimates of key parameters where significant uncertainty exists. The objective of this sensitivity evaluation is to determine if potential changes in key parameters might lead to selection of a different alternative than was selected. For example changes in the magnitude of the design storm could produce corresponding changes in the design of an alternative, which would change the cost of the alternative. Similarly changes in the design storm could modify the effectiveness of an alternative for reducing off-site movement of COCs. The evaluation of this sensitivity assumes (1) the uncertain value was studied further prior to final design (2) a new higher or lower estimate was found to be appropriate (rather than the value used herein) and (3) the alternative was then designed and constructed using this modified value. The modified alternative and its corresponding effectiveness, implementability and cost were then compared to the baseline alternative described herein.

2.0 SITE BACKGROUND AND SUMMARY OF PREVIOUS ACTIONS

2.1 Site Description

The Blackbird Mine Site is located within Lemhi County, Idaho, approximately 13 miles south of the Salmon River, and 21 miles west of the county seat of Salmon. The mine is also wholly within and surrounded by lands administered by the Cobalt Ranger District of the Salmon National Forest. The Blackbird Mine Site covers approximately 830 acres of private patented mining claims and additional areas which include unpatented claims.

The region is mountainous and in the area of focus along Blackbird Creek, the elevation varies from approximately 5,200 feet at the confluence of Blackbird and Panther Creeks to 6,800 feet near the Blackbird Mine Site Water Treatment Plant (WTP). The area surrounding the mine is a combination of forested slopes as well as unvegetated waste rock dump areas and other disturbed areas. The Blackbird Mine Site lies within two primary drainages: Bucktail/Big Deer Creek and Meadow/ Blackbird Creek drainages.

Prior to Early Actions, Bucktail Creek drained an area of approximately 1.7 square miles, which included the northern portion of the mine area and several sub-basins. The headwaters of Bucktail Creek originated just below the Blacktail Pit. Following completion of the Early Actions described in Section 2.2, the flow from the upper section of Bucktail Creek below the waste rock dumps is now collected at the 7000 Dam and downstream pump back station and is diverted to the underground mine, from where it is withdrawn for treatment and discharge to Blackbird Creek. Downstream of the 7000 Dam, Bucktail Creek flows north to its confluence with the S. Fork Big Deer Creek. Downstream of the 7000 Dam, the high gradient creek drops approximately 1500 feet to an elevation of about 5500 feet at the confluence with the S. Fork Big Deer Creek.

Meadow Creek is the southern drainage of the mine site. This basin formerly contained the surface mine facilities. Waste rock from the Blacktail Pit was disposed at the 7800 Dump at the headwaters of Meadow Creek and waste rock from underground adits was disposed along the valley sides and bottom. Meadow Creek extends from the basin boundary near an approximate elevation of 7,500 feet for 1.5 miles to its confluence with Blackbird Creek near the WTP at 6,800 feet. The basin area is very steep, as is the Meadow Creek channel, which exhibits an 11 percent grade.

The Blackbird Creek basin is separated into two sub-basins by the clean water reservoir. The upper section of the basin located west of Meadow Creek and upstream of the dam consisted of undisturbed forest prior to the Clear Creek fire, which burned portions of the area during the summer of 2000. Flows from the upper Blackbird Creek basin flow through the conduit from the dam and discharge to the Blackbird Creek channel at a point upstream of the WTP. From this point and prior to implementation of

Early Actions, Blackbird Creek was in contact with waste rock for a limited section until it entered a pipeline and joined with Meadow Creek. Currently, Blackbird Creek (below the clean water reservoir to just downstream of the WTP) and Meadow Creek are conveyed in a concrete channel constructed as part of Early Actions. The channel runs from below the 7100 Dam to just downstream of the WTP, and was constructed on top of a clean soil cover, which was installed as part of the Early Actions to cover waste rock in the valley bottom. Blackbird Creek discharges to its normal channel at a culvert located immediately downstream of the treatment plant. From the mine site, Blackbird Creek flows for approximately 3.3 miles where it is joined by the West Fork Blackbird Creek. Blackbird Creek then flows approximately 2.5 miles downstream of West Fork Blackbird Creek to its confluence with Panther Creek. The Blackbird Creek drainage basin covers approximately 21 square miles, which includes the Meadow Creek and West Fork Blackbird Creek drainage basins.

The area of focus for this evaluation report is Blackbird Creek between the WTP and the confluence of Blackbird Creek and Panther Creek. Along this stretch of Blackbird Creek, the West Fork of Blackbird Creek enters Blackbird Creek over the West Fork Tailings Impoundment.

2.2 Site History

Mining activity at the Blackbird Mine Site resulted in construction of approximately 15 miles of underground workings (12 levels with more than 15 adits and portals), an 18-acre open pit mine, numerous graded roads, waste rock piles, and a tailings impoundment facility. The Calera Mill has been removed. Electrical power is supplied by a 69 kV power line originating from Salmon, Idaho. A water treatment plant was placed in service in 1980 to treat mine seepage from the 6850 Adit. A more complete summary of the site history is included in numerous documents, including the Focused Feasibility Study for the Blackbird Mine Site (Golder 2002a).

The Blackbird Mine Site Group (BMSG) has been conducting environmental response actions at the Blackbird Mine Site since 1994. The environmental work is being conducted pursuant to a November 1994 Administrative Order on Consent (AOC) with the EPA for a Remedial Investigation/Feasibility Study, an April 1995 Consent Decree with the United States and the State of Idaho for response actions and restoration of natural resources, a June 1995 AOC with EPA for implementation of early removal actions, and a July 2003 EPA Unilateral Administrative Order (UAO) for implementation of remedial actions.

The BMSG has conducted extensive emergency response actions, early actions and remedial actions at the Blackbird Mine Site and constructed permanent facilities for diversion, collection, storage and treatment of impacted waters. These actions are described briefly in the sections below.

2.2.1 Emergency Response

Emergency Response Actions were conducted in 1993 at the West Fork Tailings Impoundment to minimize the potential for release of tailings into Blackbird and Panther Creeks. Prior to these actions, the West Fork Blackbird Creek flow was through a pre-existing buried concrete culvert and there was concern that mass failure of the tailings storage facility was possible if the culvert became plugged. The Emergency Response Actions as described in Knight Piésold (1998) included construction of a channel and spillway to convey the West Fork of Blackbird Creek over the top of the tailings impoundment, installation of a slurry cutoff trench to minimize alluvial groundwater discharge into the tailings and filling of the existing concrete drainage culvert beneath the tailings with pea gravel.

2.2.2 *Early Actions*

Early Actions were initiated during the summer construction season of 1995 and were continued in phases each year through 2001. From 1995 through 1998, the Phase I, II, and III Early Actions were focused on controlling sources of acid rock drainage that were impacting water quality. Generally, Phase I facilities were built during the 1995 construction season, Phase II facilities were built during the 1996 and 1997 construction seasons, and Phase III structures were initiated during the 1997 construction season and completed during the summer of 1998.

Phase IV and V Early Actions consisted of overbank deposit removal actions, which were conducted along Panther Creek and Blackbird Creek to mitigate potential risk to human health associated with elevated levels of arsenic present in mine related deposits. These actions have also reduced potential risk to terrestrial and aquatic ecological receptors. Phase IV activities were initiated in 1998 and completed in 1999. Phase V activities were initiated in 1999; however, the forest fire during 2000 caused delays and Phase V was completed during 2001. The design and removal reports for these actions were completed between 1995 and 2001 (Golder 1995, 1996a, 1996b, 1997, 1998a, 1998b, 1999, 2000 and 2001a).

Early Actions within the Bucktail drainage included a range of actions including construction of the 7000 Dam and associated piping, construction of the 6930 Adit, construction of a pump station and associated piping, relocation of waste rock, construction of a waste rock repository (the Blacktail Pit), installation of clean-water diversion ditches and collection ditches to route water either to or away from the 7000 Dam, installation of sediment control ditches and debris traps, construction of two temporary sediment control dams, and relocation of a portion of the debris flow material along Bucktail Creek.

Early Actions within the Meadow Creek basin at the Blackbird Mine Site included:

- Upgrade to and expansion of the existing WTP to a capacity of 800 gallons per minute (gpm)
- Installation of a sludge pipeline from the WTP to the Hawkeye Ramp
- Construction of the 7100 Dam to collect and store water draining from the Meadow Creek waste rock dumps
- Installation of pipelines to convey water between the 7100 Dam, the mine workings and the WTP

- Construction of a contaminated water collection system below the 7800 Waste Rock Dump
- Construction of a series of clean water ditches and pipelines to divert clean water around the 7100 Dam reservoir
- Relocation of waste rock from the canyon walls of Meadow and Blackbird Creek
- Construction of a waste rock cover in the Meadow and Blackbird Creek basin, including underdrain system to convey contaminated groundwater to the WTP
- Construction of a concrete channel across the top of the cover to convey Meadow and Blackbird Creeks
- Construction of a groundwater cutoff wall upstream of the WTP
- Removal of overbank deposits along Blackbird and Panther Creek and construction of three sediment basins along Blackbird Creek (more detailed information is provided in Section 2.2.5 below)

2.2.3 West Fork Dam Assessments

A stability analysis was conducted for the West Fork Tailings Impoundment Dam (Golder 2001b). The report concluded that when considering both static and seismic conditions, adequate factors of safety and tolerable embankment displacements were calculated for the overall global stability of the tailings embankment, provided the water table remains near or below its present level.

The water surface elevation within the tailings impoundment is monitored on a quarterly basis and has continued to rise since the initial stability evaluation. Due to a concern regarding continued rise in the elevation of water within the impoundment, an addendum to the stability report was prepared to review the water surface elevations and their potential impact on the stability of the embankment (Golder 2008a). The assessment found that the embankment is stable, even with the continued rise in water level in the impoundment. Continued monitoring and maintenance of the dam embankment will be performed to ensure stability is not compromised.

As a part of the remedial actions, a closure cover design was completed to allow placement of materials excavated from Blackbird and Panther Creeks and to provide positive drainage of surface runoff to the existing West Fork channel. The West Fork Tailings Impoundment Facility has been used as a repository for materials since the cover design was completed in 2003. A review of capacity for further material placement may be required to determine potential capacity constraints.

2.2.4 Remedial Actions

Following completion of the Feasibility Study (Golder 2002a), a series of final remedies were identified and carried out. A summary of the activities is included below:

- Design of the final cover and closure of the West fork Tailings Impoundment Facility (Golder 2003a)
- Construction of the 6350 Detention Dam separating clean runoff from contaminated seeps below the 7800 Waste Rock Dump in the Meadow Creek Basin, as well as

installation of a cutoff wall and seep collection structures in the Bucktail Basin (Remedial Design of Meadow Creek and Phase I Bucktail Creek included, Golder 2002c).

- Removal of contaminated overbank materials along Blackbird Creek, modification of surface drainage pathways and armoring of erodible materials (Golder 2002b)
- Reconstruction of the Panther Creek Inn (PCI) ponds, raising the road grade in the area of the PCI, removal of overbank materials along Blackbird Creek between the Panther Creek Bridge and the confluence, repair of channel containment berms and installation of deflector structures downstream of the bridge and removal of contaminated materials on the PCI property (Golder 2003b)
- Overbank removal at the Cobalt Townsite, Rufe, Straun, Rogers, and Hade properties (Golder 2005d, 2005e, 2004d, 2004e)
- Removal of the Upper Bucktail Sediment Dam and restructuring channel, installation of seepage collection facilities in the Bucktail basin, construction of the Lower Bucktail Pump Station and associated piping (Golder 2004b, 2005b)
- Installation of a pumping well to convey groundwater with elevated levels of copper from downstream of the Blackbird Creek Cutoff Wall (Golder 2007c)
- Installation of a pumping system in the Old Blackbird Creek pipeline to convey water with elevated levels of copper from the pipeline to the WTP (Golder 2004c)

2.2.5 Removal Work on Blackbird and Panther Creeks

This section provides a more detailed description of the removal and stabilization work completed along Blackbird and Panther Creeks.

Beginning in late 1998 and continuing during 1999 through 2001, overbank deposit removal actions were conducted along portions of Panther Creek. These actions were primarily focused on removal of mine-related materials that contained elevated concentrations of arsenic concluded by EPA to pose an unacceptable risk to human health (CH2M Hill 1999a). The removal actions have also reduced any risk that these materials may have posed to terrestrial and aquatic ecological receptors. The Clear Creek fire delayed completing these actions during 2000.

Early action removal activities included:

- Removal of visually obvious, erodible tailings from overbank deposits at several locations along Blackbird Creek (Golder 1998a)
- Overbank removals at the PCI, and the PCI campground for ¼ mile downstream along Panther Creek (Golder 1998b)
- The Riprap Bar area approximately 1 mile downstream from the Cobalt Townsite, the Sillings/Fernandez property approximately 2 miles downstream of the Cobalt Townsite, the Deep Creek Campground, the Bevan property located about 5.5 miles upstream of the confluence of Panther Creek and the Salmon River (Golder 1999)
- The Cobalt Townsite and the adjacent pasture area immediately downstream of the Cobalt Townsite and at Napias Creek area just upstream from the confluence of Napias and Panther Creeks (Golder 2001c)

Remedial action removal activities included:

- Removal of contaminated overbank materials along Blackbird Creek, modification of surface drainage pathways and armoring of erodible materials (Golder 2002b, 2005a)
- Removal of overbank materials along Blackbird Creek between the PCI bridge and the confluence as well as on the PCI property (Golder 2003b)
- Overbank removal at the Cobalt Townsite, Rufe, Straun, Rogers, and Hade properties (Golder 2005d, 2005e, 2004d, 2004e)

During both early actions and remedial actions, approximately 53,000 cubic yards of overbank material with arsenic concentrations ranging between a few thousand mg/kg and over 10,000 mg/kg was removed from Blackbird Creek and is no longer available for transport to Panther Creek.

Due to high runoff during the spring snowmelt in 2003, additional materials were deposited in low lying areas of Panther Creek. As a result, an additional 8,500 cubic yards of overbank materials were removed along Panther Creek. Removals were conducted at the Cobalt Townsite (1,350 cubic yards), the Rufe Property (530 cubic yards), the Hade Property (6,470 cubic yards), the Rogers Property, and the Shook (now the Cellan property, but previously referred to as Straun/Bowman) property (210 cubic yards) (Golder 2005d, 2005e, 2004d, 2004e).

2.3 Applicable or Relevant and Appropriate Requirements and Remedial Action Objectives

2.3.1 Applicable or Relevant and Appropriate Requirements

Potential Applicable or Relevant and Appropriate Requirements (ARARs) for the overall Blackbird Mine Site were originally identified in the FS (Golder 2002a). EPA determined *what ARARs were applicable or relevant and appropriate*[2] for the selected remedy in Section 13.2 of the ROD (USEPA 2003). The action-specific, chemical-specific and location- specific Federal and State ARARs that were *selected* in the ROD and that are *applicable or* relevant *and appropriate* to the remedial alternatives evaluated in this document are listed below.

Idaho Water Quality Standards and Wastewater Treatment Requirements (IDAPA 58.01.02). These rules designate uses that are to be protected in waters of the State of Idaho and establish standards of water quality protective of those uses.

The State of Idaho rules designate Panther Creek for all uses, including protection of cold water aquatic life, salmonid spawning, and secondary contact recreation. The State of Idaho has removed the

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designated aquatic life uses through a use attainability analysis (UAA) for Blackbird *Creek below Meadow Creek* and West Fork Blackbird Creek downstream of the *West Fork Tailings Impoundment. This UAA was* approved by EPA. *Idaho's Water Quality Standards also contain numeric water criteria for protection of human health and aquatic organisms. These are cleanup criteria for surface waters at the Blackbird Mine Site and these criteria must be met by any discharge to surface waters resulting from the conduct and implementation of the remedial actions.*

Clean Water Act Section 304 – Federal Ambient Water quality. Section 304(a)(1) of the Clean Water Act requires EPA to develop, publish and revise criteria for water quality. Section 121(d)(2)(A) of CERCLA provides that the remedial action shall attain the water quality criteria established pursuant to Section 304 of the Clean Water Act. *For the ROD,* EPA reviewed EPA's published National Recommended *Aquatic* Water Quality Criteria dated November 2002 (AWQC) and found that the AWQC for human health based on "consumption of organisms only" is relevant and appropriate for evaluating arsenic in the creeks that are designated for protection of aquatic life (i.e. Panther Creek). In evaluating this AWQC for Panther Creek, EPA utilized the AWQC of 10-4 risk level for arsenic *and set the water quality cleanup level in the ROD at* 14 µg/L *total arsenic.*

Clean Water Act National Pollutant Discharge Elimination System (NPDES) Permit (40 CFR 122-125, 40 CFR 440). All point source discharges, including those associated with the WTP, the West Fork Tailings Impoundment, and other waste areas, must meet the substantive requirements of the NPDES regulations. These regulations establish a national permit program for discharges to waters of the United States. These regulations identify specific effluent limitation guidelines for discharges within specific industrial categories. The NPDES regulations also require, where a discharge causes or has the reasonable potential to cause or contribute to an excursion of water quality standards, that effluent limitation be established to meet beneficial uses. Such water quality based effluent limits are calculated based on achieving water quality criteria in the receiving water.

In accordance with the Clean Water Act and the State of Idaho Water Quality Standards (IWQS), point source discharges may allow a mixing zone. A mixing zone is an allocated impact zone where the cleanup levels can be exceeded. The Idaho WQS provide the criteria for evaluating the size, configuration and location of a mixing zone. This evaluation includes a determination that the mixing zone does not cause unreasonable interference with or danger to beneficial uses and provides guidance regarding the size of the mixing zone. (IWQS 58.01.02.060) Monitoring is necessary to ensure that the mixing zone does not interfere with beneficial uses.

The requirements for point source discharges established under the NPDES regulations and the Idaho regulations, including the mixing zone guidelines, are applicable to point source discharges into Blackbird and Panther Creeks. The effluent limitations for these point sources must take into consideration the potential impacts to water quality in Panther Creek which is protected for aquatic life. Surface water cleanup levels can be exceeded within the mixing zone, but must not be exceeded at the edge of the mixing zone.

Clean Water Act Stormwater Multi-Sector General Permit for Industrial Activities (40 CFR 122.26). The substantive requirements of the *most current* Stormwater Multi-Sector General Permit for Industrial Activities *(MSGP), including Idaho-specific provisions,* apply to elements of the alternatives evaluated in this document that result in discharges of stormwater from "industrial activities". "Industrial activities" include inactive mining facilities as well as the construction and operation of mine waste repositories. Best management practices (BMPs) must be used, and appropriate monitoring performed, to ensure that stormwater runoff does not exceed state water quality standards. *The current MSGP effective in the State of Idaho is dated February 2009.*

Clean Water Act NPDES General Permit for Stormwater Associated with Construction, (40 CFR 122.26), NPDES Permit No. IDR10-0000 (aka "2008 Construction CGP"). *33 U.S.C. § 1342(p) defines "storm water discharge associated with industrial activity" to include discharges associated with small construction activity, including clearing, grading, and excavation resulting in land disturbance of equal to or greater than one acre and less than five acres [40 C.F.R. l22.26(b)(15)(i)]. The substantive requirements of the currently effective general permit for construction activities apply to elements of the alternatives that result in discharges of stormwater from the various construction activities. The most current Construction General Permit, with Idaho-specific conditions, was issued January 2009.*

Safety of Dams, State of Idaho Rules and Regulations (Chapter 17, Section 42-1714, Idaho Code and provisions of Section 42-1709 through 42-1721, Idaho Code). These requirements are intended to provide a guide for the establishment of acceptable standards for the construction of and safety evaluation of new or existing dams. These rules are considered applicable to response activities at the Blackbird Mine Site that include the use of dams for surface water impoundment because these rules apply to all new dams, to existing dams being altered or repaired and maintenance activities to existing dams as provided in the rules.

State of Idaho Stream Channel Alteration (IDAPA 37, Title 03, Chapter 07). The objectives of regulations under IDAPA 37, Title 03, Chapter 07 are to protect stream channels and their associated environments against alteration so that fish and wildlife habitat, aquatic life, recreation, aesthetics and water quality are also protected. Substantive portions of these requirements are applicable to response actions at the Blackbird Mine Site that involve alteration of stream channels.

Endangered Species Act (16 USC *1531 et seq.*). This law and implementing regulations identify threatened and endangered species and establish requirements necessary for their protection. The Endangered Species Act (ESA) and implementing regulations are applicable to activities of the alternatives evaluated in this document that could affect federally designated threatened or endangered species and/or their habitat. EPA will be responsible for the Section 7 consultation with the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS).

Clean Water Act, Section 404 (40 CFR 230, 33 CFR 320-330). Section 404 of the Clean Water Act and associated regulations prohibit discharge of dredge or fill material to *waters of the United States.* The Army Corps of Engineers implements the Section 404 permit program which provides guidelines for the identification of wetlands and implements protective requirements for actions involving wetlands. Section 404 is applicable *if dredge or fill materials are discharged into waters of the United States or* if regulated wetlands are identified and potentially impacted by the alternatives evaluated in this document.

Migratory Bird Treaty Act (16 USC 703-712). *The Migratory Bird Treaty Act makes it unlawful to pursue, capture, hunt, or take actions adversely affecting a broad range of migratory birds. This act and its implementing regulations is relevant and appropriate to remedial activities that could affect any protected migratory birds.*

Idaho Classification and Protection of Wildlife (IDAPA 13.01.06). *These regulations are relevant and appropriate to remedial activities that could affect wildlife species protected by the State of Idaho.*

Executive Order 11990, Protection of Wetlands. This Executive Order requires federal agencies to avoid adversely impacting wetlands, minimize wetland destruction and preserve the value of wetlands. EPA policy for implementing this Executive Order is promulgated in 40 CFR 6. This Executive Order and regulations are applicable to remedial activities that could affect wetlands.

Executive Order 11988, Floodplain Management. This Executive Order requires federal agencies to evaluate the potential effects of actions that take place in floodplains and to avoid adverse impacts. EPA policy for carrying out the provisions of this Executive Order is promulgated in 40 CFR 6. This Executive Order and regulations are applicable to remedial activities within the floodplains along creeks and streams.

Fish and Wildlife Coordination Act (16 USC 661 *et seq.*) This statute requires federal agencies to consider the effect projects may have on fish and wildlife and to mitigate loss or damage to these resources. This statute is applicable to the selected remedy.

USFS Regulations for Special Use Authorization (36 CFR 251.53). These regulations govern the issuance of special use authorizations for National Forest System land. Special use authorizations are applicable to rights-of way, reservoirs, canals, ditches, pipes and pipelines, for the impoundment, storage and transportation of water and for system and related facilities for generation, transmission and distribution of electricity. The substantive requirements of these regulations are applicable for remedial actions that require any of these facilities on National Forest System land.

To Be Considered. The US Forest Service policies that are to be considered during implementation of the remedial action on US Forest Service land include those requirements that govern public health and pollution control facilities (FSM 7400) and that govern water storage and transmission (FSM 7500).

2.3.2 Remedial Action Objectives & Cleanup Levels

Remedial action objectives (RAOs) for the Blackbird Mine Site are presented in Section 8 of the ROD. Table 2-1 provides the RAOs for human and aquatic receptors for Blackbird Creek and Panther Creek sediments and overbank deposits. Table 2-2 provides the site-specific cleanup levels and PRGs established by EPA for soils, in-stream sediments and water quality.

The RAO for human receptors is to reduce migration of surface soils and overbank deposits to downstream areas that would deposit concentrations of contaminants of concern in excess of the cleanup levels established at those downstream areas.

The RAOs for aquatic receptors are to reduce migration of metals into the water column and to the in-stream sediments of the streams so that the cleanup levels for the COCs in the surface water and in-stream sediments are not exceeded.

High runoff during spring snowmelt in 2008 and 2009 mobilized materials from the banks of Blackbird Creek that resulted in downstream deposition of arsenic and cobalt at concentrations exceeding arsenic cleanup levels or cobalt PRGs for residential and/or recreational uses in specific areas along Panther Creek. Investigations of these areas have been reported separately. In addition, mobilization of Blackbird Creek sediments has resulted in exceedance of the surface water cleanup level for total arsenic and the chronic criteria cleanup level for dissolved copper. The water quality data were presented in the annual monitoring reports (Golder 2009a and 2010a) and are summarized in Section 3.1.8 of this report.

2.4 2008 and 2009 Events

Recent flooding in Blackbird Creek in May 2008 resulted in erosion and deposition of sediments along Blackbird Creek, and deposition of sediments extending downstream into Panther Creek. The circumstances surrounding the 2007/2008 snowmelt event included a slightly above average snowpack, a cool spring which held the snow, and then rapidly rising temperatures and warm weather resulting in a fast snowmelt and runoff. The snowpack was held by the cool spring weather on north facing slopes in areas still impacted by the 2000 fire that burned vegetation in the basins contributing to Blackbird Creek. The burning of the large trees, the condition of the post-fire vegetation, and the changes in surface soil conditions contributed to the increased magnitude and timing of the May 2008 runoff event. Due to the multitude of variables to the May 2008 runoff event, and the uncertainty of the level at which each variable contributed, it is not reasonable to assign a traditional statistically derived flood event return internal to the snowmelt event.

Flooding during the May 2008 event eroded sediments in some reaches of Blackbird Creek, and then deposited those sediments in downstream reaches of Blackbird Creek. Where sediments deposited in the channel and floodplain, effectively filling it up, flows flooded the Blackbird Creek Road. BMSG responded to the flooding to protect the road and maintain access to the WTP. Photographs documenting flooding in some areas during the event are provided in Appendix A.

Sediments with elevated levels of arsenic and cobalt were deposited in depositional areas along Blackbird Creek, in the Panther Creek Inn area, and in certain areas along Panther Creek downstream of the Panther Creek Inn area. Sampling conducted following the snowmelt indicates that the sediments deposited along Blackbird Creek were below the cleanup levels identified by the Environmental Protection Agency (EPA) for those areas (4,300 mg/kg in Lower Blackbird Creek and 8,500 mg/kg in Upper Blackbird Creek). However, in residential and recreation areas along Panther Creek, there were some areas that contained sediment deposits with levels of arsenic that exceed the EPA developed cleanup criteria of 100 mg/kg for residential areas, 280 mg/kg for USFS campgrounds, 400 mg/kg for undeveloped campgrounds and 590 mg/kg for recreational day-use areas (CH2M Hill, 1999b). These sediments were below cleanup levels in Blackbird Creek, but once they were transported downstream, they exceeded the cleanup criteria for residential and occasionally for recreational areas. EPA subsequently determined human health based PRGs for cobalt (see Table 2-2), which were also exceeded in some areas. Extensive characterization of sediments along Blackbird and Panther Creeks was completed in the Fall of 2008, as summarized in Section 3.1.2.

The snowmelt period in May and early June of 2009 was similar to events during 2008. High flows occurred *in Blackbird Creek* in late May that transported large quantities of bed load. Erosion damage occurred along the Blackbird Mine access road, which was inundated in places. *Fine-grained sediments from Blackbird Creek were again transported downstream where they were deposited at overbank areas along Panther Creek at COC concentrations that exceeded the cleanup levels.* A program of suspended sediment sampling was initiated and the results are presented in the appendices of this report. Additional characterization of overbank deposits and sediments along Panther Creek was conducted during 2009 as described in Section 3.1.2.

2.5 2008 Interim Measures

The large runoff during the spring 2008 snowmelt resulted in damage to the Blackbird Creek Road, in addition to the mobilization/redistribution of sediments with elevated levels of arsenic and cobalt. The BMSG and Golder met with the EPA and trustees on site in September of 2008 to discuss the issue. Due to the imminent winter season and corresponding short construction window, "interim work" measures were implemented in the Blackbird Creek channel at selected locations through the fall and early winter of 2008, while at the same time developing a more comprehensive plan for addressing the channel that could be implemented in subsequent construction seasons. The goal for the interim work was to protect the Blackbird Creek Road by armoring and raising the road elevation at some key flood prone locations. In addition, sediment was removed in areas where the channel had filled in to provide flow capacity in the channel for runoff during the late winter and spring of 2009. Targeted areas included the channel upstream of the West Fork of Blackbird Creek and the reach around the old Haynes Stellite Mine. Some tailings deposits that were identified during this work were also removed. The construction was completed in December 2008.

2.6 2009 Phase I Blackbird Creek In-Stream Stabilization and Removal

Following completion of the second draft of the Blackbird Creek Evaluation Report (Golder 2009g), the BMSG requested agency support in streamlining the process to allow construction of stabilization measures and additional Blackbird Creek sediment removals to begin during 2009 (BMSG 2009). As a result, the Phase 1 Blackbird Creek stabilization and removal design was completed and construction began in the fall of 2009 construction season. The Phase 1 design (Golder 2009f) included elements of the evaluation report which the BMSG, EPA and Trustees agreed were likely to be a part of the selected alternative, including removal of readily erodible materials along Blackbird Creek that contained elevated levels of arsenic and cobalt, as well as in-stream stabilization design for three of the eight identified areas. During 2009, in-stream Stabilization Area 1 was fully constructed, as was the downstream structure in Area 2. In addition, approximately 43,000 cubic yard of overbank material was removed.

3.0 SUMMARY OF RELEVANT DATA COLLECTED

3.1 Data Review

3.1.1 Flow Data, Flood Flow Estimates and Channel Hydraulics

Stream flow gauges were installed in lower Blackbird Creek at several locations in the early 1990s. Data have been collected since that time although occasional problems with the gauges make the records discontinuous.

Anecdotal accounts of the May 2008 flood event describe a very rapid loss of the snowpack from the north facing slopes along Blackbird Creek, with contributing runoff to the channel all along the approximately 5.8 miles reach from the confluence with Panther Creek extending upstream to the WTP. Flows varied along the channel depending on the rate and timing of the snowpack melt. Without stream flow gauging data along the channel to record flows or other supplementary snowpack, weather, and melt data, it is difficult, if not impossible, to clearly define a statistical recurrence interval flow for the event.

Development and assessment of alternatives requires evaluation of hydrologic and hydraulic conditions along the project area channel. Available historical gauging data were compiled for Blackbird Creek and previous assessments and technical analyses were evaluated in order to develop more traditional recurrence interval storm scenarios to support the assessment addressed in this report. Data were compiled at several locations along Blackbird Creek including: gauging station BBSW-01A in the lower reaches of Blackbird Creek not far upstream of the confluence with Panther Creek, at the West Fork tributary where it meets Blackbird Creek, gauging station BBSW-03A (located just upstream of West Fork), and at the upstream end of the project area at approximately the WTP. However, the Blackbird Creek continuous stream gauging period of record (1995-2009) is insufficient to accurately predict extreme flood events with recurrence intervals of 100 and 500 years. Stream gauging data from nearby watersheds including Thompson Creek and Napias Creek, along with USGS regression data were used to provide estimates of discharge yield (cfs/sq mi) for verification of hydrologic modeling results for Blackbird Creek.

Blackbird Creek basin characteristics were evaluated using available aerial photography, topography, previous hydrologic reports, and first-hand knowledge of site conditions. These basin characteristics were used to estimate hydrologic modeling variables including time of concentration and runoff curve number (CN). Available design precipitation data and watershed areas were also compiled. The data were used in a HEC-HMS hydrologic model to develop peak flow hydrographs and storm volumes for the 2, 5, 10, 25, 50, 100, and 500-year events at selected locations along Blackbird Creek. A detailed description and results of the HEC-HMS hydrologic analysis are provided in Appendix B. The results are summarized in Table 3-1A below.

TABLE 3-1A

PEAK DISCHARGES FROM THUNDERSTORM EVENTS

Basin ID	Drainage Area (sq mi)[1]	Peak Discharge (cfs)						
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1	4.02	4	15	24	41	88	133	352
2	8.43	7	30	50	86	176	267	730
3	16.87	13	59	99	165	324	486	1,264
4	20.86	16	73	122	203	393	588	1,511

1. The Basin ID values correspond to designations for the sub-basins, delineated as part of the hydrology assessment (See Figure B1 in Appendix B).

Two of the HEC-HMS inputs are key parameters with a significant degree of uncertainty: time of concentration and CN. The assumed uncertainties of these variables are ±1.7 percent (CN=59, ±1 unit) and ±10 percent (T_c=152.2 min +/- 15 min). The sensitivity of the resulting estimated discharge due to the uncertainty of estimates of these variables is 16 to 23 percent based on a hydrologic modeling sensitivity analysis by Golder. See Table 3-1A.1 below. The range of the estimates of flows at the mouth of Blackbird Creek are 475 to 726 cfs (100-year flood event) and 1263 to 1809 cfs (500-year flood event). For purposes of this evaluation, the design flows in Table 3-1A will be used.

TABLE 3-1A.1

SENSITIVITIES OF BASIN NO. 4 PEAK DISCHARGES Q100/Q500 TO CN AND T_C

	Peak Discharges Q100/Q500 (cfs)		
CN	T_c = 137 min.	T_c = 152.2 min.	T_c = 167.4 min.
58			475/1263
59		588/1511	
60	726/1809		

The results of the hydrologic modeling were used to develop a HEC-RAS hydraulic model of Blackbird Creek, extending from the WTP downstream to the confluence with Panther Creek. HEC-RAS model results are provided in Appendix C1. The model results predict that the Blackbird Creek Road will be overtopped in several locations, mostly in the downstream reaches, starting at approximately the 10-year recurrence interval flood event upstream of West Fork, and expanding to include other areas through the 100-year event around Haynes Stellite (approximately STA 240+00) and the reach just downstream, a larger reach around the West Fork Tailings Impoundment, and several areas downstream (approximately STA 130+00, 90+00, 30+00 to 60+00). Anecdotal information from the recent May 2008 and June 2009 flood events for areas where the road overtopped corresponded well with the results of the modeling.

FIGURE 3-1

BLACKBIRD CREEK HEC-RAS FREEBOARD RESULTS

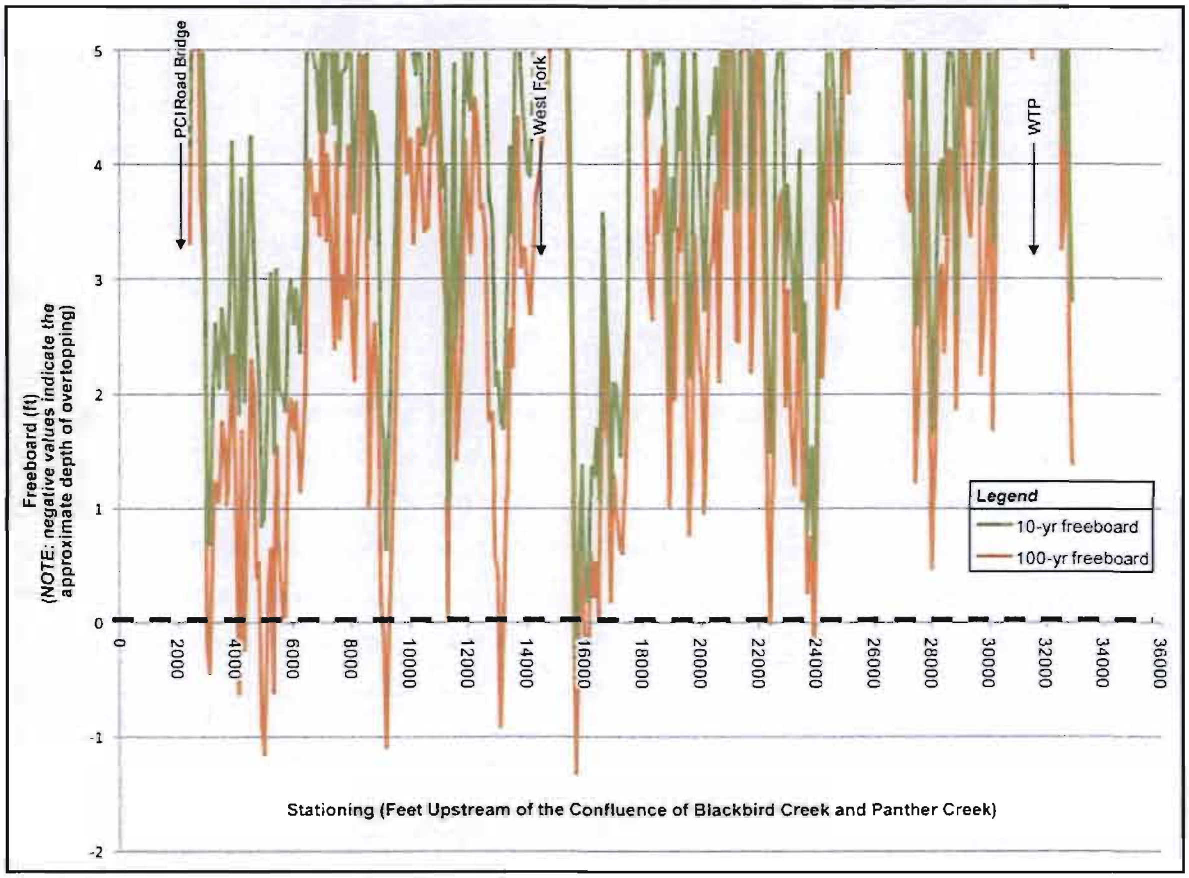


Figure 3-1 shows the difference between the road surface and the water surface elevation at stations along Blackbird Creek. The downstream end of Blackbird Creek is on the left side of the plot, and the upstream end to the right side of the plot. The West Fork is located approximately at station 150+00. Figure 5-1 provides a plan view of the entire channel. Positive numbers indicate the amount of freeboard for water surface elevations relative to the Blackbird Creek Road, while negative numbers demonstrate a lack of freeboard and show the approximate depth by which flows are anticipated to overtop the roadway. The modeling results show that the larger recurrence interval events overtop the roadway, and in some cases because the valley is so confined, fill the valley from wall to wall. The 100-year event will overtop the roadway by approximately 1 to 2 feet in some locations in the lower reach of Blackbird Creek. The 500-year event (not shown in Figure 3-1) will overtop the road by as much as 2 to 3 feet. The upstream reaches are also subject to inundation in areas where the roadway is closer in elevation to the channel. These estimates represent current channel and floodplain elevations. Future changes in channel or floodplain elevations (due to scour, erosion or deposition of sediments) may change inundation elevations and the corresponding freeboard estimates.

3.1.2 Arsenic and Cobalt Concentrations in Overbank and Channel Sediments

3.1.2.1 Overbank Sediments

Following the spring snowmelt of 2008 and 2009, sampling and characterization of sediment deposits along Blackbird and Panther Creek were completed to assess where sediment with elevated levels of arsenic and cobalt may have been deposited. Results of the 2008 characterization are included in the Work Plan for Panther Creek Area Remedial Actions report (Golder 2008b). Since the 2009 high flow events inundated the areas sampled in 2008, additional characterization was completed in 2009. The final characterization summary was included in the 2009 pre-removal characterization report (Golder 2010b).

In-situ screening level sampling was conducted along Blackbird Creek to verify arsenic concentrations were below cleanup levels established by the EPA. For Upper Blackbird Creek (above the confluence with the West Fork), the arsenic concentrations measured ranged between 308 and 4,534 mg/kg, well below the cleanup level of 8,500 mg/kg. For Lower Blackbird Creek (between the West Fork and the PCI Bridge) the arsenic concentrations ranged between 333 and 2,612 mg/kg, also below the cleanup level of 4,300 mg/kg for this area (Golder 2008b). However, because areas with readily erodible overbank materials are subject to transport downstream with the potential for deposition along private properties on Panther Creek, removal activities along Blackbird Creek were conducted in 2009 (Golder 2009d). Characterization of deposits along Panther Creek resulted in removals of materials that began on private properties in 2009 (Golder 2009e). Removal activities will continue in 2010 and will be summarized in a post-removal summary report following completion of the work.

3.1.2.2 Channel Sediments

The annual monitoring program includes sampling of in-stream sediments in Blackbird and Panther Creeks. While variable, in-stream metals concentrations show a general trend of decreasing concentrations. However, during 2009 metals concentrations show an increase in several Blackbird and Panther Creek stations over previous years. Current and historical in-stream sediment data are included in the draft 2009 monitoring report (Golder 2010a).

3.1.3 Sediment Physical Characteristics

A sediment sampling program was completed in November 2008, in conjunction with the interim work measures completed along Blackbird Creek. Sediment sampling and analysis was conducted to characterize and document the physical characteristics of sediment particles located along Blackbird Creek between the Blackbird Mine Site WTP and the confluence of Blackbird and Panther Creeks. The procedures for sampling sediments were as outlined in Appendix A of the 2008 Interim Measures Design Report (Golder 2008d).

In accordance with the aforementioned sampling plan, Golder performed particle sampling of the sediments including pebble counts of armor layer sediments (where applicable) and grab samples of substrate sediments. Pebble counts were made of armor layer sediments because of the predominately larger armor particle diameters. Grab samples were taken of the predominately smaller diameter substrate sediments (underlying armor sediments) or other targeted sediments. The determination of the presence of armor layer sediments was made by professional judgment of visual observations and manual excavations of the surface sediments relative to the underlying substrate sediments at any given location. Samples were taken along the channel alignment from the bed, banks, and in the floodplain in areas that represented mobile sediment materials. Refer to Figure D1 in Appendix D1 for locations of sample locations.

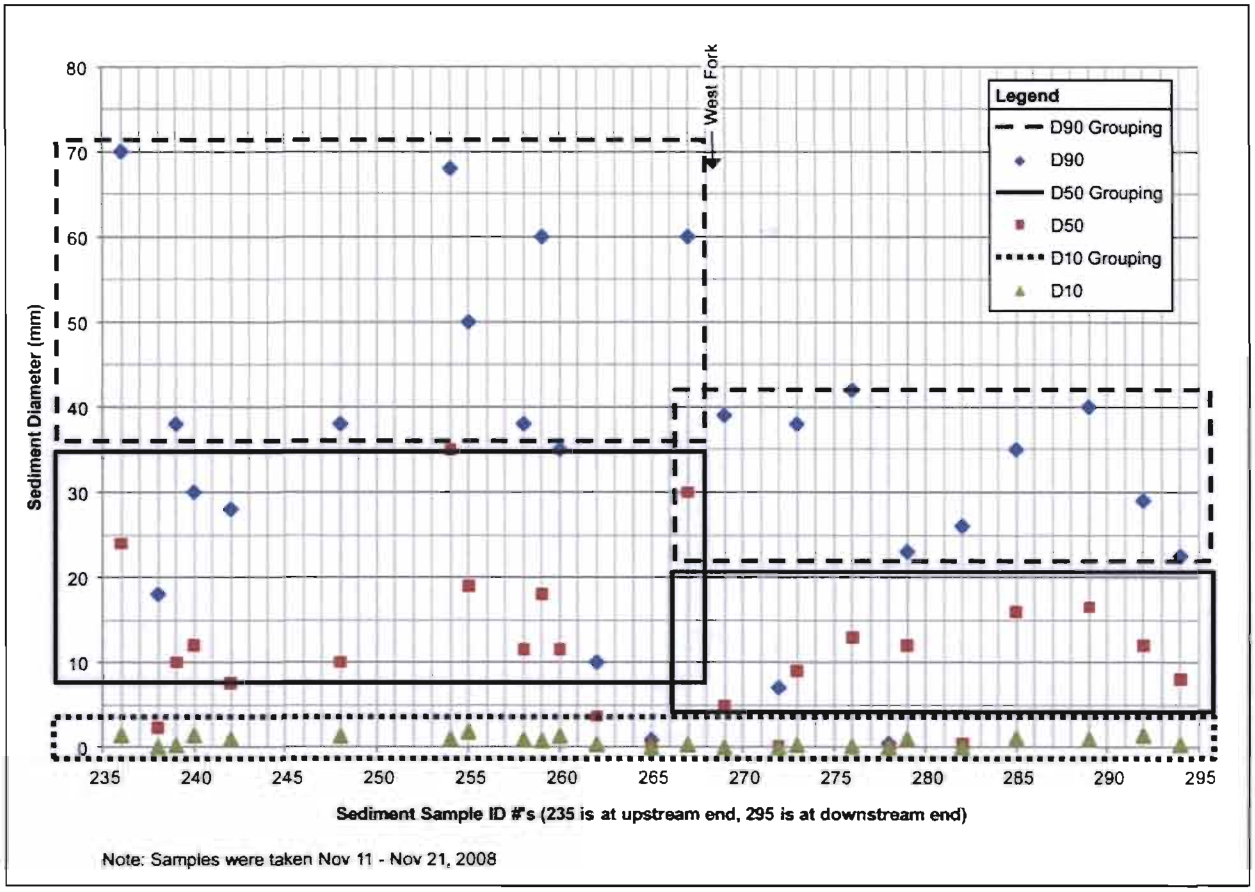
Golder began the sampling on the north end near the WTP, traversing downstream to the confluence of Blackbird and Panther Creeks. A total of twenty-two locations were sampled each of which were spaced at approximately ¼ -mile increments. Samples collected were observed to be representative of the transported bed load material from each location. At various sample locations, additional samples were taken either from the bank and/or the floodplain. Particle analysis methods consisted of pebble counts if an armor layer was observed at the particular sample location and/or grab samples of substrate sediments (i.e. typically smaller grain size diameters less than or equal to 3-inches in size) where no discernable armor layer was observed or other targeted sediments were sampled. Grain size distribution testing was completed on the grab samples, per ASTM D421, D2217, D1140, C117, D422, and C136. A total of thirty-eight grab samples were collected consisting of a combination of sub-armor layer, bank, and floodplain samples. Sample locations are included in Appendix D1.

The results of the armor layer measurements and grain size distribution (GSD) testing are included in Appendix D. Figure 3-2 below provides a brief review of the results by showing D90[3], D50, and D10 results plotted versus sample identification numbers (i.e. refer to Figure D1, No. 236 is at the upstream end of Blackbird Creek near the WTP and No. 291 is at the downstream end just upstream of the ponds at the Panther Creek Road Bridge).

[3] D90 means that 90 percent of the weight of the sample consisted of particles with grain sizes smaller than the diameter shown.

FIGURE 3-2

SUBSTRATE SEDIMENTS D90, D50, AND D10 GSD (GRAB SAMPLE) SUMMARY



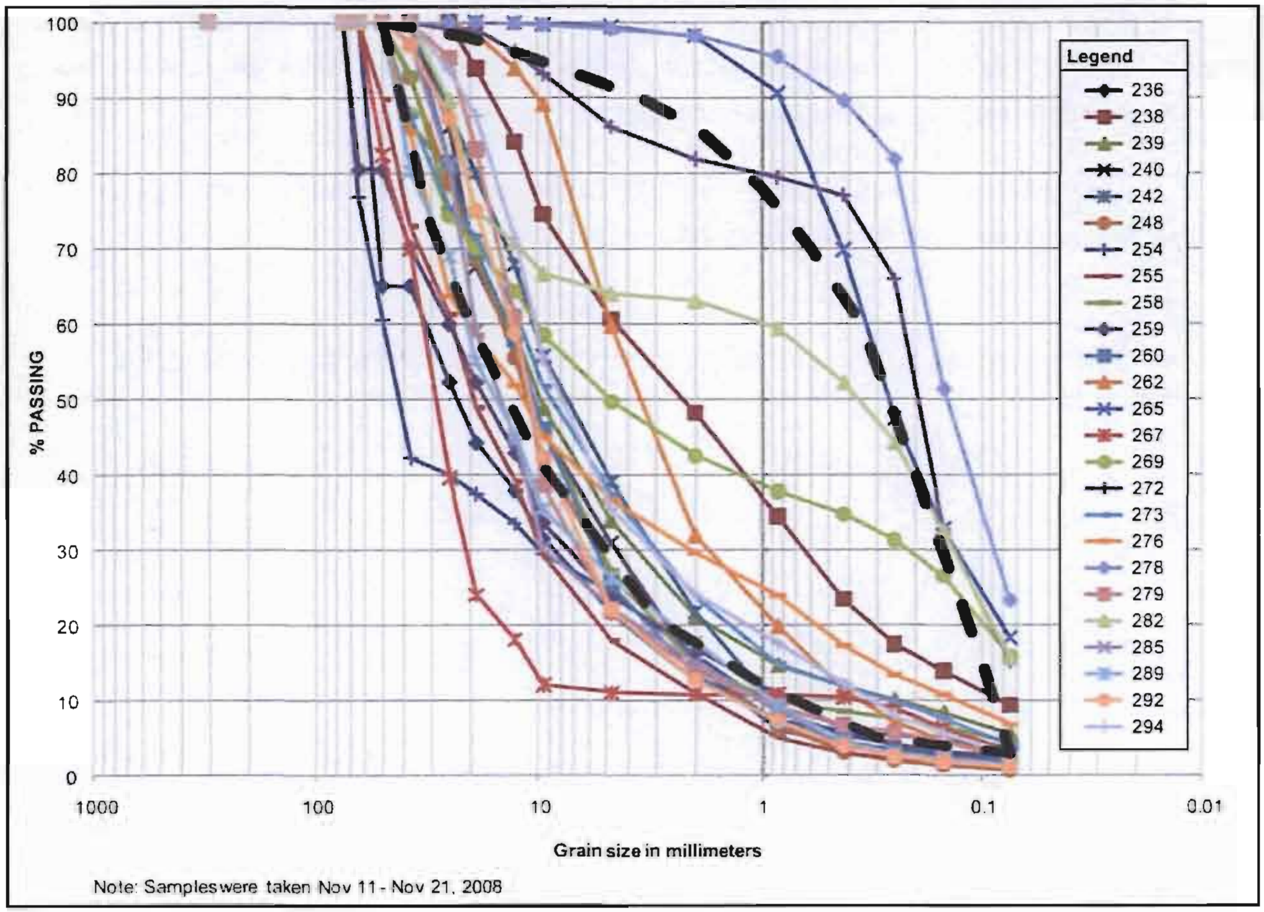
A preliminary review of the results shows an expected trend towards reduced grain size sediment diameters when comparing results from the upper reaches of Blackbird Creek to the lower reaches. D90 sediment particles ranged between approximately 70 to 35 mm above the West Fork, compared with approximately 40 to 20 mm below the West Fork. Similarly, D50 results ranged between 35 to10 mm in the upper reaches compared with 20 to 1 mm in the lower reaches. The D10 results were difficult to differentiate as they were less than approximately 2 mm throughout the project reach.

A more detailed review of the GSD results shows the majority of the samples are similar, evidenced by the large number of coarse-grained GSD curves overlaying each other in Figure 3-3A (i.e. curves on the left side of the graph with concave shape). The handful of GSD curves represented by finer grained distributions (i.e. curves shown on the right side of the graph with convex shape) represent samples taken in predominately depositional areas along the channel or in the overbank floodplain, where lower flow depths and lower energy environments are expected.

Golder Associates

FIGURE 3-3A

SUBSTRATE SEDIMENT (GRAB SAMPLE) GSD RESULTS FOR BLACKBIRD CREEK



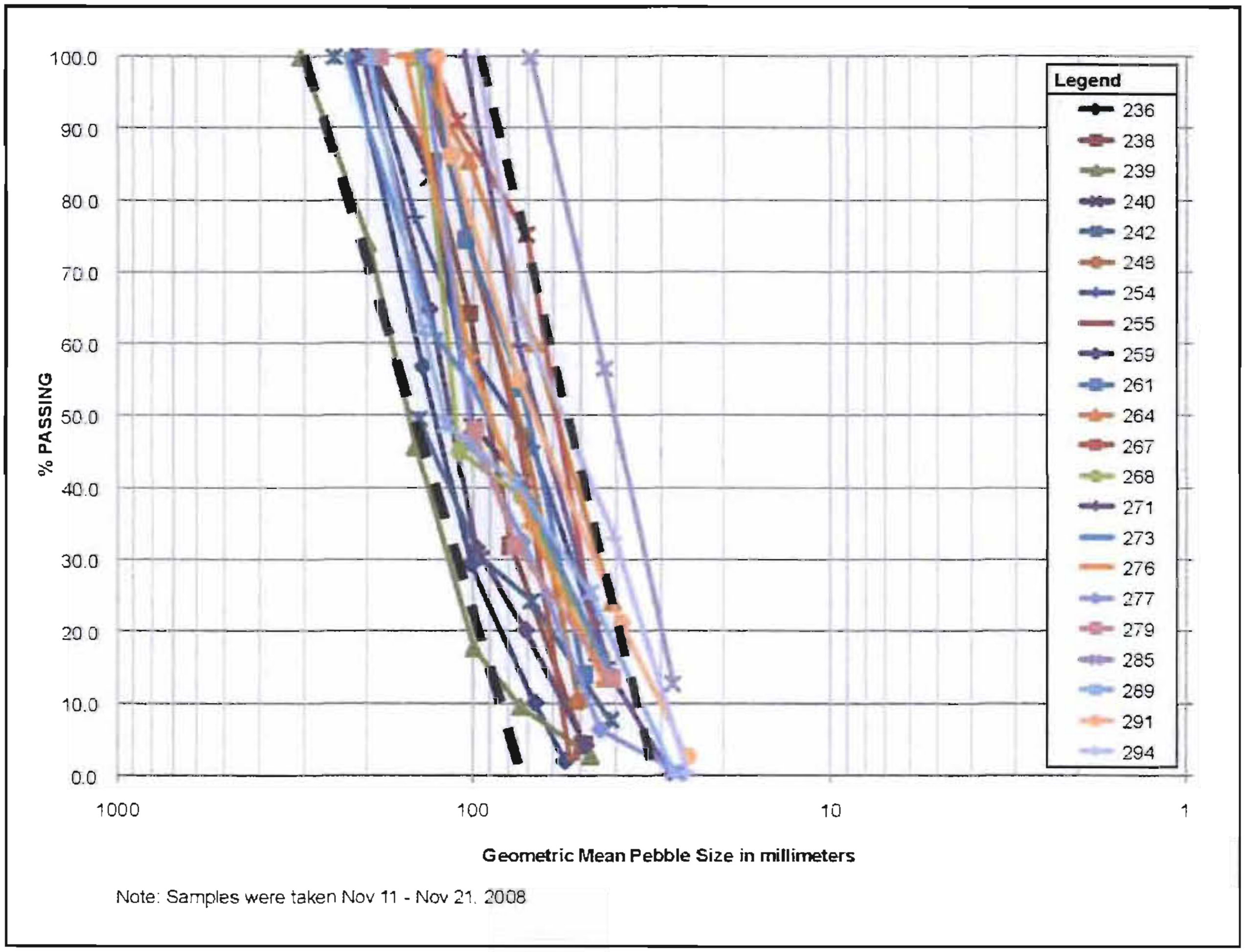
Continued sediment analysis in this report considers a range of high and low sediment grain size distributions represented by the heavy dashed lines in Figure 3-3A, and generally summarized in Table 3-1B. The sediment sample results lying outside the high and low range of grain size limits (i.e. the heavy dashed lines) were excluded from the analysis. These samples are located generally around the West Fork area at the transition from the steeper and higher energy upper Blackbird Creek reach to the lower energy in the lower reaches of Blackbird Creek (see locations for sample numbers 265, 272, 278, 279, and 282 in Figure D1). These samples most likely represent sediments that dropped out towards the back side of the hydrograph when flood energy was decreasing, which is to be expected in the transition from upper to lower Blackbird Creek. That said, they indicate areas where materials can accumulate, and then may be available for re-mobilization during the next flood event.

Sediment sampling included measurement of armor layer sediments, where armor layers were identified (Figure D1). Armoring of the channel bed and active floodplain surfaces refers to coarsening of well-graded sediment mixtures as a result of mobilization of the predominately fine-grained sediments, leaving the coarser grained sediment behind. The armor layer becomes coarser and thicker as the active channel surfaces degrade until a sufficiently thick layer develops that can resist further degradation (Julien 2002). Unless there are natural or man-made features in place in the channel to stabilize the sediments, larger floods can mobilize the armor layer by causing headcut erosion, lateral channel migration, or other erosion and scour processes. When the armor layer is mobilized, the armoring process begins again until a new armor layer is created.

The armor layer sampling (i.e. pebble count sampling) results show a representative armor layer in upper and lower Blackbird Creek sediments (Figure 3-3B).

FIGURE 3-3B

ARMOR LAYER SEDIMENT (PEBBLE COUNT) RESULTS FOR BLACKBIRD CREEK



Although there is some distribution of coarse to fine size ranges in the armor layer measurements, they do not always coincide with upstream versus downstream sample results. The results are generally closely bundled with few, if any, outlying data points, suggesting there is enough energy in the system to move coarse-grained sediments throughout Blackbird Creek, and the only limiting factor in the transport of sediment is flow volume and duration of flows.

Review of the sampling results shows the D90 sediment particles range between approximately 200 to 90 mm, the D50 results range between approximately 150 to 60 mm, and the D10 range between approximately 70 to 30 mm (Figure 3-3B and Table 3-1B). The presence of armor layers along the extent of the upper and lower reaches suggest there is an abundance of coarse bed load material in the Blackbird Creek system. Additionally, the relative abundance of coarse-grained sediments in the measured armor layers relative to the underlying substrate grab sample sediments suggests that armor layers can form fairly rapidly with a limited extent of vertical degradation. If the amount of coarse-grained sediments were limited relative to the underlying substrate, then it would take more degradation to develop the armor layer over a correspondingly longer period of time.

TABLE 3-1B

SYNTHESIZED TYPICAL SEDIMENT GRADATIONS IN BLACKBIRD CREEK CHANNEL

Particle Diameter	Substrate Sediments - Grab Samples, Percent passing (mm)		Armor Layer Sediments - Pebble Count Samples, Percent Passing (mm)	
	High (coarse)	Low (fine)	High	Low
D100	60	60	250	100
D90	45	5	200	90
D65	25	0.4	175	65
D50	15	0.25	150	60
D35	7	0.15	125	45
D10	1.5	0.1	70	30

3.1.3.1 Sediment Transport Capacity Assessment

Assessment of sediment transport potential typically involves some level of variability. Varied distributions in sediment type and size can significantly affect the calculated flux. Use of different calculation equations can also result in varied results. In an effort to offer more than one approach to the results and to provide a comparison between different methods, we used two different approaches for estimating sediment production in Blackbird Creek: A simplified single cross-section and single peak event calculation using the SEDDISCH program, and the HEC-RAS sediment transport software which incorporates hydraulic parameters over a channel reach with limitation on sediment supply and a hydrograph flow input. We compared the results from the two methods to develop planning level estimates of sediment production, and to support continued evaluation of alternatives.

SEDDISCH

A preliminary sediment transport capacity assessment was completed in order to estimate the quantity of sediment moving through the Blackbird Creek system. The 100-year storm was selected as the design event for consideration of potential alternatives in the channel. Preliminary calculations of transport were made at representative locations in upper and lower Blackbird Creek using a United States Geologic

Survey (USGS) SEDDISCH sediment transport calculation method (USGS 1989) that assesses bedload discharge. A general description and reference to additional information about SEDDISCH is included in Appendix E. Bedload discharge is the sediment that moves in continuous contact with the bed. These materials are typically coarser grained sediments, similar to the materials observed and sampled in Blackbird Creek, described above. The "total" sediment load moving through a channel is a combination of the bedload and suspended load. The suspended load, defined as the materials moving in full suspension and predominately not coming in contact with the bed of the channel, were not explicitly assessed because the majority of sediment observed in the sediment samples were coarser grained and representative of either bed material or bed load. The majority of suspended sediments are assumed to pass through the Blackbird Creek system, in suspension, and pass into tributary systems downstream. Analysis of suspended sediment loads requires more detailed sediment sampling and a longer period of record tracking of data. These data are not available for Blackbird Creek.

Estimates of the bedload sediments flux through the system allow a corresponding estimate of the quantity of suspended sediments moving through the system. Literature references suggest that bedload sediment discharge is approximately 5 to 11 percent of the total sediment discharge (i.e. the total load) in stream systems with gravel, rock or clay-like soils and having 25 percent or less sand, and upwards of 9 to 26 percent of the total sediment load for stream systems that are predominately sand (Reid and Dunne 1996). Review of the grab sample testing results (Figure 3-3A) show the percentage of sand (i.e. approximately 4.75 mm) can range from approximately 25 percent up to 100 percent, whereby the majority of the samples fell between approximately 25 and 50 percent. We selected the overlap between the percentages reported from Reid and Dunne (1996) for representative bed load discharge as a percentage of total sediment discharge, namely 10 percent. This value therefore represents an average estimate for using bed load calculations to estimate total load, and thereby suspended load.

Review of the Reid and Dunne (1996) bedload fraction relative to total load offers a qualitative comparison for range of potential results. We selected approximately 10 percent as the representative fraction of bedload relative to total load. The estimate for total load would therefore be 10 times the bedload. Based on Reid and Dunne (1996), the range of bedload relative to total load potential can vary as much as 5 percent to 26 percent, depending on the sand fraction. The corresponding calculated total load would range from 20 times to 4 times the bedload. As an example: assuming a bedload sediment transport capacity of approximately 1,000 tons/day and assuming a 10 times correlation to total load, the corresponding estimated total sediment load is approximately 10,000 tons/day. Incorporating the full range (i.e. 20 times to 4 times) of potential correlation to total load, and the range of potential estimated sediment load would be 4,000 to 20,000 tons/day.

To make estimates of bedload flux, representative cross-sections were selected in the upper Blackbird Creek in a predominately transport channel reach at Station 214+00 and in the lower Blackbird Creek in a dynamic depositional and erosion prone reach at Station 31+00. Calculations of bedload sediment discharge were completed in order to develop an understanding for the order of magnitude of sediment moving through the system during the 100-year design flood event. High and low ranges of sediment grain size distributions, derived from the substrate grab sampling results, were used as inputs in the bedload calculation to represent corresponding high and low sediment flux estimates. The calculations were completed using a representative high and low sediment gradation derived from the grab sample sediment sampling completed at the site in November 2008, and shown in Figure 3-3A and Table 3-1B. The HEC-RAS hydraulic model was used to estimate flow depth and velocity at the representative cross-section locations (i.e. 214+00 and 31+00). The substrate grab sample sediment data were used because they closely represent the majority of sediment that is mobilized once the armor layer is breached and then moves through the Blackbird Creek system. Summaries of the calculations are provided in Appendix E. The calculations report estimated bedload in tons per day (i.e. 24-hour period). Review of the hydrographs for source flows for the 2-500 year flood events in Blackbird Creek (Appendix B1) indicate the majority of the peak of an individual event occurs over approximately a 6-hour period (i.e. floods in Blackbird Creek are not high for 24 hour periods), which represents a "flashy" hydrograph common in mountainous snow-melt runoff basins. This corresponded well with anecdotal information and observations of floods in Blackbird Creek. Peak event duration of 6 hours are therefore assumed to best represent the sediment regime during which bedload sediments would be moving during the flashy events observed in the Blackbird Creek basin. Results were therefore converted from tons per day to cubic yards over a 6-hour period, assuming a uniform distribution of the calculated bedload values. Results are summarized below in Table 3-2.

TABLE 3-2

SUMMARY OF SEDDISCH POINT SEDIMENT DISCHARGE CALCULATIONS AT STATIONS 214+00 AND AT 31+00 FOR THE 100-YEAR DESIGN EVENT

Sediment Reference Section/Location	Estimated Bedload[1] (tons/day)	Estimated Bedload / 6-hour peak duration, 100-year *Runoff* Event (cubic yards)	Estimated Total Load[2] / 6-hour, 100-year *Runoff* Event (cubic yards)
STA. 214+00 (U/S)	3,500 – 8,100	540 – 1,250	5,400 – 12,500
STA. 31+00 (D/S)	6,200 – 14,100	960 – 2,180	9,600 – 21,780

[1] Calculated estimate of bedload transported during a 100-year *runoff* event using a range of values from several different sediment transport equations, and for a range of sediment sizes as reported in Table 3-1B, expressed as tons/day (mass transfer occurring uniformly over a 24-hour period).

[2] Total Load estimate includes both bedload and suspended load. Bedload is estimated to be approximately 10 percent of total load; therefore total load is calculated as 10X bedload estimates. Sediment is estimated to be 120 lbs per cubic foot for conversions from tons to cubic yards.

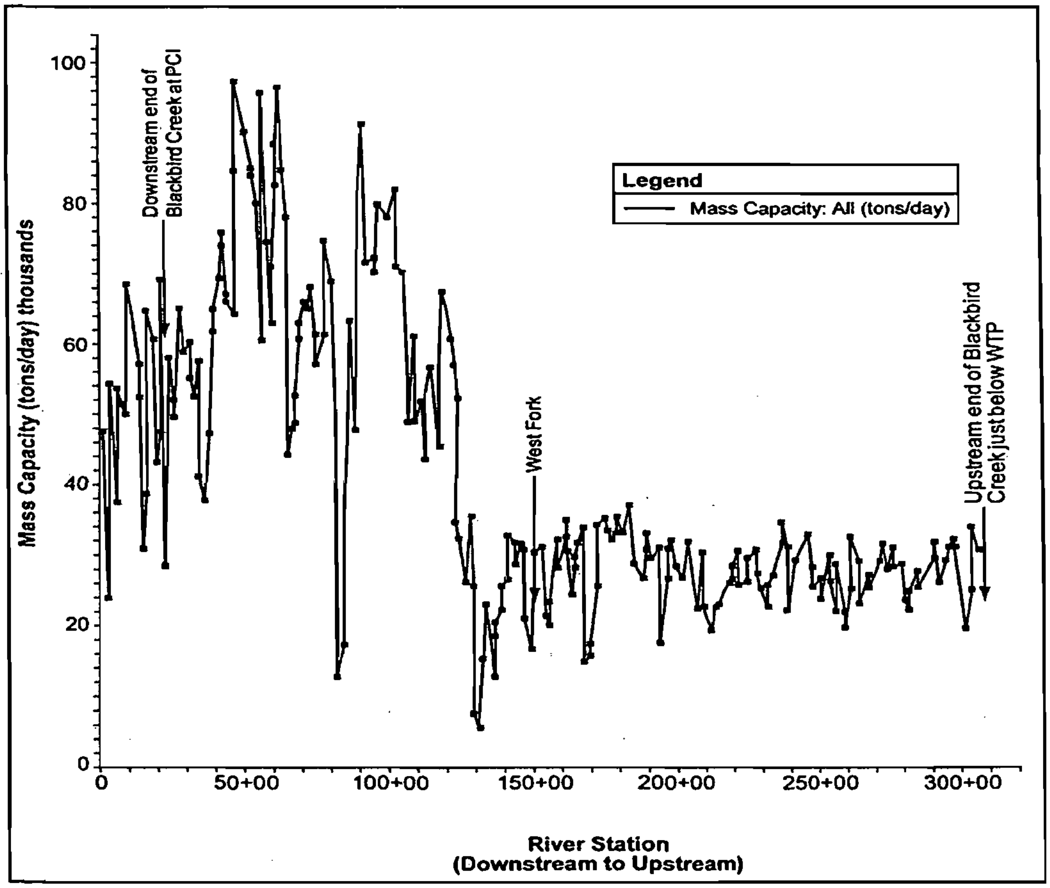
These SEDDISCH results indicate a range of potential sediment transport values, corresponding to the range of sediment grain size distributions used as inputs to the calculation. We expect the actual sediment transport values to fall within this range.

HEC-RAS

A HEC-RAS sediment transport capacity assessment was completed in an effort to evaluate sediment transport discharge potential in Blackbird Creek, and also incorporate the site specific channel geometry, sediment distributions, sediment supply, and a flow time series. The synthesized typical sediment distribution derived from the grab sample sediment data results were used to input sediment grain sizes through Blackbird Creek (Appendix D). Unlike the SEDDISCH model, which evaluates sediment transport capacity based on a single peak flow value, the HEC-RAS model incorporates a flow time series hydrograph and allows for definition of sediment supply. A flow time series representative of the 100-year flood event was developed using the results of the hydrologic analyses (Appendix B1). Limitations were introduced in the upper reaches to reflect the shallow depth of the bedrock and corresponding limited sediment supply corresponding to limited bed, bank and overbank stored sediments (i.e. the channel is confined in a narrow valley and has little or no floodplain). Figure 3-4A shows the total sediment transport potential for the project reach extending from the WTP downstream to the confluence with Panther Creek.

FIGURE 3-4A

HEC-RAS SEDIMENT TRANSPORT POTENTIAL DURING THE 100-YEAR FLOOD EVENT



The HEC-RAS modeling shows a difference in sediment transport potential between the upstream reach above West Fork and channel reaches downstream of West Fork (Table 3-3). The model accounts for the confined valley, difference in channel geometry between the upper and lower reaches, the significant increase in flow contribution at the West Fork, and the limited supply of sediment through the upstream reaches of bedrock controlled channel (i.e. limited available sediment in the bed, banks, and overbanks due to shallow bedrock and little or no floodplain) versus the numerous sediment sources in the downstream reaches of Blackbird Creek below West Fork. The sediment sources in the lower reaches of the system have an extensive supply of sediment stored in the bed and banks, representing variable floodplain surfaces, some of which are active during floods and some that are accessed by lateral channel migration and headcut erosion.

The HEC-RAS modeling indicates that some areas along the channel experience localized supercritical flow conditions (i.e. Froude numbers >1). This produces decreased transport efficiency where flow friction is increased (Lisle 1987). Based on the modeling results, the majority of the channel shows sub-critical flows (i.e. Froude number <1).

TABLE 3-3

SUMMARY OF HEC-RAS SEDIMENT TRANSPORT POTENTIAL
FOR THE 100-YEAR DESIGN EVENT

Sediment Type/Location	Estimated Bedload[1] (tons/day)	Estimated Bedload/ 6-hour peak duration, 100-year *Runoff* Event (cubic yards)	Estimated Total Load[2] / 6-hour, 100-year *Runoff* Event (cubic yards)
Upper reach above West Fork	2,000 – 3,600	310 – 560	3,100 – 5,600
Lower Reach below West Fork	5,000 – 9,000	770 – 1,400	7,700 - 14,000

1 Calculated estimate of bedload transported during a 100-year *runoff* event, expressed as tons/day (mass transfer occurring uniformly over a 24-hour period).

2 Total Load estimate includes both bedload and suspended load. Bedload is estimated to be approximately 10 percent of total load; therefore total load is calculated as 10X bedload estimates. Sediment is estimated to be 120 lbs per cubic foot for conversions from tons to cubic yards.

The reaches downstream are notably wider and have significantly more sediment supply potential, where sediments are stored in overbank floodplain areas, as well as increased flow potential. Additional flows enter Blackbird Creek from West Fork, which increases the transport potential. These results correlate with the range of results developed for the reference locations at 214+00 and 31+00. Results for the HEC-RAS modeling are provided in Appendix C1 and for the corresponding HEC-RAS sediment transport component in Appendix C2.

Based on review of the SEDDISCH and HEC-RAS results, continued evaluation of alternatives relative to sediment transport in lower Blackbird Creek will use results from the HEC-RAS assessment. Results from the two approaches correlated well, considering the assumptions and limitations in each approach.

The HEC-RAS results appear to more reasonably represent sediment transport conditions, because they incorporate a time series in-flow and can more closely account for the change in channel morphology between upper and lower Blackbird Creek.

The estimated total load of 11,000 cubic yards per *runoff* event (i.e. approximately a 6-hour duration) will be used in continued evaluation of alternatives in lower Blackbird Creek. This value was selected as the average between approximately 7,700 and 14,000 cubic yards per *runoff event,* as reported for the lower reach of Blackbird Creek below West Fork.

The estimated total load may vary, depending on the assumed correlation of bedload to total load. Reid and Dunne (1996) indicate the percentage of bedload relative to total load may range by as much as approximately 5 percent to 26 percent, depending on the sand fraction and other variations in grain size distribution. Applying these ranges to the results from the HEC-RAS sediment transport results provides a qualitative assessment of the potential variability in estimated total sediment load. For example, application of the above reported range in bedload to total load to the calculated range of bedload in Table 3-3 results in a potential total load flux of approximately 3,000 to 28,000 cubic yard of total sediment load per *runoff event.* These values are derived by applying a 5 percent and 26 percent correlation to both the calculated 770 and 1,400 cubic yards of bedload per *runoff event,* and then selecting the highest and lowest results.

3.1.3.2 Average Annual Mass of Sediment Transported

An estimate was made of the mass and volume of sediment that is transported on an annual average basis. The calculations above are directed at extreme events, the 100 year event in this case. Much less sediment is transported in typical high flow events that occur over an average year. The cumulative volume of these smaller annual events are captured in the existing sediment ponds along Blackbird Creek. The volume for average annual sediment transported was estimated by assessing the performance of the sediment ponds in Blackbird Creek located just upstream of the PCI ponds. The volume of these ponds is approximately 1 acre-foot, and they have been cleaned out once every five years on average (pre-2008). Therefore the average annual inflow of bed load materials is approximately 0.2 acre-feet per year, assuming this volume is composed mostly of retained bed load. This is equivalent to 322 cubic yards/year or approximately 400 cubic yards/year. We estimate that it ranges from 200 cubic yards to 800 cubic yards annually, based on professional judgment.

The total sediment flux from the basin can be estimated based on the bedload flux. Assuming that bed load volume is 10 percent of the total sediment load, the total load is about 2 acre-feet/year, which is equivalent to 3,227 cubic yards/year, or approximately 4,000 cubic yards/year. Therefore a reservoir large enough to provide settling times necessary to remove suspended sediments would be expected to fill with sediment deposits at the rate of approximately 4,000 cubic yards/year, on average.

Based on previous discussion and review of Reid and Dunne (1996), the percentage of bedload as a fraction of total load can range from 5 percent to 26 percent. We have assumed an average value of 10 percent, resulting in a corresponding sediment production in the ponds, and corresponding average annual production rate of approximately 4,000 cubic yards/year. Incorporating the range of values reported by Reid and Dunne (1996), the average annual total sediment production rate expected to range between approximately 1,600 (400/0.25) and 8,000 (400/0.05) cubic yards/year.

While the bedload and suspended load transported in low flow or average year is relatively modest (~ 4,000cubic yards), the bedload volumes vary upward to very high values in response to high flow events and other disturbances like forest fires in the basin. In both 2008 and 2009 snowmelt flows moved bedload that completely filled the PCI ponds in a matter of a few days. Also, during the 2009 event, a significant amount of bed load (1 to 2 feet) was deposited in Blackbird Creek between the bridge and Panther Creek, indicating that the bedload transported in 2009 exceeded the capacity of the PCI ponds. The hydrologic conditions (snow depths) in 2008 and 2009 were only slightly above average. However, the melt rate was high in both years and the effects of the 2000 fire remain in the upper basin and contribute to unusually high runoff rates. These factors lead to the high bedload transport volumes.

Thunderstorm events can produce even larger sediment transport volumes and snowmelt events. For example during the summer of 2002 and 2003, shortly after the 2000 fire, major thunderstorms occurred in the lower Panther Creek basin. These events transformed the lower basin by generating landslide and debris flows that deposited sediments many feet deep in the Panther Creek channel, its tributaries and overbank areas.

In summary the estimated average annual total sediment volume is approximately 4,000 cubic yards and may vary by as much as 1,600 to 8,000 cubic yard per year, but the probabilities are not normally distributed and are skewed upward, meaning that there is a relatively high likelihood of an event with sediment volumes many times larger than the mean.

3.1.4 Floc Data

The West Fork Tailings Impoundment is a source of iron loading to Blackbird Creek. Discharge of tailings seepage to Blackbird Creek results in the precipitation of iron oxyhydroxides within the creek and subsequent attenuation of metals/metalloids due to adsorption and/or co-precipitation. In October 2008, a field investigation was conducted to characterize metal concentrations in iron oxyhydroxides (i.e., "floc") downstream of the West Fork Tailings Impoundment. The scope of this investigation is described in *Sampling and Analysis Plan for Blackbird Creek Iron Oxyhydroxide Solids, Lemhi County, Idaho* (Golder 2008c). Chemical analysis and settleability testing results were presented in *Draft Report for EPA Review – Blackbird Creek Iron Oxyhydroxide Solids Sampling Report* (Golder 2008e).

Both pH and redox conditions control whether iron occurs in the aqueous phase or the solid phase. The stability field for ferrihydrite [Fe $(OH)_3$] (iron oxyhydroxide) is shown in Figure 3-5. As seepage containing dissolved iron discharges to surface water below the West Fork Tailings Impoundment, both an increase in solution pH, due to mixing with Blackbird Creek and West Fork bypass waters, and a change to more oxidizing conditions, due to exposure to atmospheric oxygen, promote precipitation of ferrihydrite.

Floc sampling focused on collection of iron oxyhydroxides, a secondary mineral phase that is reddish in color and exists as partially settled or settled material. The greatest accumulation of this material is within the vicinity of the West Fork Tailings Impoundment. Downstream of the West Fork Tailings Impoundment, floc material that had settled from the water column and formed coatings on the bed sediments was collected. Floc samples likely included some contribution from sediment (defined as consisting of primary mineral phases), with the contribution from sediment increasing with distance from the West Fork Tailings Impoundment.

The primary objective of the floc investigation was to characterize its arsenic content. The copper, cobalt, iron, manganese and sulfate contents of the floc were also characterized. Floc chemical analysis results are presented in Table 3-4 and Figures 3-6 to 3-8. Sample locations are shown in Figure 3-9. Floc samples collected at the base of the West Fork Tailings Impoundment yielded arsenic concentrations ranging from 556 to 4,710 mg/kg, with the highest concentration found in the sample collected from the West Fork Interceptor Ditch at the base of the West Fork embankment. Floc samples collected downstream of the tailings impoundment yielded arsenic concentrations ranging from 473 to 1,700 mg/kg, with the sample collected furthest downstream within Panther Creek yielding the lowest arsenic concentration. Both iron and TOC may act as sorbents for arsenic. The relationship between floc arsenic concentrations and iron and TOC are shown in Figure 3-6.

In addition to iron and arsenic, the floc contains sulfate, copper, cobalt and manganese. Figures 3-7 and 3-8 show the spatial trends in floc metal concentrations and paste pH from upstream (West Fork Tailings Impoundment) to downstream (Panther Creek). Floc paste pH demonstrates an increasing trend with distance downstream of the West Fork Tailings Impoundment. The observed changes in the distribution of metals present in floc reflect the pH dependency of metal sorption onto iron oxyhydroxide. Sorption reactions are pH dependent, because this variable controls both the distribution of species in solution and the charge of mineral surfaces, factors that influence the affinity of a particular constituent for a sorbent. As conditions become more acidic, cationic trace metals, such as copper and cobalt, tend to desorb and sorption of anions, such as arsenic and sulfate, will increase.

In general, floc samples collected close to the West Fork Tailings Impoundment yielded lower paste pH values and higher arsenic and sulfate concentrations, indicating preferential adsorption of these constituents under more acidic conditions. As pH increases with distance from the West Fork Tailings Impoundment, copper is adsorbed followed by cobalt and manganese. The concentrations of these metals demonstrate increasing trends between BBSW-02 and the bridge (sample Blackbird D shown on Figure 3-9) as paste pH values increase from 5.3 to 6.3. Metal concentrations then show a decreasing trend in the lower most reaches of Blackbird Creek and in Panther Creek, most likely due to dilution.

Floc cobalt concentrations ranged from 76 to 1,460 mg/kg (Table 3-4). Along Blackbird Creek, cobalt floc concentrations generally demonstrated an increasing trend with distance from the West Fork Tailings Impoundment. A similar increasing trend was observed for manganese floc concentrations, which ranged from 34 to 916 mg/kg (see Table 3-4 and Appendix F – Figure 2).

The source of iron forming the floc is the West Fork Tailings Impoundment seepage. Once formed, the floc is transported downstream. The density of the floc is less than that of sediment, which affects its rate of physical transport downstream.

The 2008 settleability analysis of the floc was conducted, generally in accordance with the approved Sampling and Analysis Plan (SAP). Three samples were placed in 1 liter beakers and stirred. The level of the interface was then measured at varying intervals of time. The first measurement was taken 3 minutes after stirring. At that time the interface levels were at or below the mid-point of the beaker in all cases, and the supernatant was beginning to clear. Further measurements revealed that the interface continued to fall, suggesting consolidation of the solids on the bottom of the beaker with very little further settlement from the supernatant. Assuming the beaker is 8 inches high, we concluded that the settlement velocity of nearly all of the floc was 4 inches in 3 minutes, or greater. A settlement velocity of 1 inch/minute was used in further evaluations.

3.1.5 Early 2009 Suspended Sediment Sampling

During the snowmelt runoff in May 2009, suspended sediment sampling was completed to provide information on the settleability of the suspended sediments in Blackbird Creek flows. The sampling locations and methods and testing procedures are described in the SAP and testing plan (Golder 2009b and Golder 2009c).

3.1.5.1 Sampling Results

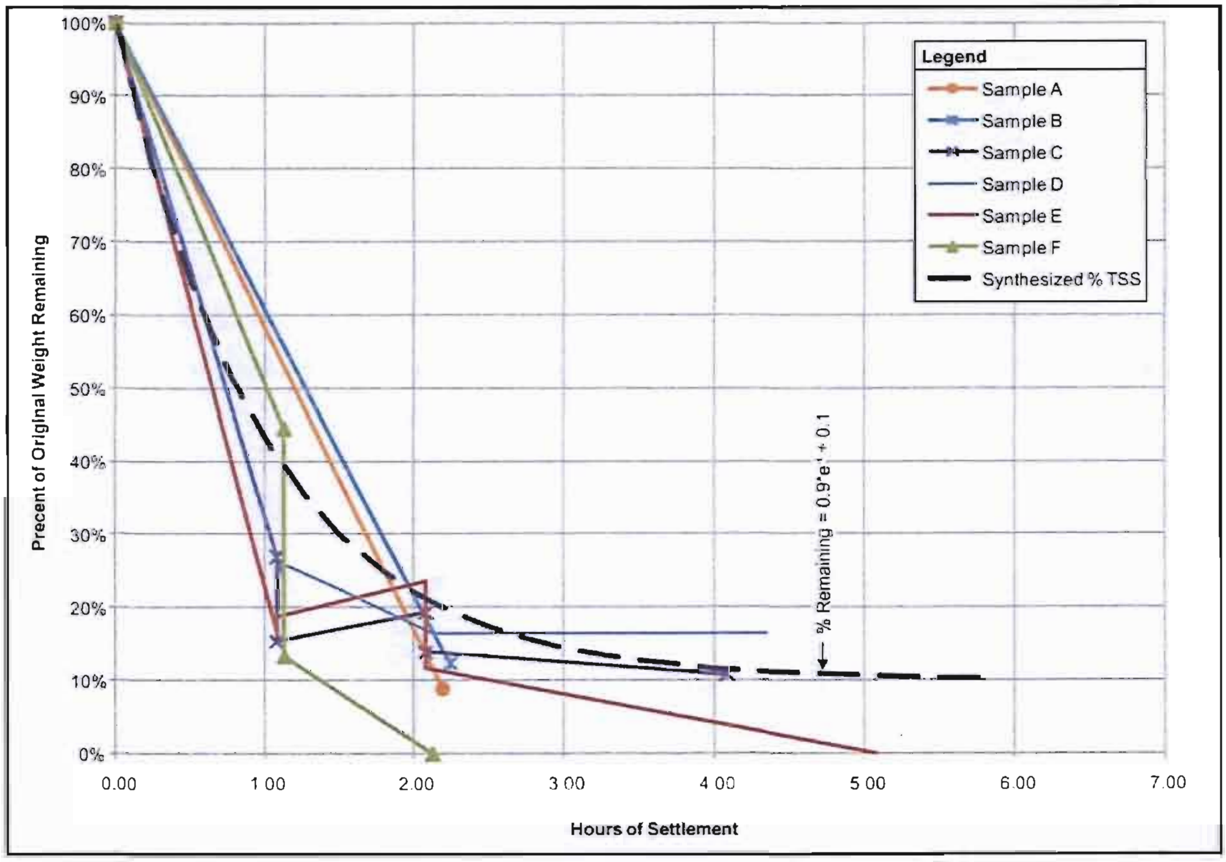
The results of the sampling done in 2009 are presented in Appendix H1. Total Suspended Solids (TSS) concentrations ranged from over 2,110 mg/L to 28 mg/L. Generally the samples taken early in the snowmelt runoff period contained the highest TSS concentrations. The sampling was completed generally during the recessional portion of the seasonal hydrograph so TSS concentrations are not representative of the higher TSS expected during the rising limb of the hydrograph. However, the grain size and settleability of the suspended sediments are believed to be similar. For this reason the results of the sampling can be used as a basis for estimating settling times, but cannot be used alone as a basis for estimating volumes of expected sediment.

3.1.5.2 Settling Tests

The settlement tests described in Appendix H1 provided a basis for estimating the effectiveness of reservoirs in removing all suspended load, both suspended sediments as they have been described above and the floc. These tests do not differentiate between the two fine-grained sediments which are both potential sources of COCs. The results of several tests were synthesized to develop a relationship between percent removal and time (retention time or time for settlement). The test results and synthesized curve are presented in Figure 3-4B below.

FIGURE 3-4B

PERCENT SOLIDS REMAINING SUSPENDED VERSUS TIME OF SETTLEMENT



This relationship is used in Section 6 to evaluate the *capture* of suspended sediment and floc by the reservoirs. The percent removal by settling is a major element in the effectiveness of the alternatives using reservoirs. Approximately 10 percent of the suspended sediment is unsettleable and will flow through a storage reservoir; however, the same suspended sediment will also be unlikely to settle in overbank areas along Panther Creek.

3.1.6 *Late 2009 Panther Creek Overbank Soil/Suspended Sediment Sampling and Testing*

In September 2009 overbank sediment samples were taken at eight sampling stations along Panther Creek from its confluence with Blackbird Creek downstream to the Bevan property. These samples were submitted to a laboratory for testing to determine the GSD of the sediments in the samples as well as the arsenic and cobalt concentrations within each of the grain size brackets (sieves). The results of this sampling and testing program are presented in Appendix H2.

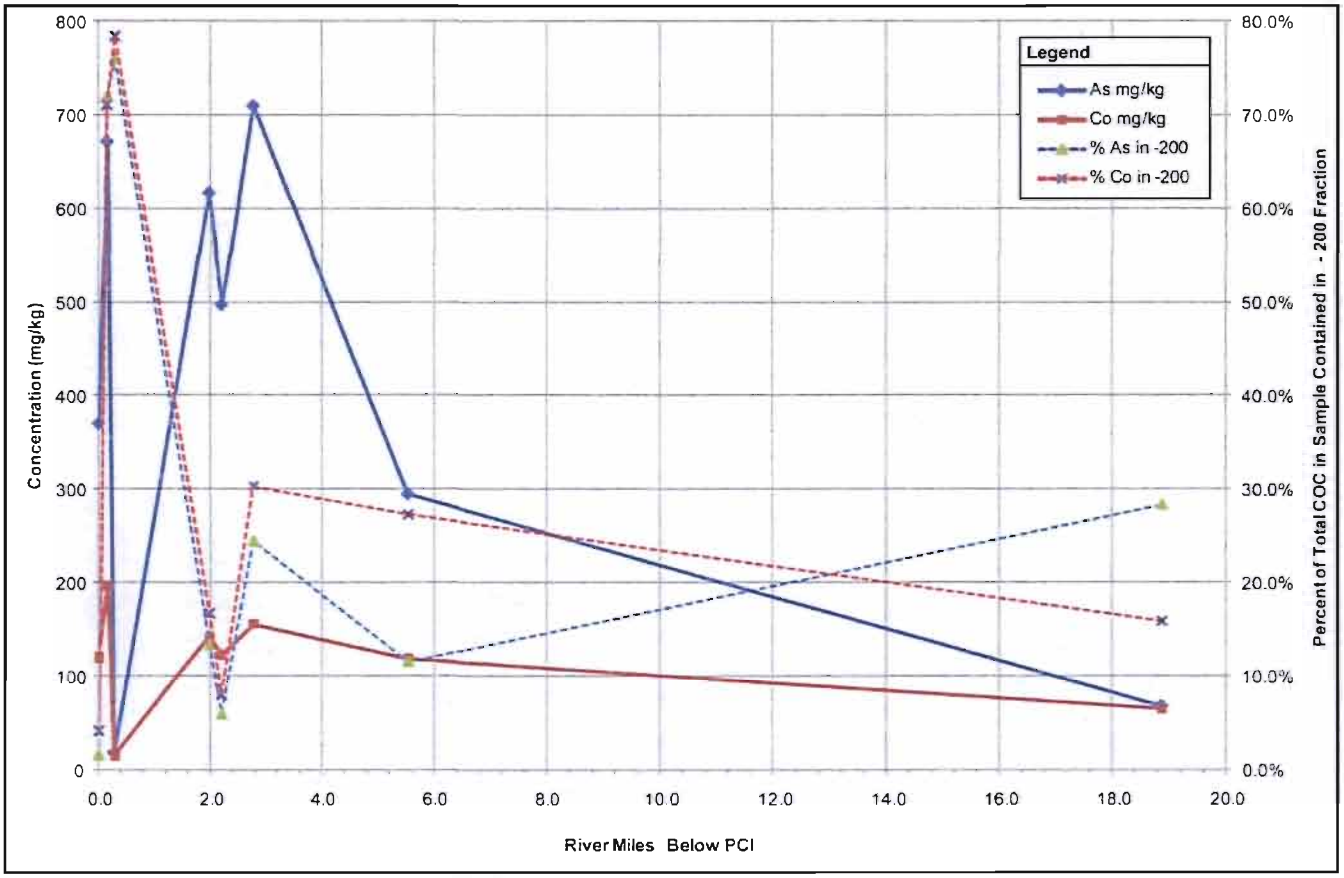
The objective of the sampling and testing program was characterization of the sediments that might be captured by a diversion and settling basin system located near the PCI. The proportion of COCs contained in each bracket of the GSD was of particular interest because that information would help evaluate the potential effectiveness of settling basins. The sampling locations along Panther Creek were selected because this is the same material that is problematic and that the settling basins would seek to capture.

The sampling shows that the concentrations of COCs in the sediments generally decline from the upstream stations to those downstream. This trend is expected since the source of most of the COCs is Blackbird Creek at the upstream end of the reach and the total sediment load is increasing with increasing drainage area downstream. The other sediments being added are believed to be clean, so those sediments tend to dilute the COCs from Blackbird Creek. However the data also show significant variability. The COC concentrations likely vary widely for various reasons. The depositional environments are variable and uncontrolled, meaning that the fines concentrations and the corresponding concentrations of COCs will vary because some samples were taken from higher or lower energy depositional areas than others. The sediments in Panther Creek are not all from Blackbird Creek and they tend to move in waves, so some overbank sediments may be predominately composed of materials that did not originate in Blackbird Creek and are relatively free of COCs.

The COCs are generally distributed uniformly with respect to grain size, although there are some exceptions to this rule. The figure below shows that COCs in a sample are generally 10 to 30 percent from the minus 200 fraction, but this can vary widely. For example the two samples at the PCI Campground show a high proportion (+70 percent) of the COCs are in the minus 200 fraction (0.075 mm) when the total COC concentration is very high and very low. These variations likely result from the sample variability discussed above.

FIGURE 3-4C

PANTHER CREEK OVERBANK CONTAMINANT CONCENTRATION & PERCENT OF TOTAL COC IN SAMPLE IN THE MINUS #200 SIEVE FRACTION BY RIVER MILE DOWNSTREAM OF THE PCI PROPERTY



3.1.7 Sequential Extraction Testing

In November 2009, an investigation was conducted to evaluate the abundance of floc (i.e., secondary iron oxyhydroxide precipitates) containing arsenic and cobalt in overbank deposits along Panther Creek. This study was intended to provide data to support or refute the hypothesis that iron oxyhydroxide floc formed from West Fork Tailings Impoundment seepage is a major contributor to total arsenic and cobalt concentrations in overbank materials along Blackbird Creek. The investigation and results of the study are described in the report titled *Report on Panther Creek Overbank Sampling for Sequential Extraction Analysis* (Golder 2010b - provided as Appendix F).

In summary, the study involved collection of three composite overbank samples from along Panther Creek at the following locations: Cobalt Townsite; Napias Creek; and, Bevan Property. Sample collection targeted areas containing new deposition material from recent flood events. Samples were shipped to ACZ Laboratories Inc. for sequential extraction analysis. The objective of this leach test was to quantify the amount of arsenic and cobalt present in association with floc in overbank materials.

A liquid separation procedure, as recommended by the EPA, was performed prior to sequential extraction analysis to remove primary sulfides, present in association with tailings material, from the sample.

3.1.8 Water Quality Data

3.1.8.1 Panther Creek

Cobalt and copper are the primary aqueous constituents of concern in Blackbird Creek. Water quality monitoring has been conducted to determine compliance with the chronic copper cleanup level in Panther Creek three times during the spring snowmelt (usually in April or May and June). Monitoring is also conducted for cobalt. Each event occurs over a 96 hour period to determine compliance with the chronic cleanup level for dissolved copper, as required by the ROD Scope of Work (SOW) and as specified in the Performance Monitoring Plan (Golder 2006). Results of water quality monitoring are provided in the annual monitoring reports (Golder 2007d, 2008f, 2009a, and 2010a). The chronic dissolved copper cleanup level was exceeded during some of the spring runoff monitoring events from 2006 through 2009. *The chronic dissolved copper cleanup level was not exceeded during any of the fall monitoring events from 2006 to 2009.* The *dissolved* cobalt cleanup level was not exceeded in Panther Creek *in any of the* water quality monitoring *events* during this period. A summary of the monitoring results is as follows:

- 2006 – The cleanup level was exceeded at stations PASW-09, PASW-05 and PASW-04X during two of the three spring 96-hr sampling events. During the first spring sampling event dissolved copper concentrations ranged from 0.008 to 0.010 mg/L at PASW-09 compared to the corresponding hardness-based chronic cleanup level, which ranged from 0.005 to 0.006 mg/L. Dissolved copper concentrations ranged from 0.006 to 0.009 mg/L at PASW-04X, and 0.005 to 0.007 mg/L at PASW-05. The corresponding IWQS ranged from 0.004 to 0.005 mg/L at both PASW-04X and PASW-05. During the second spring sampling event dissolved copper ranged from 0.004 to 0.007 mg/L at PASW-09 compared to the IWQS which ranged from 0.0035 to 0.004 mg/L. Dissolved copper concentrations ranged from 0.004 to 0.007 mg/L at PASW-04 and from 0.003 to 0.006 mg/L at PASW-05. The chronic cleanup level at both of these stations was 0.0035 mg/L for all samples. The cleanup level was not exceeded during the third sampling event in June at any of the stations.
- 2007 – The cleanup level was met at all stations during all of the three sampling events.
- 2008 – The cleanup level was exceeded at stations PASW-09, PASW-05 and PASW-04 during two of the three spring 96-hr sampling events. During the first spring sampling event dissolved copper concentrations ranged from 0.006 to 0.007 mg/L at PASW-09, at PASW-04X they ranged from 0.005 to 0.006 mg/L, and at PASW-05 they ranged from 0.004 to 0.006 mg/L. The corresponding hardness based Idaho Water Quality Standard (IWQS) at PASW-09 was typically around 0.005 mg/L and at PASW-04X and PASW-05 it ranged from 0.0035 to 0.004 mg/L. During the second spring sampling event dissolved copper concentrations ranged from 0.003 to 0.014 mg/L at PASW-09, from 0.004 to 0.013 mg/L at PASW-04X, and from 0.004 to 0.012 mg/L at PASW-05. The corresponding chronic cleanup level ranged from 0.0035 to 0.004 at PASW-09 and was 0.0035 during all sampling at PASW-04X and PASW-05. The cleanup level was met during the third sampling event in June at all of the stations.
- 2009 – The cleanup level was slightly exceeded (p value of (0.0134) at station PASW-09 during the first round of spring sampling with dissolved copper concentrations ranging from 0.004 to 0.006 mg/L compared to the IWQS which ranged from 0.0035 to

0.005 mg/L. Concentrations did not exceed cleanup levels at PASW-04X and PASW-05 during the first round of sampling. During the second round of spring sampling the cleanup level was exceeded at stations PASW-09, PASW-04X, and PASW-05. Dissolved copper concentrations ranged from 0.005 to 0.020 mg/L at PASW-09, and from 0.005 to 0.017 mg/L at both PASW-04X and PASW-05. Corresponding chronic cleanup level at these stations was 0.0035 at all stations for all samples. The cleanup level was met during the third round in June at all of the stations.

In general, the chronic criteria exceedances for copper have coincided with high runoff in Blackbird Creek and prior to peak runoff in Panther Creek.

3.1.8.2 Blackbird Creek

Copper and cobalt exhibit unique behavior in Blackbird Creek. Fall and spring synoptic sampling results from the past four years (2006 to 2009) for selected constituents are shown in Figures 3-10 and 3-11. These figures include stations BBSW-03A/03, located upstream of the West Fork Tailings Impoundment, and BBSW-02 and BBSW-01A, located between the West Fork Tailings Impoundment and the confluence of Blackbird and Panther Creeks. The discussion that follows is based on the synoptic sampling results from 2005 to 2009.

3.1.8.2.1 Cobalt

Cobalt concentrations in Blackbird Creek are higher in the fall than in the spring. In the fall, discharge of seepage from the West Fork Tailings Impoundment results in an increase in dissolved cobalt concentrations from approximately 0.2 mg/L to 0.5 mg/L between BBSW-03/03A and BBSW-02. A decline in dissolved cobalt to approximately 0.3 to 0.4 mg/L is observed between BBSW-02 and BBSW-01A. This decline is attributable to dilution from groundwater recharge and cobalt attenuation in association with (oxy)hydroxide phases. In the spring, dissolved cobalt concentrations at BBSW-03/03A range from 0.06 to 0.08 mg/L. A small decrease in cobalt concentrations is consistently observed between BBSW-03/03A and BBSW-02 (approximately 10 to 20 parts per billion (ppb)). This decline is attributed to dilution by inflow from West Fork Blackbird Creek. Between BBSW-02 and BBSW-01A, dissolved cobalt concentrations remain relatively stable or decrease slightly. As in the fall, declines may be attributable to dilution from groundwater recharge or cobalt attenuation in association with (oxy)hydroxide phases. Although cobalt will adsorb to manganese and iron (oxy)hydroxide phases, the pH of Blackbird Creek (generally 6 to 7.5) is below the range for optimal cobalt adsorption. Olsen (Camp Dresser and McKee, 1995) noted cobalt in association with a manganese/iron oxyhydroxide phase in a sediment sample collected downstream of the West Fork Tailings Impoundment, indicating some cobalt attenuation is possible. The October 2008 floc data also suggest cobalt attenuation in association with iron phases.

3.1.8.2.2 Copper

Dissolved copper concentrations in Blackbird Creek at BBSW-03/03A are similar in the spring and the fall (approximately 20 to 40 ppb). In both the spring and fall, dissolved copper concentrations between

BBSW-03/03A and BBSW-02 consistently decline (BBSW-02 concentrations range from approximately 10 to 20 ppb). This decline in dissolved copper is attributed to both dilution from the clean water inflow from the West Fork Blackbird Creek and adsorption of copper onto iron (oxy)hydroxides. In the spring, dilution is likely the dominant factor for the observed decrease. In the fall, downstream of BBSW-02, dissolved copper concentrations continue to decline to a few ppb. This decline is attributed to copper adsorption onto iron (oxy)hydroxides. Blackbird Creek pH conditions are within the range to promote maximum copper adsorption. Olsen (Camp Dresser and McKee, 1995) confirmed the association of copper with an iron oxyhydroxide phase in sediment collected downstream of the West Fork Tailings Impoundment. In the spring, dissolved copper concentrations downstream of BBSW-02 decline slightly or remain relatively stable. Therefore, in the fall, dissolved copper concentrations are lower at the mouth of Blackbird Creek than in the spring.

3.1.8.2.3 Iron

Dissolved iron concentrations in Blackbird Creek are higher in the fall than in the spring. West Fork Tailings Impoundment seepage contributes iron loading to Blackbird Creek. In both the spring and fall, dissolved iron concentrations increase between BBSW-03/03A and BBSW-02; however, in the fall, this increase is greater. Dissolved iron concentrations typically decrease downstream of BBSW-02.

3.1.8.2.4 Arsenic

Dissolved arsenic concentrations in Blackbird Creek are similar in the spring and fall. At BBSW-03/03A, dissolved arsenic concentrations are typically on the order of approximately 10 ppb. Although arsenic is present in West Fork Tailings Impoundment seepage, a decrease in dissolved arsenic concentrations consistently occurs between BBSW-03/03A and BBSW-02. This decrease is attributed to both dilution from the clean water inflow from the West Fork Blackbird Creek and arsenic attenuation. Arsenic in tailings impoundment seepage is attenuated by adsorption on iron oxyhydroxides. At the mouth of Blackbird Creek, dissolved arsenic concentrations are low (less than 8 ppb and sometimes less than detectable limits).

3.1.9 Water Quality Data - West Fork Tailings Impoundment Seepage

Golder has estimated that the West Fork Tailings Impoundment seepage discharges to Blackbird Creek at a rate of 100 to 200 gpm (Golder 2002a). Surface seepage (i.e., shallow groundwater seepage that discharges to the West Fork Interceptor Ditch or the tailings impoundment underdrain) accounts for most of this flow, with the contribution from groundwater underflow estimated at less than 10 gpm. The 100 to 200 gpm estimate of total seepage discharge from the West Fork Tailings Impoundment Area to Blackbird Creek was presented in the Feasibility Study (Golder 2002a). Three methods were used to estimate groundwater discharge as follows: (1) estimation of total recharge; (2) estimation of groundwater discharge based on the increase in cobalt loading to Blackbird Creek; and (3) estimation of groundwater discharge from a Darcy calculation (i.e., Q=KiA). The first two methods provide an estimate of total groundwater discharge including both surface seepage and underflow. The third method provides an estimate of subsurface groundwater discharge (i.e., underflow). These calculations indicate that most groundwater discharge reports as surface seepage with groundwater underflow accounting for approximately 10 percent of the total flow. Additional detail on the calculations described above are presented in Appendix I.

The flow and quality of surface seepage at the West Fork Tailings Impoundment are currently monitored at two primary locations: the West Fork Interceptor Ditch (location WFINTDITCH) and the toe tailings underdrain (location WFTTSW-01). Table 3-5 presents flow data for these two monitoring locations. Over the period of record, average total flow for these two stations has been 141 gpm. The combined measured flow at the two stations has ranged from 105 to 192 gpm[4].

Water quality data for the following monitoring locations were used to characterize current West Fork Tailings Impoundment seepage quality: WFINTDITCH (surface seepage), WFTTSW-01 (surface seepage) and WFMW-01S (groundwater seepage). Well nest WFMW-1 is located downgradient of the tailings impoundment between the dam and Blackbird Creek. The shallow (WFMW-01S) and deep (WFMW-01D) completions are screened within the alluvium and fractured bedrock, respectively. Groundwater quality in the shallow well indicates a greater impact from tailings impoundment seepage than in the deeper well.

Water quality monitoring results through 2009 for selected constituents are shown in Figures 3-12 through 3-17. West Fork Tailings Impoundment seepage quality has generally demonstrated an improvement over time. Seepage pH has generally increased over time (Figure 3-12). Coincident with an increase in pH, sulfate, dissolved copper and dissolved cobalt concentrations have gradually decreased. Dissolved arsenic concentrations at some monitoring locations demonstrate an increasing trend (Figure 3-15). Recent data[5] from WFTTSW-01, WFINTDITCH and WFMW-01S were used to define the quality of West Fork Tailings Impoundment seepage for the treatment evaluation (see Section 4.1.6).

3.1.9.1 West Fork Tailings Impoundment Seepage Collection and Treatment Evaluation

To control the formation and downstream transport of floc, collection and treatment of West Fork Tailings Impoundment seepage is considered in Section 4 of this report. For constituents that behave conservatively in Blackbird Creek, the beneficial effect of this alternative on downstream water quality is easily evaluated. Any constituent load removed due to capture and treatment of seepage would result in an equivalent load loss in the creek. The effect of collection and treatment of West Fork Tailings seepage

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4 Water quality and flow data from WFSW-01 were not used to characterize West Fork Tailings Impoundment seepage flow or quality. The historical data record for this site suggests that sampling on occasion may have been conducted at the West Fork bypass as opposed to the West Fork underdrain.

5 The 2009 monitoring data were not considered in the current evaluation as the initial study pre-dated these data.

on copper concentrations in Blackbird Creek, however, is not as straightforward. Iron loading from the West Fork Tailings Impoundment currently contributes to a net decline in dissolved copper concentrations in lower Blackbird Creek by acting as an adsorbent. Therefore, collection of tailings seepage, which would reduce iron loading to the creek, could conceivably result in an increase in Blackbird Creek copper concentrations. In the lower reaches of Blackbird Creek, some attenuation of cobalt and manganese also occurs due to sorption onto iron oxyhydroxide.

The Feasibility Study evaluated the effect of a reduction in iron loading (due to placement of a cover on the West Fork Tailings Impoundment) on Blackbird Creek water quality, specifically copper concentrations (Golder 2002a). Geochemical modeling was conducted to simulate the mixing of groundwater and surface water and resultant chemical reactions (i.e., precipitation of ferrihydrite and adsorption of metals). For this study, a similar modeling effort was conducted to evaluate the effects of collection and treatment of tailings impoundment seepage on Blackbird Creek water quality.

As in the Feasibility Study, geochemical modeling was performed using PHREEQC (Parkhurst and Appelo 1999). PHREEQC is an equilibrium speciation and mass-transfer code developed by the United States Geological Survey (USGS). This model has the ability to simulate the pertinent processes occurring in Blackbird Creek, including precipitation/dissolution of selected solids, redox reactions, and adsorption/desorption of metals. The Minteq.V4 thermodynamic database was used.

3.1.9.1.1 Model Approach

Geochemical modeling was conducted to simulate the mixing of groundwater and surface water at the West Fork Tailings Impoundment. Blackbird Creek water quality upstream of the West Fork Tailings Impoundment was mixed with West Fork Tailings Impoundment seepage and the clean water diversion discharge. The following stations were used to define input water qualities:

- Upstream Blackbird Creek – BBSW-03/03A
- West Fork Impoundment Surface Seepage - West Fork Interceptor Ditch (WFINTDITCH) and the West Fork Tailings Impoundment underdrain (WFTTSW-01)
- Groundwater discharge - WFMW-01S
- Clean Water Diversion discharge - (WFSW-03, WFSW-02.5 and WFSW-02)

For each inflow, a representative water quality was assigned (Table 3-6). Recent water quality data[6] were used to calculate average constituent concentrations. For surface water inflows that exhibit seasonal variability in water quality (i.e., Blackbird Creek and the clean water diversion), both a spring and fall water quality were defined. Measured water qualities for the West Fork Interceptor Ditch and the West Fork Tailings Impoundment underdrain were assumed representative of the quality of seepage at

[6] The 2009 monitoring data were not considered in the modeling evaluation as the initial study pre-dated these data.

the point of discharge to the surface and upon entry into Blackbird Creek. In reality, the quality of this water changes as it flows along ditches at the base of the West Fork Tailings Impoundment, as evident by the occurrence of floc within the ditches (Figure 3-18). Redox values for input water chemistries were assumed to be 500 mV for all but the subsurface groundwater inflow for which a redox value of 200 mV was assumed.

Mixing proportions were calculated based on the relative flow of each input. Assumed base case flows and the basis for their derivation are shown in Table 3-7. Both fall and spring flow conditions were simulated. To evaluate the effects of a reduction in West Fork Tailings Impoundment surface seepage on Blackbird Creek water quality, simulations were conducted in which inflows from the West Fork Interceptor Ditch and the West Fork Tailings Impoundment underdrain were both reduced by (1) 50 percent and (2) 90 percent.

Following mixing, geochemical controls on resultant water quality were evaluated. Precipitation of ferrihydrite and adsorption onto this phase was simulated. The number of available ferrihydrite adsorption sites was calculated assuming 0.005 strong bonding sites and 0.2 weak bonding sites per mole of ferrihydrite precipitated. A specific surface area of 600 m^2/g was assumed. These three values are default values developed by Dzombak and Morel (1990) and incorporated in PHREEQC as part of the standard thermodynamic database. Solution chemistries were assumed to be at equilibrium with atmospheric carbon dioxide (i.e., P_{CO2} of $10^{-3.5}$ atm).

3.1.9.1.2 Model Results

Model results for spring conditions are presented in Table 3-8 and Figure 3-19. In the spring, dissolved copper concentrations decrease by approximately a factor of two between BBSW-03/03A and BBSW-02. This reduction in concentration is primarily attributed to dilution by inflow from the clean water diversion. The model predicts that some additional reduction in dissolved copper concentrations is possible due to adsorption onto ferrihydrite. The magnitude of copper adsorption predicted by the model is a function of a number of factors including pH, number of adsorption sites and the concentration of other competing adsorption species (e.g. arsenic). The model predicts lower dissolved copper concentrations than have been observed in lower Blackbird Creek during recent spring synoptic sampling events. Because the objective of geochemical modeling is to evaluate changes following collection of West Fork Tailings Impoundment surface seepage, some different in predicted versus measured concentrations is acceptable.

In the spring, for the conservative mixing simulation, collection and treatment of West Fork Tailings Impoundment seepage is predicted to have little effect on dissolved copper concentrations downgradient of the tailings impoundment. This result is due to the fact that dissolved copper concentrations in West Fork Tailings Impoundment seepage are similar to the dissolved copper concentrations in Blackbird Creek upgradient of the West Fork Tailings Impoundment. Dilution from the clean water diversion remains the primary mechanism affecting dissolved copper concentrations. When secondary reactions are considered, the model predicts a slight improvement in dissolved copper concentrations due to collection and treatment of West Fork Tailings Impoundment seepage.

Model results for fall conditions are presented in Table 3-9 and Figure 3-20. In the fall, West Fork Impoundment Seepage accounts for a larger proportion of the total flow in Blackbird Creek than in the spring; however, dilution by the clean water diversion is still the most significant factor contributing to a decline in dissolved copper between BBSW-03/03A and BBSW-02. As in the spring simulations, adsorption onto ferrihydrite is predicted to result in some additional reduction in dissolved copper concentrations. The predicted dissolved iron concentration at BBSW-02 (approximately 0.015 mg/L) is consistent with recent measured synoptic sampling concentrations (i.e., 0.014 to 0.019 mg/L). The synoptic data indicates further reductions in dissolved copper and iron concentrations downstream of BBSW-02 to a few ppb, indicating that attenuation due to adsorption continues downstream. The solid phase floc data are consistent with this observation. In the fall, collection of West Fork Tailings Impoundment seepage is also predicted to result in a slight decrease in dissolved copper concentrations in lower Blackbird Creek.

Collection of West Fork Tailings Impoundment seepage is also predicted to result in a decline in cobalt concentrations in lower Blackbird Creek in both the spring and fall. Because dissolved cobalt concentrations are more than an order of magnitude higher in West Fork Tailings Impoundment seepage than in Blackbird Creek upstream of the impoundment, collection of West Fork seepage results in greater reductions in cobalt concentrations downstream of the impoundment than copper concentrations.

Sensitivity analysis simulations identified that the assumed redox values for input solutions have an effect on model results with respect to both the amount of ferrihydrite precipitation and the affinity of copper for ferrihydrite. Table 3-10 and Figure 3-21 present the results of a redox sensitivity analysis using the average fall input water qualities and flows. The effect of an increase in the initial redox value of 100 mV for all solutions is shown (i.e., input water chemistries were assigned initial redox values of 600 mV and 300 mV for surface and groundwater inflows, respectively). An increase in the initial redox value results in an increase in the amount of ferrihydrite precipitation (shown as a decline in the concentration of dissolved iron). The reduction in dissolved copper is attributed to both an increase in the number of sorption sites and the form in which copper occurs in solution. For the original simulation, copper in solution occurs primarily as Cu^{+}. A slight increase in redox conditions results in an increase in the amount of Cu^{2+}, which is more readily sorbed on ferrihydrite.

As shown in Figure 3-21, the redox sensitivity simulation results indicate a different conclusion with respect to the effect of collection and treatment of West Fork Tailings Impoundment seepage on Blackbird Creek dissolved copper concentrations. For the simulations which include geochemical controls, an increase in dissolved copper concentrations is observed following collection of seepage as follows:

0.004 mg/L (current conditions); 0.006 mg/L (50 percent capture and treatment); and 0.009 mg/L (90 percent capture and treatment). These simulations predict an adverse effect on dissolved copper concentrations following collection and treatment of seepage.

In summary, collection and treatment of West Fork Tailings Impoundment seepage is not predicted to have a significant impact on lower Blackbird Creek dissolved copper concentrations; however, there is the potential for small increases in dissolved copper concentrations following a reduction in iron loading. Model simulations are very sensitive to the assumed redox condition and therefore the results are inconclusive. In the spring, the observed reductions in copper concentrations are attributed largely to dilution from the clean water diversion. The fall synoptic data indicate that the reductions in dissolved copper concentrations due to adsorption are more significant, particularly in the lower reaches of Blackbird Creek. An adverse effect on dissolved copper concentrations due to removal of iron loading is therefore more likely to occur in the fall, if at all.

Collection and treatment of West Fork Tailings Impoundment seepage is predicted to result in a reduction in cobalt concentrations downgradient of the impoundment. It is expected that collection would result in greater declines in Blackbird Creek cobalt concentrations downstream of the impoundment in the fall than in the spring.

3.2 Summary – Conceptual Model of Arsenic and Cobalt Fate and Transport

Within Blackbird Creek, solid phase arsenic is present as both primary and secondary mineral phases. Arsenic and cobalt are present as cobaltite [CoAsS], a primary mineral phase whose presence is indicative of a tailings source. Arsenic exists in other site minerals but cobaltite is the dominant primary mineral source. Arsenic also occurs in association with iron oxyhydroxides (Camp Dresser and McKee, 1995).

Erythrite has been observed by Idaho Department of Environmental Quality (IDEQ) along the Blackbird Creek drainage. Erythrite [$Co_3(AsO_4)_2 \cdot 8(H_2O)$] is a secondary mineral phase that may be formed in association with oxidation of cobaltite. It may occur in areas affected by mining, but also occurs naturally in mineralized areas. Due to its high solubility, erythrite would not be stable within Blackbird Creek and if present in dry areas (i.e., in overbank materials or mineralized outcrops), it would likely dissolve during *runoff events*. Because erythrite is not considered to be a significant control on arsenic and cobalt concentrations within the inundated Blackbird Creek sediments, it was not considered as a source of arsenic or cobalt in the current evaluation.

In the present report, arsenic that is present predominantly as a primary mineral phase is defined as a sediment source and arsenic present in association with iron oxyhydroxides is defined as a floc source. The same is true for cobalt.

3.2.1 Arsenic and Cobalt in Sediment

Within Blackbird Creek, 2008 sediment arsenic concentrations range from 246 mg/kg to 2,290 mg/kg and cobalt concentrations range from 81 to 356 mg/kg (Golder 2009a). Annual sediment sampling is currently conducted during low flow conditions at four locations on Blackbird Creek: BBSW-01, BBSW-03, BBSW-07 and BBSW-08. Due to a BMSG oversight, sediment sampling was not conducted in 2008 at BBSW-08. Because sediment arsenic and cobalt concentrations at this station have historically been lower than the other downstream stations, the lower range values presented above are likely biased high. Between 1995 and 2007, sediment sampling from three events indicated the following range of concentrations at BBSW-08: 30 to 73 mg/kg arsenic; and, 18 to 72 mg/kg cobalt (Golder 2009a).

Elevated arsenic and cobalt concentrations in Blackbird Creek sediment are attributed to historical releases of tailings material to Blackbird Creek. This sediment, and associated arsenic and cobalt, is transported downstream by natural hydrologic processes. Cobaltite is an insoluble mineral, but exposure to atmospheric oxygen results in its oxidation and release of acidity, cobalt, arsenic and sulfate. If oxidation of cobaltite can be prevented, release of arsenic and cobalt are inhibited as well.

Bed load (coarse-grained sediments) and suspended load (fine-grained sediments) are mixed together and present along all of Blackbird Creek. The bedload sediments are assumed to be generally low in arsenic and cobalt content. Arsenic and cobalt are associated with the fine-grained sediments which include tailings from historic mining operations. Because most sediments are not completely segregated by size, arsenic and cobalt are present in some portion of most of the sediments along Blackbird Creek.

Most of the existing sources of bed load and suspended load moving along Blackbird Creek come from the Blackbird Creek channel bed, banks and overbank areas, as part of normal geomorphic processes. These sediments are eroded from, and deposited and transported along the length of the channel. Steep narrow reaches have sediment transported through them. Flatter and wider reaches are zones of deposition and are subject to erosion during high flow events. The transport reaches have accumulations of bed load sediments and little or no accumulation of suspended sediments. The depositional reaches have accumulations of bed load and suspended load sediments, mixed together.

The sediments in the depositional areas are re-mobilized during floods through erosion and scour of the bed, banks, and floodplain deposits. This occurs at the surface and at depth. Some portion of the sediments that are eroded and scoured move downstream. The coarse sediments move short distances downstream, while the finer grained sediments move farther downstream and potentially out of the Blackbird Creek drainage in a single event.

As part of natural geomorphic processes, sources of new bed load and suspended load to the main stem of Blackbird Creek originate in the many small uncontrolled contributing sub-basins of Blackbird Creek. These sediments are generally free from high arsenic and cobalt concentrations. The possible source areas for sediments (other than those in and along Blackbird Creek downstream of the WTP) with potential high arsenic and cobalt are controlled and do not normally contribute sediments. These areas include the West Fork, which is controlled by the tailings impoundment, Meadow Creek which is controlled by the 7100 Dam and the waste rock covers, and Blackbird Creek which is controlled by the Clear Water reservoir, concrete channel and waste rock covers. In the future the clean sediments from the small uncontrolled sub-basins will migrate down the Blackbird Creek valley, mantling and mixing with the existing sediments located there today.

3.2.2 Arsenic and Cobalt in Floc

Diffusion of oxygen into the West Fork Tailings Impoundment results in weathering of cobaltite and release of arsenic and cobalt. Downgradient of the West Fork Tailings Impoundment, dissolved arsenic concentrations in groundwater range from approximately 0.01 to 0.13 mg/L (Figure 3-15). Because tailings impoundment seepage also contains iron, upon discharge to Blackbird Creek, dissolved arsenic is attenuated by adsorption/co-precipitation with iron oxyhydroxide as a floc material. This floc is transported downstream by natural hydrologic processes, forming a reddish coating on the streambed. Synoptic sampling data from 2005 to 2008 indicate that dissolved arsenic concentrations in Blackbird Creek downgradient of the West Fork Tailings Impoundment are low (less than 0.01 mg/L), indicating no significant re-release of arsenic from the floc material to the water column.

Downgraident of the West Fork Tailings Impoundment, dissolved cobalt concentrations in groundwater are currently on the order of a few mg/L. Since 2004, dissolved cobalt concentrations have generally remained below 5 mg/L. A general decreasing trend in dissolved cobalt has been observed over time. For example, in the mid 1990's, dissolved cobalt concentrations at WFMW-01S ranged from 12 to 16 mg/L (3 sampling events). Since 2004, dissolved cobalt concentrations at WFMW-01S have ranged from 4.3 to 6.6 mg/L (5 sampling events).

As indicated earlier, dissolved arsenic concentrations in groundwater downgradient of the West Fork Tailings Impoundment ranges from approximately 0.01 to 0.13 mg/L. As shown in Figure 3-15, an increasing trend in dissolved arsenic concentrations has been observed at the West Fork Interceptor Ditch (WFINTDITCH). The increasing concentration trend, which occurred coincident to rising water levels within the West Fork Tailings Impoundment, may be the result of flushing of sulfide oxidation products. The observed increase in arsenic, without a coincident increase in other constituents associated with sulfide oxidation (e.g., Cu, Co, Fe and SO_4) may be attributed to greater mobility of arsenic under the geochemical conditions within the West Fork Tailings Impoundment. Although the increasing arsenic concentration trend may indicate a potential for an increase in future arsenic floc concentrations, an alternative explanation for the increasing trend follows.

At the WFINTDITCH, most constituents indicate an overall improvement in water quality over time. At this monitoring location, pH demonstrates an increasing trend and sulfate, iron, cobalt and copper demonstrate decreasing trends. It is possible that the observed increasing arsenic concentration trend at the WFINTDITCH is attributed to a change in the rate of attenuation of arsenic, rather than an increase in arsenic loading from the source (i.e., the West Fork Tailings Impoundment). The observed increase in arsenic at the WFINTDITCH occurs in association with a slight decline in iron. It is possible that the amount of ferrihydrite available for adsorption has decreased over time, resulting in a reduction in the rate of arsenic attenuation. It is also possible that the observed increase in pH has resulted in an increase in the adsorption of copper and cobalt, which will compete with arsenic for adsorption sites. Adsorption of copper and cobalt increases as pH increases. It is important to note that because dissolved arsenic concentrations at BBSW-02 have not increased in recent years, there is no indication of an increase in arsenic loading to Blackbird Creek. Therefore, although a change in the rate of attenuation may have occurred, arsenic is still attenuated close to the source.

Dissolved arsenic concentrations in WFMW-01S show an increasing trend. Dissolved arsenic concentrations in WFTTSW-01, WFMW-01D, and WFMW-09 also demonstrate a general increasing trend; however, the rate of increase in these wells is lower than that observed at the WFINTDITCH. During the past five years, the other monitoring wells in the area were not routinely sampled.

Figure 3-15 contains a break in the groundwater quality monitoring record during the period the BMSG was not required to collect that data (Golder 2007e). Recent dissolved arsenic concentrations in WFMW-01S are higher than the concentrations measured in 1995. As noted previously, WFINTDITCH dissolved arsenic concentrations show an increasing trend. Because an increase in dissolved arsenic concentrations in West Fork Tailings Impoundment seepage may result in an increase in floc arsenic concentrations, continued monitoring of West Fork Tailing Impoundment seepage quality and water quality trends is recommended.

Although arsenic can move downstream into Panther Creek in the stream sediments and in the floc, the mass loading rates are very different. The estimates of sediment transfer rates described in Section 3.1.3.2 concluded that, on average, approximately 4,000 cubic yards per year of sediment is moved downstream. The average arsenic concentration in the bulk sediment ranges from approximately 300 mg/kg to over 4,500 mg/kg, with a mean of approximately 1,100 mg/kg (Golder 2008b). Using a density of 100 pounds per cubic foot (lb/cu ft) and the mean arsenic concentration together with the average annual sediment transfer rate results in an estimated transfer of approximately 4,350 kg per year of arsenic from Blackbird Creek into Panther Creek in the bed load and suspended sediments. The loading rate for arsenic in the floc can be estimated using similar methods. The estimated weight of floc produced from 200 gpm at 200 mg/L iron is 416 kg/day dry weight. Based on the 2008 samples collected close to the source, we conservatively assumed the arsenic concentration in that floc would be approximately 3,030 mg/kg of floc (an average concentration of the 2008 samples collected at WFIDSW-01 and WFTTSW-01). This results in an estimate transfer of approximately 460 kg/year of arsenic in the floc. While these values are estimated and approximate, they show that the sediments carry about 10 times more arsenic than the floc per year. Efforts to control arsenic should reflect this significant difference in level of contribution between the two sources.

For the most part, floc is not visible in Panther Creek on the channel bottom or in the overbank areas. During 2008, floc was observed just downstream of the confluence with Blackbird Creek, but was not visible further downstream. Floc is easily mobilized and is therefore carried downstream through Panther Creek system without concentrated areas of deposition.

Because floc has such low density, floc is constantly moving through the Blackbird Creek system even at low flow, although more floc does move in response to high flow events. Floc migration is most noticeable during the first phase of spring snowmelt, as the ice in the channel breaks up and scours the channel perimeter. Under normal conditions this floc moves into Panther Creek and further downstream without being deposited in any concentrated areas because of Panther Creek's much larger transport capacity, even under low flow conditions.

Panther Creek typically does not experience a peak snowmelt discharge condition coincident with Blackbird Creek because of the differences in basin size, ground cover, elevation and aspect. When the peak snowmelt flow occurs in Panther Creek, typically about two weeks after Blackbird Creek, the floc contribution from Blackbird Creek is well below its previous peak. While the potential for Blackbird Creek to contribute floc to the over bank deposits along Panther Creek is low, it is not zero. In 2008 the peak snowmelt flow of Blackbird Creek and Panther Creek were sufficiently coincident that there was deposition of floc in overbank areas along Panther Creek contributing to COCs above cleanup levels.

The results of the November 2009 sequential extraction study were consistent with the statements above regarding minimal deposition of floc within Panther Creek overbank deposits. Chemical characterization of Panther Creek overbank materials indicated that the floc accounts for only a small portion of the total arsenic concentration. For the three overbank samples collected along Panther Creek, the portion of total arsenic attributed to floc was estimated at 3.5 to 11 percent by weight. In these samples, the floc accounted for a larger portion of the total cobalt, ranging from 14 to 24 percent by weight. Based on the procedure and data interpretation guideline outlined in the sequential extraction SAP (Golder 2009h), if the floc contributed less than 10 percent of the metal fraction, the floc was likely insignificant, while floc contributing between 10 and 50 percent was possibly significant. Based on those evaluation guidelines, the arsenic in the floc was identified as likely insignificant while cobalt in the floc was identified as possibly significant. However, further evaluation noted that the arsenic concentrations (30 to 74 mg/kg) and cobalt concentrations (44 to 72 mg/kg) attributed to floc in the fine suspended fraction of the three overbank samples tested were all below the EPA's residential action levels of 100 mg/kg arsenic and 97 mg/kg cobalt, respectively. The low cobalt concentrations attributed to floc were due in part to the lower concentrations of total cobalt in the initial samples relative to arsenic. This is typically the case for overbank samples collected during 2009. Based on the results of the sequential extraction testing, EPA determined that further evaluation of treatment options for groundwater discharging from the West Fork Tailings Impoundment is not currently necessary (USEPA 2010).

Based on the results of three samples, the percentage of total arsenic and total cobalt in overbank materials, assumed to be present in association with iron oxy-hydroxide floc, increased with distance down Panther Creek. In a typical, complex riverine system, overbank deposits are often segregated by size due to variations in settling velocity, differences in flow conditions and the tendency of sediment to move in waves through a transport reach. These characteristics tend to move smaller and lighter particles, like floc, further through the system, while coarser sand and gravel particles are left behind. This tendency for particle segregation may explain the observed trends in floc metal concentrations within Panther Creek overbank samples. These trends are consistent with the description of floc transport presented in the preceding paragraphs.

3.2.3 Arsenic and Cobalt in Panther Creek Overbank Sediments

The sediments containing arsenic and cobalt that move down Blackbird Creek eventually reach Panther Creek where they mix with clean sediments from the upper Panther Creek basin and begin their migration downstream through the Panther Creek system. As discussed in Section 3.1.6, overbank samples from along Panther Creek were tested in late 2009 to determine the concentrations of arsenic and cobalt by grain size grouping. The testing shows a general tendency for declining concentrations in the overbank deposits from the mouth of Blackbird Creek downstream to the Bevan property. However the results are highly variable, which is likely due to the mixing with clean sediments and segregation. The percentages of the arsenic and cobalt in the samples that were associated with the fine fraction (minus #200 sieve, 0.075mm) appeared to be reasonably constant at 10 to 30 percent, although variability was observed here too.

4.0 CONTROL TECHNOLOGIES

This section identifies the applicable control and treatment technologies based on site-specific conditions. Control technologies will be different for sediment stabilization and floc control. The floc control technologies are discussed first, followed by the sediment control technologies.

4.1 Floc Control Actions

Floc treatment was considered in earlier versions of this document and the details of the evaluations are included in Appendix J. A study was conducted during the Fall 2009 to evaluate the abundance of floc containing arsenic and cobalt in overbank deposits along Panther Creek (Appendix F). This study indicated that the floc accounted for only a small proportion of the total arsenic concentration (i.e., less than approximately 10 percent) and up to approximately 25 percent of the total cobalt concentration present in the overbank deposits. As a result of these studies EPA determined that treatment of flocs is not required at this time. The floc treatment alternatives are summarized in this section for completeness. Flocs will be monitored and floc treatment may be considered in the future by EPA if the flocs are determined to be problematic.

4.1.1 No Action/Monitoring

The existing creek acts as a natural water treatment system. Where the seepage from the West Fork Tailings Impoundment mixes with the Blackbird Creek water, an iron oxyhydroxide floc forms and settles out of the water column along Blackbird Creek. With no further treatment action, the system would continue to naturally settle out the iron floc. This floc would continue to be transported downstream where it has historically been flushed through the Panther Creek system. There have been depositions of material that contain elevated levels of arsenic and cobalt; however, this is primarily from deposition of sediments containing elevated levels of arsenic and cobalt rather than floc depositions as indicated by the results of the Fall 2009 study noted in the previous section.

Monitoring of the overbank areas along Panther Creek would provide awareness of the existence of sediments containing COCs that could present a human health risk. The monitoring would provide a basis for determining the need for cleanup actions. Monitoring is part of the existing Baseline Remedy and is therefore included in the no action alternative. The monitoring would consist of:

- Continued monitoring of in-stream sediments on an annual basis
- Following a high stream flow events, if the EPA determines that unacceptable levels of depositions occur, the BMSG will prepare a sampling and analysis plan to evaluate the overbank deposits. If the EPA determines that unacceptable deposition has occurred, the BMSG will develop and work plan and carry out removal actions

4.1.2 On-Stream Reservoir

A dam and reservoir on Blackbird Creek could be configured to produce a pond area that would be partially effective in removing the floc by providing still water for settlement. As discussed in

Section 4.2.4.1, the effectiveness is a function of the reservoir or pond surface area, the inflow rate and the turbulence in the reservoir. Blackbird Mine Site AOC criteria suggests that the design criteria for this work should require 100 percent effectiveness during the peak flow of the 100-year *runoff event*. However, a pond much smaller than required by such criteria would be effective most of the time.

Alternatives which address sediment *capture* using an on-stream reservoir are discussed in detail in Section 4.2. These reservoirs would also be effective in removing floc.

4.1.3 Off Channel Settling Basins

If water is diverted out of the main channel and into off-channel ponds or basins, these temporary storage areas can be used for *capture* of suspended sediments. Because the land around the PCI and the area downstream are now available to the BMSG these areas can be used for construction of settling basins. A system for diversion of Blackbird Creek flows near the mouth and conveyance of those flows to a point of treatment within settling basins on the existing campground area is described in more detail in Section 4.2.5.1.

4.1.4 Water Treatment at the Existing Water Treatment Plant

The existing WTP could be used to treat West Fork seepage, thereby removing the iron and other metals and eliminating the potential for formation of floc. This approach would require the seepage to be pumped from West Fork upstream to the existing WTP, which is located approximately 15,000 feet upstream and 1,000 feet higher in elevation. Energy costs as well as operation and maintenance (O&M) costs would be significant. The continuous additional inflow of 200 gpm would influence the ability of the existing WTP to meet its current demand. Additional treatment capacity and/or additional storage capacity would be required to accommodate the additional influent. The existing plant would also be required to address sludge disposal sooner. Because of the many additional costs and uncertainties associated with a pump-back scheme, this alternative was not evaluated further.

4.1.5 Passive and Active Water Treatment Options at the West Fork

Prior to the completion of studies during the Fall 2009 which characterized the sources of arsenic and cobalt in overbank deposits in Panther Creek, floc was assumed to be a significant contributor of potential COCs in overbank sediments. Under this assumption, an evaluation of passive and active water treatment technologies for removal of floc was conducted. The evaluation included:

- an initial screening of potentially applicable technologies
- conceptual development of treatment processes, utilizing the most promising of the technologies and any additional pre- or post-treatment steps deemed necessary to optimize efficiency or handle secondary wastes
- evaluation of the effectiveness, implementability and cost of the conceptual treatment processes

The details of the water treatment evaluation are included in Appendix J.

4.1.5.1 Passive Water Treatment Options at the West Fork

Passive water treatment technologies generally utilize "natural" flow regimes (e.g. constructed wetlands or aerobic lagoons). Microbiological processes which generate metal-sulfide or metal-hydroxide precipitates provide the contaminant metal removal mechanism. Passive treatment systems are designed for minimal maintenance, relying on gravity flow and the naturally occurring balance of microbial population with nutrients required for sustained microbial activity. Passive systems may be augmented with addition systems for chemical reagents required for efficient conversion of dissolved metals to metal precipitates, addition of microbial nutrients, or pumped flow if necessary. The primary benefit of a passive treatment system is relatively low maintenance and operations requirements. Passive treatment systems may operate for periods of years essentially unattended, with the only maintenance activity being replacement of the biological substrate when it is exhausted. A detailed evaluation of passive water treatment alternatives developed to address floc control are presented in Appendix J.

4.1.5.2 Active Water Treatment Options at the West Fork

Active water treatment options were also evaluated. Applicable active water treatment technologies for removal of metal contaminants generally include pH adjustment and chemical reaction for removal of metals as hydroxide precipitates. In this way active treatment would "force" the formation of floc. Floc would be then removed from the treated effluent, eliminating floc as a potential source of downstream overbank deposits of cobalt and arsenic. The primary benefit of active water treatment alternatives is the flexibility to accommodate changes in influent flow rates or contaminant loads while producing an effluent of consistent quality. The detailed evaluation of active water treatment alternatives developed to address floc control are presented in Appendix J.

4.1.6 Active Water Treatment of All of Blackbird Creek

For completeness, USEPA requested that a screening evaluation of a water treatment plant for all of Blackbird Creek be included in this report. Such a plant would need to be coupled with a sediment control option so that the plant's function was primarily to remove floc from the entire flow of Blackbird Creek. Since the project design criteria is to comply with water quality/sedimentation requirements for conditions up to the 100-year event (588 cfs at the mouth of Blackbird Creek), it is assumed that the water treatment plant would be sized for this flow rate. In order to treat all of the Blackbird Creek water, the treatment plant would need to be near the mouth of Blackbird Creek on the PCI property. Based on comparable sized treatment systems, there is inadequate space on the 4 acre PCI property to construct a treatment system. Even if such a system could be constructed, the environmental impacts of such a large system in a remote location would be substantial and the cost would be orders of magnitude higher than other viable alternatives. The cost of a water treatment plant can be estimated from standard cost curves. The capital cost of potable treatment plants for surface water are approximately $1.5 million per million gallons per day (mgd)[7] and this plant would be similar. Therefore the capital cost of a water plant for Blackbird Creek with a treatment capacity of 380 mgd (588 cfs) would be approximately $570 million. The total project cost would also include annual O&M costs amounting to approximately $40 million. The total net present worth of a water treatment plant to treat all of Blackbird Creek (at a discount rate of 7 percent for 30 years) would approach $1 billion, and the effectiveness would not be substantially greater than other alternatives being considered. Because there is not sufficient space available near the mouth of Blackbird Creek for a treatment plant this large, and because of the extremely high costs compared to the marginally greater effectiveness, this option was not considered further.

4.1.7 Summary of Options for Controlling Floc

Based on the sequential extraction evaluation described in Section 3.2.2, the EPA has determined that further evaluation of treatment of groundwater discharging from the West Fork Tailings Impoundment is not currently required. Therefore, the representative option for treatment of West Fork groundwater to be carried forward in Section 5 of this evaluation is *no action* with continued monitoring to evaluate future potential downstream impacts. If future monitoring demonstrates that arsenic or cobalt from the oxyhydroxide flocs is a significant contributor to future recontamination of overbank areas along Panther Creek, treatment of West Fork Tailings Impoundment groundwater discharges may again be considered by EPA.

Although groundwater treatment is not carried forward into alternatives in Section 5, the alternatives developed do include technologies that address sediment control, which are also effective at controlling the relatively small proportion of arsenic and cobalt loading that are contributed by floc. All alternatives assume that continued monitoring of downstream overbank areas following *runoff event*s will be required periodically.

4.2 Sediment Control Actions

Several alternative methods for addressing migration of sediments from Blackbird Creek downstream into Panther Creek were identified and are described in the following sections.

4.2.1 No Action

Although the name for this alternative suggests no activity, the inaction only applies to the lack of an active program initiative to control sediments. Substantial intermittent cleanup would be required as it has in the past. This approach is consistent with EPA's decision in the 2003 ROD. Blackbird Creek in its current state continually mobilizes sediments from the stream and overbank areas and deposits them downstream. With no further action, the system would continue to move these sediments downstream. Over time, the annual volumes of sediments with elevated levels of arsenic and cobalt would become smaller, with lower concentrations. The deposits of arsenic contaminated sediments in and along

[7] http://www.northgeorgiawater.com/files/ww_t9-10_app-b.pdf

Blackbird Creek are documented through past testing and removal activities. Deposits with elevated arsenic and cobalt generally occur in depositional reaches along Blackbird Creek. Depositional reaches in upper Blackbird Creek are long, shallow, thin, bench deposits in limited floodplain areas along the relatively steep channel alignment. The potential arsenic and cobalt risks from most of these areas were addressed as part of past removal activities. Depositional reaches in lower Blackbird Creek are broader, deeper, flatter areas that can be readily identified; there are a few locations where most of the sediments have historically accumulated.

Although many surface deposits with arsenic contamination were identified and removed as part of past remediation work along the channel, sediments with arsenic and cobalt contamination may still exist at more substantial depths in depositional areas. These sediments may be exposed by erosion and scour during future floods, which would result in them being re-suspended and mobilized downstream, releasing the fine-grained sediments with potentially elevated arsenic and cobalt levels and allowing them to move farther downstream. In addition, bank erosion that occurred during the 2009 spring snowmelt exposed a number of deposits along the stream bank that may contain elevated arsenic concentrations. These materials were characterized for arsenic and cobalt concentrations during 2009 and were summarized in the pre-removal characterization report (Golder 2010b). As sediments containing arsenic and cobalt are mobilized in the future, these sediments might be re-deposited in downstream depositional areas, or they may be carried out of the basin and into Panther Creek.

4.2.2 Excavate Contaminated Sediments

The Blackbird Creek Valley contains both accumulated contaminated sediments in the stream bed, as well as additional soils containing arsenic and cobalt deposited by historical breaks in pipelines carrying tailings, or because the road bed in some areas may have been constructed with material containing arsenic and cobalt. Excavation and removal of these materials is one potential alternative to address continued release of sediments containing arsenic and cobalt.

This would require significant excavation of materials along the length of the valley, as well as require the replacement of clean materials. The extent of disturbance would be large and the environmental disruption would be extensive. Sediment removal was evaluated as a part of the Feasibility Study (Golder 2002a). Due to the difficulty and cost of removing all materials with potentially elevated levels of arsenic, the EPA did not select this alternative in the ROD. This technology will not be considered further; however removal activities may be employed to address specific areas.

4.2.3 In-Stream Stabilization of Sediments, With Selective Removal of Sediments

Channel and floodplain sediments with potentially elevated levels of arsenic and cobalt may be present at depth along the Blackbird Creek channel and in floodplain sediments below the ground surface. With the remedial actions completed on site, there is little continuing influx of contaminated sediments. Existing material could be mobilized through erosion of the bed or banks of the channel, or by scour and erosion of floodplain sediments. Stabilization of these sediments would significantly reduce the potential delivery of arsenic and cobalt contaminates to Blackbird Creek and downstream tributaries. These sediments could be stabilized by installing bank armoring, grade control structures, or bendway weirs at targeted locations along Blackbird Creek. Further explanation is provided below:

- **Bank Armoring** – Armoring of channel banks in targeted areas to minimize the delivery of sediment to the channel, or to protect the roadway, or to protect other targeted facilities. Bank armoring would consist of placement of riprap rock materials.
- **Grade Control Structures** – Sources of sediments with potentially elevated arsenic and cobalt levels are most likely located in depositional, wide, braided, flat-gradient reaches along Blackbird Creek. Steep, high energy, transport reaches have a lesser potential for accumulating sediments, as these reaches typically deliver sediments to the aforementioned reaches. Installation of low elevation (generally matches current floodplain ground levels), horizontal, grade control structures that stabilize the depositional areas where these sediments accumulate, would limit the delivery of these sediments to downstream reaches. Grade controls would be constructed using riprap rock materials, and would span the active channel and floodplain. The ends of the structures would be keyed into the valley wall, bedrock where it exists, into or through the roadway, or into some other suitably stable valley feature. The structures would be installed generally perpendicular to flood flows. The structures would be installed in series, starting at the downstream end of targeted depositional sediment areas and continuing upstream in small stair-stepped increases in vertical elevation through the targeted reach at a spacing dictated by further design and assessment. The net effect of the structures is to control the elevation by which head-cut erosion, scour, and bank erosion may mobilize sediments away from the site. Over time, the underlying potentially contaminated sediments would be stabilized, while clean sediments originating from natural colluvial and alluvial sources would move across the top of the stabilized sediments, potentially allowing vegetation to become re-established and further stabilizing the materials.
- **Bendway Weirs** – Bendway weir structures would look and act similar to the grade control structures, but may not extend all the way across the active channel and/or floodplain. For instance, in some reaches the active channel flows along one side of the valley leaving the floodplain between the channel and the roadway, or between the floodplain and existing bedrock exposures. In these situations, the bendway weirs would extend out to the channel, but not cross it. Any form of stabilization on one side of the channel may induce erosion on the other side of the channel and/or floodplain. The placement of bendway weir structures would be coordinated with potential erosion patterns on both banks of the channel and floodplain, grade control structures, bank armoring, or existing bedrock exposures to minimize the potential for detrimental erosion in downstream and/or opposite bank areas, and to stabilize targeted areas (i.e. areas where contaminated sediments may exist). The structures may be oriented and installed to direct floodplain flows as needed, to stabilize targeted side gravel bar areas, or to protect against erosion of the targeted sediment areas. Bendway weirs would also be constructed using riprap rock materials.
- **Selected Removal of Tailings** – Areas of concentrated tailings deposits with a potential to be mobilized by Blackbird Creek would be removed under this alternative. For example, the upper Blackbird Creek basin, above the West Fork confluence, includes reaches that are high gradient and abut steep talus slopes on the right bank. These right bank slopes contain residual tailings pipeline break materials at many locations. In-stream stabilization is not feasible in these reaches. Recent erosion in 2009 has exposed zones of tailings that were spilled onto these talus slopes and were not removed

during previous removal efforts. To prevent these tailings deposits from becoming continuing sources of COCs, they would be removed as part of implementation of In-Stream Stabilization. There also appear to be freshly exposed lenses of previously deposited tailings in cut-banks at several locations upstream and downstream of the West Fork Tailings Impoundment. These materials would be either be removed or stabilized in place.

The conceptual layout and configuration of in-stream stabilization structures is discussed in more detail in the Section 5.0.

4.2.4 In-Stream Settling Ponds/Dams

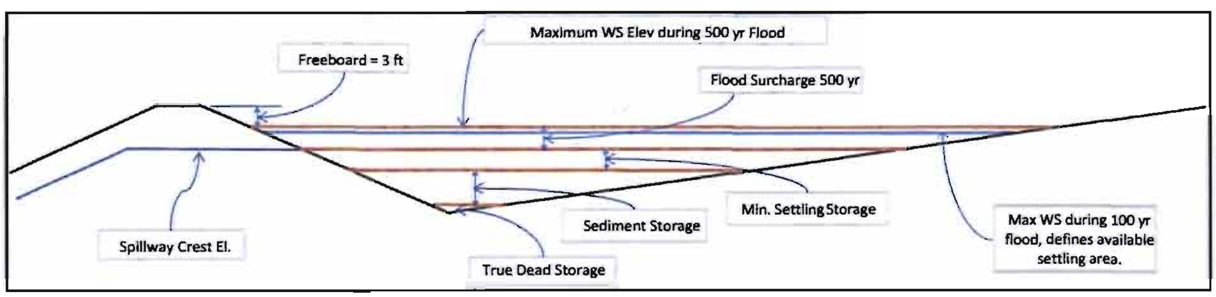
In-stream settling ponds/dams were considered as a technology to allow settling and removal of sediments and floc. Two configurations were considered: a single dam or a series of three smaller dams. Each of these would have similar design criteria. To develop the conceptual designs for the in-stream dams and reservoirs or ponds, criteria were established that are similar to other Blackbird Mine Site criteria using for evaluating early actions. Any dam on Blackbird Creek should be subject to certain performance and safety criteria. The hydrologic criteria for the site are generally the 100-year floods for cleanup criteria, and 500-year floods for dam safety. These criteria were applied to the in-stream settling ponds/dams.

4.2.4.1 Dam and Reservoir Sizing

A typical profile along the creek is presented in the figure below, showing the various components of the reservoir in an idealized view.

FIGURE 4-1

TYPICAL IN-STREAM DAM PROFILE



The various dam and reservoir components are:

Dead Storage: This is the existing volume upstream of the dam toe that is not periodically cleaned.

Sediment Storage: This is the volume provided for storage of sediment, including floc, which is periodically removed and hauled to a permanent disposal location. This volume would fill and then be removed at a frequency to be determined. The volume is determined by the average annual sediment volume, the peak expected annual sediment volume, the floc volume and the average frequency of removal being assumed.

The coarse sediment volume flux (non-floc component consisting of suspended load and bed load) can be estimated by reviewing the frequency of removal of sediment from the Lower Blackbird Creek ponds. The sediment produced by the design storm (100-year storm) must also be calculated. The allocated sediment volume should be the larger of either 1) average annual volume times the cleanout recurrence or 2) the peak single event sediment volume from the design storm.

An estimate of the average annual sediment volume was made using historical data. Previously, three in-stream sediment storage ponds were sized in the Phase IV-A design (Golder 1998a). The total volume of the sediment storage ponds was 1.0 acre-foot. It is our understanding that the ponds have been cleaned out every five years and have been approximately half full at clean out. The bedload sediment collecting in the ponds is generally on the order of 10 percent of the total volume of the total load of sediment traveling downstream (Reid and Dunne 1996). To be conservative, it has been assumed that the volume generated will be on the order of 1 acre foot/5 years, and that the volume is 10 percent of the total sediment volume. Therefore, the average total sediment flux is estimated to be 2 acre-feet/year or approximately 4,000 cubic yards (1 acre-foot/5 years/10 percent).

The estimates of the volume of total sediment load transported past a single point by the 100-year storm, described in Section 3.0, are variable. Of the many estimates, the HEC-RAS model is the most refined and provides a range of 7,700 cubic yards to 14,000 cubic yards, which is consistent with the SEDDISCH estimates. For sizing of required sediment retention features, a value of 11,000 cubic yards was used; this value was used for comparison of alternatives and should be reviewed prior to final design.

The floc volume must be added to the coarser grained sediment volume described above. The annual floc volume was estimated by computing the estimated annual floc production from the West Fork Tailings Impoundment expressed as tons/year together with a modest density. Seepage of 200 gpm with 200 mg/l iron would produce on the order of 64 cubic yards per year of floc (see the calculation in Appendix H-5). This volume is insignificant in comparison to the volumes required for retention of the bed load and suspended load (combined as the total sediment load).

Reservoir Effectiveness for *Capture* of Floc and Suspended Sediment: The Churchill methodology was used to assess the effectiveness of the reservoirs in removing incoming sediment. The reservoir length, reservoir volume and the rate of inflow surface area were used to develop a *Sedimentation Index* that is related the efficiency of each reservoir for removing sediment. The reservoir effectiveness is a key parameter used in the sensitivity evaluation of the alternatives. The Churchill method for estimating effectiveness was evaluated with respect to its uncertainty. The range of variability for this parameter was derived from the uncertainty in the field measurements of effectiveness when it was plotted against the *sedimentation index*.

Flood Surcharge: A dam and spillway must be able to accommodate the design inflow flood. For a dam safety issue, a 500-year event was selected as the design event to be consistent with other project features. The water depth from this event is necessary to drive the peak design flood flow through the selected spillway. Spillway requirements are described in the following sub-section.

Freeboard: As is common practice for dam safety, freeboard is provided between the maximum expected water surface elevation during the design flood (the 500-year event in this case) and the top of the dam. A freeboard of 3 feet was used to develop the design alternatives.

4.2.4.2 Spillways for In-Stream Settling Ponds and Dams

Because the in-stream ponds present a risk of overtopping and breach a spillway must be included, or the embankment must be hardened to prevent breaching during overtopping. For the purposes of this comparison, spillways were used in all cases. The design criteria for the spillways were selected to be the 500-year event, which is consistent with the design of other features on the Blackbird Mine Site.

For simplicity, a reinforced concrete ogee crest spillway was assumed for all dams. This spillway control structure would be constructed over the dam crest, delivering water to a similarly sized concrete chute that would convey flood flows to a U.S. Bureau of Reclamation (USBR) Type III stilling basin located near the toe of the dam. Nominal dimensions were selected for the concrete spillway components that were scaled to the necessary dimensions for the dam and spillway design flow.

4.2.5 PCI Off-Channel Settling Basins

Off-channel settling basins near the PCI were considered as a technology for *capture* of sediments and their associated potential COCs. A conceptual design was developed for a system to divert Blackbird Creek near its mouth and convey the flows in a pipeline to settling basins located on the old PCI campground where potentially contaminated sediments would be captured and retained for disposal.

4.2.5.1 Conceptual Design of the Diversion System and Settling Basins

4.2.5.1.1 Objectives and Criteria

The objective of this technology is to reduce the occurrence of overbank deposits of potentially contaminated materials along Panther Creek downstream of Blackbird Creek. During modestly high snowmelt events in both 2008 and 2009, deposition occurred along Panther Creek and required cleanup. If very large events occur in the next several years, before stream stabilization is fully effective, the settling basins would be in place to capture a large portion of the fine-grained sediments during high flow events in Blackbird Creek and reduce the likelihood of migration of potentially contaminated sediments downstream.

The availability of the PCI campground area presents an opportunity to capture suspended sediment that might otherwise be deposited downstream along Panther Creek. The current area that can be used for settlement is limited to the existing campground areas, although a review of modifying the alignment of Panther Creek to widen the land available for settling will be completed during the design process. The objective of the PCI Settling Basins is to capture suspended sediments from snowmelt events similar to those that occurred in 2008 and 2009, using all the available land. For this reason, there is no specific recurrence interval for the design inflow to the ponds, but rather the design uses all the available area and evaluates the effectiveness of the system to capture suspended sediments during a snowmelt event similar to those that occurred in 2008 and 2009.

The sizing of the system hydraulics was done to accommodate the estimated peak flow occurring at the mouth of Blackbird Creek in 2009. Because the BBSW-01 was damaged at the time of the flow, the magnitude of the peak discharge was estimated based on the judgment of site personnel familiar with operation of the site stream gages. They estimated a peak flow of 200 cfs occurred in 2009 and this was used for sizing of the features. Because the diversion dam is a dam with some downstream risk the dam includes a spillway that is adequate to accommodate the 500-year event (1,511 cfs), in accordance with the requirements of the criteria letter (USEPA 1994).

4.2.5.1.2 System Features

The proposed features of this technology include a diversion dam, a conveyance system for suspended sediment laden flows, and the settling basins. Each of these features has several appurtenances. An overview of the system is shown in Figure 4-2.

Diversion Dam

The diversion dam is an earthen embankment approximately 15 feet high, with a 15 crest width, see Figures 4-3 through 4-5. The left abutment of the dam is also part of the mine access road. Closer to the channel is an overflow spillway structure that leads to the conveyance system for diverted flow. The diversion system is capable of handling 200 cfs with the reservoir water surface elevation 1 foot above the crest of the inlet control crest. The inlet to the diversion system would be controlled by a sluice gate. The dam also includes a low flow outlet for passing flows that are not laden with suspended sediment, and occasionally for flushing bedload that accumulates in the reservoir. This low level outlet includes a 5 foot by 5 foot sluice gate that can be closed to force water to fill the reservoir and flow out through other avenues, primarily the diversion system. The entire right side of the dam is an overflow spillway capable of passing the peak flow from a 500-year thunderstorm event. The central and downstream portions of the embankment in this area would be protected by grouted riprap and/or gabions.

Conveyance System

After diversion from Blackbird Creek water would be conveyed under the Panther Creek Road, past the PCI and into the settling basins, see Figure 4-2. For the purposes of this alternatives analysis we assumed that the conveyance consists of a 48-inch diameter HDPE pipe set at a grade of approximately 1 percent. This would convey the necessary 200 cfs. The crown of the pipe will pass under the Panther Creek Road with 2 feet of cover and the invert of the pipe can be maintained above the maximum water surface elevation of the ponds. The alignment generally follows the south edge of the Panther Creek Road with the pipe itself buried in a berm adjacent to the road.

Water would be distributed to the settling ponds by tapping the bottom of the 48-inch diameter pipe at frequent intervals. Flow control will be included such that basin influent flow is proportional to the available settling area.

During final design alternative conveyance system designs will be evaluated. At a minimum the evaluation will include a delivery pipe, as described herein, and an open channel. These design approaches will be evaluated on the basis of implementability, effectiveness and cost, but the primary differentiators are expected to be hydraulic performance and ease of maintenance.

Collector pipes or others similar features will be included in the berms on the south side of the settling basins. These 24-inch pipes will have holes in the tops to provide a uniform withdrawal of water.

Settling Basins

The settling basins would be defined by earthen berms constructed along the alignments shown in Figure 4-2. The southern faces of these berms would include riprap to protect against erosion from Panther Creek during high flows.

During final design the alignment of these berms or dikes will be optimized by examining alternative alignments, including those that increase the size of the ponds but may impinge on the necessary flow area of Panther Creek. The selected alignment will seek to provide the largest possible basin area and effectiveness while avoiding significant impingement of Panther Creek.

4.2.5.1.3 System Operation

The diversion system and settling basins would be set to divert and treat all of Blackbird Creek flows essentially continuously. Although most suspended sediment would be collected and stored during spring snowmelt annually, the system would be operated during other months, making it more likely to capture sediments in the event of sudden thunderstorms. Diversion would cease for maintenance purposes as required. *The diversion of Blackbird Creek flows into the settling basins would* divert nearly all water from approximately 570 *feet of the current channel of Blackbird Creek between the diversion* *structure and the confluence with Panther Creek. Some seepage through or below the structure would likely occur and resurface below the diversion structure. The discharge of Blackbird Creek flows into Panther Creek would be moved approximately 700 feet or 1,500 feet downstream, depending on how the settling basins are operated. This would affect the mixing zone(s) in Panther Creek downstream from the discharges.*

4.2.5.2 Assessment of the Effectiveness of the Settling Basins

The effectiveness of the PCI Settling Basins for *capture* of COCs in suspended sediments and floc was evaluated using four methods

1. Shear Stress: the grain size of particles experiencing incipient motion due to shear stress on the bottom of the pond was compared to the expected grain size distribution of incoming sediments and their COC contents.
2. Standard Tank Settling: The minimum particle size that can be captured in the basin, computed by using Stokes Law was compared to expected grain size distribution of incoming sediments and their COC contents.
3. Settling Velocity from Floc Tests: This method uses the estimated settling velocity of 3 inches per minute derived from testing of sampled floc.
4. Settlement Time Testing: Laboratory testing was done on field samples of sediment and floc to determine the time necessary for complete settlement. These times were used to evaluate the effectiveness of the ponds.

The calculations supporting these estimating methods are presented in Appendix H3.

These methods produce somewhat different results but all of them suggest that the settling ponds as conceived will retain most of the COCs contained in their influent at flow rates as high as 200 cfs. Flows in Blackbird Creek rarely exceed 200 cfs. The shear stress methods indicates that, if a particle reaches the floor of the settling basins, only particles much smaller than a #325 sieve (0.044 mm) can be remobilized by the peak flow rates anticipated. The suspended sediment testing presented in Appendix H1 indicates that only a small fraction of the COCs are associated with the sediments smaller than a #325 sieve. Using the standard tank settling velocity method indicates that particles in the influent with a diameter much smaller than a #325 opening will be retained by the basins. Estimates based on a settling velocity of 1.3 inches per minute indicate that sediments much smaller than a #325 sieve will be retained in the basins. The fourth and last method uses time as a basis for estimating *capture* and this calculation suggests that everything larger than a #150 sieve (0.104 mm) will be removed. The results using the fourth method deviate from the others and the testing method was simplistic so the results from the first three methods were considered to be more representative of expected field conditions.

The *capture* effectiveness depends on 1) the proportion of the total load that can be diverted into the settling basins, 2) the minimum size material that can be removed from the influent and 3) the proportion of the total load that is attached to the retained portion of the suspended sediment. If the diversion were operated as described in Section 4.2.5.1.3, all flows up to 200 cfs would be diverted into the settling basins. The proportion of the total flow volume that occurs as flows larger than 200 cfs is very small, estimated to be substantially less than 1 percent[8]. The particle size retained by the settling basins would be expected to be between the #325 sieve and the #150 sieve, with the best estimate being closer to the #325 sieve. The larger particle size estimates are from tests that do not consider actual pond configurations and/or are based on tests that were poorly controlled. The percent of the total load that would be retained as a function of particle size depends on the sample location. Using overbank samples from near the PCI, approximately 98 percent of the total COC load is associated with sediments larger than the #325 sieve. Considering overbank sediments near Napias and Bevan, approximately 90 percent of the total COC load is associated with sediments larger than the #325 sieve. This means that the percent reduction of COCs in the PCI Settling Basins would be between 90 percent and 98 percent at the design flow of 200 cfs. During periods when Blackbird Creek flows were less than the design flow of 200 cfs, these COC *capture* efficiencies would be higher.

4.2.6 Evaluation of Alternative Actions to Control Sediment

Sediment control actions comprise the major elements of the alternatives that are defined, evaluated and compared in this report. Therefore, assessments of the technologies are evaluated in the following Sections 5 and 6, as fully developed alternatives.

[8] The estimate that flows exceed 200 cfs less than 1 percent of the time is based on a calculation of the probable volume of flow occurring at rates greater than 200 cfs compared to the average annual flow volume of Blackbird Creek at the mouth. The calculation evaluates thunderstorm hydrographs that exceed 200 cfs and determines the probability-weighted increments of volume above 200 cfs. The calculation results in an estimate of 0.06 percent. The calculation assumes that the peak flows from snowmelt hydrographs (long duration) rarely exceed 200 cfs and would not significantly change the results.

5.0 DEFINITION OF ALTERNATIVES

Alternative facility configurations were defined using the components described in the preceding sections. These alternatives were assembled in order to address the project objectives of control of contaminated sediments to reduce potential human health risk and of maintaining road access to the site. The alternatives were developed using a range of approaches from a small and widely distributed solution to a single, relatively large solution.

5.1 General Approach to Development of Alternatives

The alternatives to be evaluated include:

- **Alternative A - Baseline Alternative:** This alternative is the ROD remedy including continued intermittent cleanup. This alternative includes no initial capital improvement action, but O&M activities are required to address the continued natural deposition of sediments in downstream overbank areas.
- **Alternative B – In-Stream Stabilization/Removal**: This alternative stabilizes contaminated sediments in-place using various stabilization features, as well as removal of readily erodible material in some locations.
- **Alternative C – In-Stream Stabilization/Removal and PCI Settling Basins**: As an intermediate solution, this alternative stabilizes sediments in place but also includes settling basins near the PCI that will serve to remove sediments and floc from Blackbird Creek flows during normal annual snowmelt events.
- **Alternative D – A Single Large In-Stream Dam and Reservoir:** This alternative uses a single dam and reservoir to provide control of sediment and floc, to the extent possible.
- **Alternative E – A Single Dam with In-Stream Stabilization/*Removal***: This alternative uses both a single moderately sized in-stream dam and reservoir as well as in-stream stabilization to provide control of sediment, as well as removal of readily erodible material in some locations.

These alternatives do not include treatment, either passive treatment or active systems, because the sequential extraction testing completed in 2009 indicated that the floc in Blackbird Creek was transporting only a small percentage of the total load of COCs in the creek. Based on the results of the sequential extraction analysis, EPA determined that treatment of groundwater discharges from the West Fork Tailings Impoundment to reduce floc concentrations in Blackbird Creek is not currently *necessary*. Therefore, none of the treatment technologies discussed in Section 4.1 were included in any of the alternatives presented below. However, if future monitoring were to indicate that the flocs are a significant contributor to recontamination of overbank areas along Panther Creek, *EPA would re-evaluate the need for* treatment *of the groundwater discharges from the West Fork Tailings Impoundment.*

Post construction cleanups along Panther Creek may be required for some alternatives. The probabilities of needing Panther Creek cleanups varies with the alternative and therefore different assumptions were made about monitoring and cleanup frequency. For costing purposes, it is assumed that a monitoring program is required after a cleanup. Alternative A is assumed to require a major cleanup every 2 years. Alternative B is assumed to require two modest cleanups, one in year 2 and the second in year 4.

Alternative C and E are assumed to require only one minor cleanup in year 2. Alternative D is assumed to not require any Panther Creek cleanups.

5.2 Alternative A –Baseline Alternative

This alternative is included as a baseline for comparison with the other alternatives. Alternative A is the remedy defined in the ROD (EPA 2003) for the Blackbird Mine.

In accordance with the ROD (Section 12.2.5) removal of overbank deposits along Blackbird Creek that exceed the human health cleanup levels and could be re-mobilized during high flow events with downstream deposition at in-stream or overbank areas is required. Section 12.2.6 of the ROD addresses requirements for removal of in-stream sediments and overbank deposits in the vicinity of the Panther Creek Inn to meet residential cleanup levels. Due to the BMSG acquisition of the PCI property, this requirement is no longer applicable. Finally, section 12.8 provides for contingent actions including additional removals along Panther Creek if monitoring following *large runoff events* indicates deposition of overbank deposits that exceed remediation goals.

In compliance with the ROD (EPA 2003) requirements described above, Alternative A includes the ongoing inspection, O&M required to manage the sediment migration from the Blackbird Creek drainage. Sediment detention ponds in Blackbird Creek at the West Fork and upstream of the PCI property are operated and maintained to control sediment release. Annual monitoring of in-stream sediments is conducted. In addition, when high flows occur, overbank areas along Blackbird and Panther Creek are inspected and tested for arsenic and cobalt. The BMSG conducts removal of material where concentrations exceed the cleanup level for arsenic or the PRG for cobalt.

5.2.1 Proposed Construction

No capital construction would be performed for this alternative.

5.2.2 Operation & Maintenance

This alternative assumes that the BMSG would continue to identify and remove overbank deposits of COCs along Panther Creek downstream of the Blackbird Creek confluence following significant snowmelt or thunderstorm events.

5.3 Alternative B – In-Stream Stabilization and Removal

5.3.1 Proposed Construction

Construction of bank armoring, grade control structures and bendway weirs at selected locations within and along Blackbird Creek would stabilize the arsenic and cobalt contaminated fine-grained sediments as well as the bedload within Blackbird Creek and in the overbank areas. Stabilization of the sediments in sediment source reaches would reduce the potential for mobilizing both bed load and the suspended load sediments (present with bedload sediments) during floods, and thereby reduce the continued delivery of fine-grained sediments containing arsenic and cobalt that may be present at depth, and stored in the bed and overbank sediments.

The proposed work would target stabilization of sediments in-place, in the identified sediment source reaches where sediments are stored through deposition and then re-mobilized through erosion, scour, lateral channel migration, or headcut erosion. The in-stream stabilization approach would use structural measures (i.e. grade controls, bendway weirs, and armoring) in the identified sediment source reaches to limit continued mobilization of all sediments, including the fine-grained sediments potentially containing elevated arsenic and cobalt concentrations. The final configuration of grade controls, bendway weirs, or armoring structures would be defined during final design. The structures would address erosion and channel dynamics specific to each identified site, and would take advantage of local bedrock or floodplain configurations to optimize their function and efficiency. Placement of structures would consider potential erosion impacts to downstream and opposite bank floodplain areas.

The proposed method of in-stream stabilization consists of grade control structures or bendway weirs installed in series at identified areas along Blackbird Creek. Stabilization measures would span the active floodplain. There are eight areas currently identified for stabilization (Figures 5-1 and 5-7). The eight reaches are areas where sediments were observed, or the HEC-RAS modeling identified channel morphology where sediments could accumulate (due to local gradient changes or deposition along the back side of the hydrograph) and then be eroded into downstream reaches as energy increases or erosion processes (i.e. headcut erosion or lateral channel migration, erosion, or scour) move sediments through the system. These transitional areas may accumulate sediments during an event, and these accumulated sediments are then mobilized within the same event or during later events from that area into downstream reaches. The stabilization reaches were identified by visual observations of channel morphology from previous site visits, anecdotal information from long-term operation of the mine site, observations from past flood events (i.e. early 2003, May 2008, and most recently in May of 2009), and from HEC-RAS modeling results identifying changes in channel gradient, Froude number, flow velocity, and stream power along the Blackbird channel. The stationing and average slope of each location are presented in Table 5-1. The locations of the grade control structures required as a part of in-stream stabilization are shown in Figure 5-1 in conjunction with other alternatives, and in Figure 5-2 showing conceptual grade control structure number and layout. Conceptual schematic details of grade control structures, bendway weirs, and bank armoring are included in Figures 5-3 through 5-5.

TABLE 5-1

CHANNEL REACHES WITH IN-STREAM STABILIZATION

Stabilization Area	Stationing	Average Slope (percent)
1	280+83 to 270+78	5.0
2	256+50 to 251+50	5.0
3	233+00 to 240+00	5.4
4	155+00 to 173+00	4.7
5	134+00 to 140+00	2.3
6	102+00 to 119+00	2.6
7	60+00 to 71+12	2.2
8	30+00 to 38+00	2.4

Conceptual layout and elevation designs for grade control structures assumed full floodplain spanning structures of typical cross-section and varying length and spacing. Structures would be made of riprap rock material. The typical cross-section would be trapezoidal, with a 1H:1V upstream slope, a 2H:1V downstream slope, and variable top width and height. The elevation difference between successive structures would vary, depending on the channel and floodplain gradient and the spacing of the structures. Changes in elevation between individual grade control structures were evaluated for heights of 2 feet, 4 feet, and 6 feet, with center to center spacing of the grade control structures ranging from 40 feet to 600 feet.

Bendway weirs would be provided to protect both channel banks along with armoring in some areas. These structures would vary and the designs would likely be modified in the field to adapt to actual conditions encountered. The budget estimates developed in this report assume a conservatively high number of floodplain spanning grade control structures. The configuration, placement, length, dimensions, and layout of grade controls, bendway weirs, and bank armoring would be determined in final design. The estimated number of grade control structures used in the cost estimate for this report is summarized in the table below.

TABLE 5-2

NUMBER OF IN-STREAM STABILIZATION STRUCTURES IN EACH CHANNEL REACH

Area	Grade Control Structures (#)	Structure Spacing (ft)	Approx. Area within Stabilization Area (SF)
1	11	~100	61,000
2	7	~90	48,000
3	13	~100	69,000
4	16	~100	104,000
5	6	~300	163,000
6	10	~150	48,000
7	7	~200	109,000
8	5	~200	44,000

The total volume of riprap estimated for the above cross-valley grade control structures is 30,500 cubic yards. An additional 15,000 cubic yards of riprap and associated excavation work is assumed in the estimate for Alternative B to address areas that may be identified for stabilization outside of the eight areas listed above. In addition, the alternative includes 7,000 cubic yards of riprap for road and bank stabilization efforts throughout the length of Blackbird Creek from the PCI sediment ponds to the WTP.

The work would also include removal of contaminated sediments on both sides of the existing channel. Areas along the south bank upstream of West Fork likely contain additional spilled tailings from the tailings pipeline breaks. To the extent that these sediments might be mobilized by future floods, they would be removed and hauled to the West Fork Tailings Impoundment, Blacktail Pit or other appropriate disposal area. Similarly contaminated sediments along or within the Blackbird Mine Site Road would be removed or stabilized in place when there is a potential for mobilization. In particular, contaminated areas between the targeted stabilization reaches would be excavated and disposed of in the pit. The quantity of contaminated materials that would be excavated is not known at present. Estimates of the volumes were made that are believed to be conservative.

The Phase 1 Blackbird Creek stabilization design and removal effort in 2009 addressed much of the removal work described above, as well as included designs for Stabilization Areas 1 through 3, although only Area 1 was constructed (Golder 2009f). If selected, the Phase 2 design will address all remaining stabilization areas. Additional stabilization structures may be added to supplement the structures within the designated reaches, or to target new areas requiring stabilization. The areas for removal and for additional stabilization structures would be identified during design and construction of Phase 2. Following initial construction, continued monitoring of channel and floodplain conditions would be performed to track potential changes resulting from future floods, with additional measures taken as needed. The technology, materials, and design approach may be adjusted over time as actual performance is observed. Where additional stabilization is required in areas not identified in the first phase of work, grade control structures, bendway weirs, or bank armoring would be installed as needed. This alternative assumes the sediment ponds at the West Fork and at the Panther Creek Bridge would continue to be operated.

5.3.2 Operation & Maintenance

Some maintenance of the stabilization structures is expected. A pilot grade control structure (STA 118+00) and 3 bendway weirs (STA 110+00) were installed along Blackbird Creek during removal activities in 2004. These structures are operating as intended. The bendway weirs are unchanged from the 2008 flood. The grade control structure survived the May 2008 and 2009 events with only minor changes where it crosses the main channel. The grade control is clearly stabilizing sediments in the localized upstream reach. Maintenance for this structure would include reconfiguring the existing riprap material, or possibly adding a small amount of riprap to supplement the current structure. This existing structure provides an example of how future grade control structures can work. The proposed stabilization work would include combining grade control structures, bendway weirs and bank armoring to provide an effective, robust, easy to install, easy to maintain, and fairly simple construction method for stabilizing sediments along Blackbird Creek.

If allowed to occur, the channel processes that could mobilize sediments at the in-stream stabilization areas along Blackbird Creek are headcut erosion, lateral channel migration, and erosion of surface sediments. The proposed in-stream stabilization measures would protect against mobilization of sediments below the invert elevation of the structures, which together with selective removal, would immediately and permanently stabilize and retain the vast majority of the existing contaminated fine-grained sediments in the Blackbird Creek channel and overbank areas. Some re-working of surface sediments is anticipated after installation. Re-working of sediments would be limited to the surface areas in the channel bed and overbank areas, and not at depth where the majority of the potentially fine-grained and contaminated sediments exist. After a few flood events, the surface sediments would naturally "armor", as the finer grained sediments are mobilized and winnowed (i.e. flushed) out of the coarser surface sediments that are left behind and accumulate along the surface. The development of an armor layer is expected to take several years (on the order of approximately six years). Surface sediment pebble count sampling and grab samples from the underlying sediments (Appendix D) confirmed the presence of an armor layer in the areas where in-stream stabilization is proposed, and throughout the Blackbird Creek system. This suggests there is enough coarse material in the system to develop an armor layer fairly quickly, and thereby minimize surface erosion of sediments. The armor layer will result in degradation of the surface materials in overbank areas, but degradation would not occur below the invert of proposed in-channel stabilization structures. As the armor layer develops, new clean sediments would continue to be delivered to the Blackbird Creek channel and mantle the stabilized sediments. This process would allow for continued natural sediment regime dynamics in the Blackbird Creek system.

Additional in-stream stabilization may be completed in the future as needed. Future stabilization work would be performed as needed for new reaches identified as arsenic or cobalt source areas, as well as for existing areas that may require maintenance. This would be part of the on-going monitoring and maintenance work, which is expected to diminish over time.

5.4 Alternative C – In-Stream Stabilization and Removal with PCI Settling Basins

5.4.1 Proposed Construction

This alternative would combine in-stream stabilization and selective *removal* of sediment with off-channel settling basins at the PCI for *capture of* floc and sediment. The in-stream stabilization would be the same as that described in Alternative B above. The configuration of the PCI Settling Basins is described in Section 4.2.5.1. The off-channel sediment settling basins would provide *capture* of suspended sediment with potential COCs that are mobilized by high snowmelt flows during the first several years following installation of in-stream stabilization.

The settling basins would remove a substantial portion of the floc migrating downstream during snowmelt flows.

5.4.2 Operation & Maintenance

The O&M considerations for the in-stream stabilization portion of the work would be the same as those identified for Alternative B in Section 5.3 above. The off-channel PCI Settling Basins would require regular O&M. The diversion dam would require an operator for the gates and maintenance to remove sediment deposits and floating debris from the diversion dam reservoir. The diversion pipeline would require occasional cleaning. The settling basins would require sediment removal. The basin discharge piping would also require maintenance during operation to prevent blockage due to sediment, ice and debris. The dikes defining the southern edge of the basins, along Panther Creek, would require occasional maintenance of the riprap following periods of high flow and/or ice jambs. Although no floc treatment system is included in this alternative, floc would be captured by the settling basins along with other suspended sediments in the water column.

5.5 Alternative D – Single Large In-Stream Dam

5.5.1 Proposed Construction

Alternative D consists of a single in-stream dam and reservoir located on Blackbird Creek just upstream of the Panther Creek confluence. See the proposed single dam location in Figure 5-1 and Figure 5-6. Analyses were performed to estimate the volume-elevation and capacity available at the site. The dam would create a reservoir for settlement and storage of the total sediment load expected from a 100-year flood event plus *capture* of a major percentage of the floc. The dam and corresponding reservoir would be designed (sized) to be *highly effective* in terms of sediment capture. Because it is not possible to capture 100 percent of the suspended sediment and floc by simply making the reservoir larger, a nominally *large* dam was developed, resulting in a dam height of approximately 150 feet. The resulting dam, reservoir and spillway configuration is summarized in Table 5-4. No specific criteria were used in determining the size of the reservoir.

A conceptual access road is also included to route the Blackbird Creek Road around the dam. Upstream of the dam, the road is assumed to be approximately 1-foot above the top of the dam (therefore 4 feet above the maximum water surface). Downstream of the dam, the road grade was assumed to be a maximum of 6 percent. The road upstream of the dam would be cut into the hillside to avoid road fill infringing on the reservoir volume, and the materials from the cut would be used as fill to construct the road downstream of the dam. Diversion ditches are also conceptualized along the road alignment to provide for diversion of Blackbird Creek flow around each dam site during construction.

The assumed road width (including diversion ditches) is 20 feet and the assumed slope of cuts and fills associated with the road construction is 1.2H:1V. The average existing slope along the valley was assumed to be 1.6H:1V. A uniform cross-section area for a 20 foot wide road based on the existing valley slope of 1.6H:1V and the cut and fill slope inclinations of 1.2H:1V was used to estimate the volume of fill and excavation associated with the road construction. Costs for the roads and diversion ditches are included in the cost estimates in Appendix G and a potential road layout is shown schematically in Figure 5-6.

5.5.2 Operation & Maintenance

Alternative D would be operated with the reservoir water surface elevation at the spillway crest elevation, providing retention storage for all flows entering the reservoir. All of the bedload and a portion of the suspended sediment load entering the reservoir would be captured in the reservoir and would be stored for many years before removal. Although no floc treatment system is included in this alternative, floc would be captured by the reservoir along with other suspended sediments in the water column.

TABLE 5-3

SUMMARY OF SIZING OF THE ALTERNATIVE D SINGLE LARGE DAM AND RESERVOIR

SUMMARY OF SIZING OF ALTERNATIVE D DAM		
Dam Station	(-)	33+00
Drainage Area	(SQ MI)	20.84
Elevation of Upstream Toe	(FT)	5,259
Dead Storage Volume	(CY)	0
Elevation of Top of Dead Storage	(FT)	5,259
Estimated Annual Floc Flux	(CY)	64
100-yr Flood Sediment Volume	(CY)	11,000
Est. Annual Sediment Volume	(CY)	4,000
Sediment Volume Provided	(CY)	2,180,000
Assumed Years between Cleanout	(YR)	25
Reservoir Surface area at 100-year flood	(SQ FT)	1,258,300
Reservoir Length at 100-year flood	(FT)	4,290
Peak Inflow during 100-year Flood	(CFS)	588
Peak Outflow during 100-yr Flood	(CFS)	255
Percent *Capture* for 100-yr Flood - using Churchill Method	(-)	64%
Elevation of Spillway Crest	(FT)	5,398
Flood Surcharge Selected	(FT)	7
Spillway Width Required	(FT)	10
Spillway Concrete Required	(CY)	640
Elevation of Top of Flood Surcharge	(FT)	5,405
Freeboard Provided	(FT)	3
Dam Crest Elevation	(FT)	5,408
Dam Height (from upstream toe)	(FT)	149

5.6 Alternative E – In-Stream Stabilization *and Removal* with a Single Moderately Sized In-Stream Dam

5.6.1 Proposed Construction

Alternative E combines in-stream stabilization *and removal* with a single in-stream dam and reservoir located on the Blackbird Creek just upstream of the Panther Creek confluence. The in-stream stabilization *and removal* measures are the same as those included in Alternative B, described in detail in Section 5.3. The dam is similar to that described for Alternative D, except that the dam is smaller since it is combined with in-stream stabilization *and removal.* See the proposed single dam location in Figure 5-1 and Figure 5-6. See Table 5-4 above for a summary table of sizing for the Alternative E dam. The dam would create a reservoir for settlement and storage of the total sediment load expected from a 100-year flood event plus some capacity for settlement of floc. The dam and corresponding reservoir would be designed (sized) to be *moderately effective* in terms of sediment capture. It is not possible to capture 100 percent of the suspended sediment and floc by simply making the reservoir larger, a nominally *moderately sized* dam was developed, resulting in a dam height of approximately 36 feet. The resulting dam, reservoir and spillway configuration is summarized in Table 5-4. No specific design criteria were used to establish the reservoir size.

Conceptual access roads were also included to route the Blackbird Creek Road around each dam. Upstream of the dam, the road is assumed to be approximately 1-foot above the top of the dam (therefore 4 feet above the maximum water surface). Downstream of the dam, the road grade was assumed to be a maximum of 6 percent. The road upstream of the dam would be cut due to lack of space for fill, and the materials from the cut would be used as fill to construct the road downstream of the dam. Diversion ditches were also conceptualized along the road alignment to provide for diversion of Blackbird Creek flow around each dam site during construction.

The assumed road width (including diversion ditches) is 20 feet and the assumed slope of cuts and fills associated with the road construction is 1.2H:1V. The average existing slope along the valley was assumed to be 1.6H:1V. A uniform cross-section area for a 20 foot wide road based on the existing valley slope of 1.6H:1V and the cut and fill slope inclinations of 1.2H:1V was used to estimate the volume of fill and excavation associated with the road construction. Costs for the roads and diversion ditches are included in the cost estimates in Appendix G and a potential road layout is shown schematically in Figure 5-7.

TABLE 5-4

SUMMARY OF SIZING OF THE ALTERNATIVE E SINGLE MODERATELY SIZED DAM AND RESERVOIR

SUMMARY OF SIZING OF ALTERNATIVE E DAM		
Dam Station	(-)	29+30
Drainage Area	(SQ MI)	20.84
Elevation of Upstream Toe	(FT)	5,242
Dead Storage Volume	(CY)	0
Elevation of Top of Dead Storage	(FT)	5,242
Estimated Annual Floc Flux	(CY)	64
100-yr Flood Sediment Volume	(CY)	11,000
Est. Annual Sediment Volume	(CY)	4,000
Sediment Volume Provided	(CY)	33,000
Assumed Years between Cleanout	(YR)	8
Reservoir Surface area at 100-year Flood	(SQ FT)	185,000
Reservoir Length at 100-year Flood	(FT)	950
Peak Inflow during 100-year Flood	(CFS)	588
Peak Outflow during 100-yr Flood	(CFS)	588
Percent *Capture* for 100-yr Flood - using Churchill Method	(-)	23%
Elevation of Spillway Crest	(FT)	5,268
Flood Surcharge Selected	(FT)	7
Spillway Width Required	(FT)	30
Spillway Concrete Required	(CY)	380
Elevation of Top of Flood Surcharge	(FT)	5,275
Freeboard Provided	(FT)	3
Dam Crest Elevation	(FT)	5,278
Dam Height (from upstream toe)	(FT)	36

5.6.2 Operation & Maintenance

The O&M considerations for the stabilization component of Alternative E are the same as those identified for Alternative B in Section 5.3.2 above. Bedload would be stabilized in place. During the first 6 years of operations, some finer grained materials would be winnowed out of the surface sediments and a portion of this would be captured in the moderately sized reservoir. The dam component of Alternative E would be operated much like Alternative D. Bedload and suspended sediments captured in the reservoir would need to be removed every few years. Although no floc treatment system is included in this alternative, floc would be captured by the reservoir along with other suspended sediments in the water column.

6.0 COMPARISON OF ALTERNATIVES AGAINST CRITERIA

In this section the performance of the alternatives developed in Section 5 is compared based on established criteria. Each of the criteria used for comparison are described in the following sub-sections. A description of the evaluation of the performance of each of the alternatives with respect to the individual criteria is presented in subsequent paragraphs. The recommended alternative is described in Section 7.

6.1 Criteria for Comparison

The following criteria were used to compare the alternatives.

6.1.1 Effectiveness

- **Overall Protection of Human Health and the Environment:** Effectiveness of the alternative in controlling the potential risk posed by arsenic and cobalt to human health, potential risk to aquatic biota to in-stream sediments containing arsenic, cobalt and copper, and potential risk to aquatic biota due to increased dissolved copper concentrations.
- **Compliance with ARARs:** The degree to which the alternatives comply with ARARs associated with remedial actions to address arsenic and cobalt in sediments will be evaluated. Table 6-10 provides a summary of the ARARs and a comparative evaluation of how they apply to the alternatives.
- **Long Term Effectiveness and Permanence:** This component of effectiveness addresses whether the alternative is permanent, enduring and an effective solution to the problem. It includes the reliability of the alternatives, the need for future modifications and O&M, the permanence of the treatment system put in place, if any, the quantity and type of sediments and/or floc left in place, and the overall reduction of mobility of the sediments and floc. It also includes the EPA's arsenic cleanup levels and cobalt PRG in the areas where the alternatives are implemented, as well as downstream. The effectiveness of the alternative in addressing sediment and floc control will be evaluated. The effectiveness of the alternative in addressing water quality and in-stream sediments in Panther Creek will also be evaluated.
- **Reduction of Toxicity, Mobility and Volume Through Treatment:** None of the retained alternatives include treatment to reduce toxicity, mobility or volume. However, the extent to which alternatives reduce mobility of sediments will be assessed. In addition, the extent to which alternatives include removal to reduce the volume of sediments will also be assessed.
- **Short Term Effectiveness:** The potential impacts to the environment during the action, the length of time required to implement the action and protection of workers and community during the work.

6.1.2 Implementability

- **Ease of Construction:** What are the potential risks associated with construction? Is the construction complex?
- **Suitability of the Proposed Technology:** Is research and development necessary prior to implementation of the technology?
- **Ease of Implementation:** The ease of initial construction as well as any additional future work that may be required. Ability to complete construction in the shortest possible time.
- **Administrative Constraints:** The ability to meet the substantive requirements of other laws and regulations.

6.1.3 *Cost*

- Capital Costs
- O&M Costs: Including periodic (replacement) costs – of stabilization repairs, water treatment components, sediment removal, etc.
- Total Net Present Cost: Sum of the capital costs and the net present cost (NPC) of the annual O&M expenses.

6.1.4 *Sensitivity*

The sensitivity of the design, effectiveness, implementability and cost of each alternative to changes in certain key parameters will be evaluated. This will be done mostly qualitatively for each alternative as well as for the summary comparison. As discussed in previous sections, the key parameters with uncertainty include 1) the magnitude of the peak flows for the design flood events, 2) the quantity of sediment that is transported by the design storms and on an average annual basis, 3) the effectiveness of the reservoirs for *capture* of sediment, and 4) the percentage of West Fork seepage that passes into Blackbird Creek as direct groundwater flow. The range of uncertainty for each of these parameters was discussed in the previous sections, where the parameters were described. With one exception the effects of the variations will be discussed as part of the comparison. The last parameter involving West Fork Tailings Impoundment seepage is not discussed because the amount of seepage is moot since none of the alternatives include treatment.

6.1.5 *Acceptance*

Each alternative will also be evaluated with respect to the criteria of state acceptance and community acceptance. These evaluations will be made in the EPA's decision document.

6.2 Methodology for Estimating Costs of Alternatives

Preliminary, comparison-level cost estimates were developed for each alternative. Costs include total construction costs (including materials and installation) as well as O&M costs.

6.2.1 *Total Construction Costs*

The development of total construction costs included calculations of quantities and materials to construct each project, unit costs for materials and installation, and construction cost related factors such as engineering design and contingency. Each of these factors is described in greater detail in the following sections.

6.2.1.1 Quantities and Materials

Planning level quantities and materials were developed for all major components of each alternative using the preliminary designs as a basis. Typical quantities include: grading, excavation, various fill materials, riprap armoring, access roads and ditches. Quantities were also developed for specialized works required for each alternative (i.e. concrete volumes for dam spillways).

6.2.1.2 Unit Costs

Updated unit costs were provided for commonly used materials (i.e. excavation, riprap) from Dahle Construction based on recent Blackbird Mine Site construction projects. Other specialized unit costs were developed using previous Blackbird cost estimates and accounting for inflation and relative project size. For instance, for the dam alternatives, the costs for the outlet works were developed using the 7100 Dam design and increased for inflation. The unit costs were then scaled up or down, depending on project size.

6.2.1.3 Cost Factors

Standard cost factors were applied to each total construction cost to develop the total construction cost. These factors include mobilization at 10 percent, construction quality assurance (CQA) at 10 percent, engineering design at 10 percent, and a planning-level contingency of 15 percent for all alternatives. These factors are compounded.

6.2.2 Operations and Maintenance

O&M costs were developed for each alternative. O&M costs were based on assumed activities to operate and maintain each alternative, which include materials, equipment, labor, and power (where applicable). These estimates are preliminary planning level estimates for comparison purposes only.

The O&M costs were converted to Net Present Value (NPV[9]) using an interest rate of 7 percent over a time period of 30 years. Some alternatives would have a useful life greater than 30 years; however, 30 years was used for all alternatives on a comparison basis.

6.2.3 Summary of Cost Estimates for Alternatives

Table 6-1 below summarizes the results of the estimates of capital costs, O&M costs and the total NPC for all the alternatives. Detailed costing information is included in Appendix G.

[9] Sometimes designated as NPC for Net Present Cost

TABLE 6-1

ALTERNATIVE COST SUMMARY

Alternative	Alternative Costs			Total Cost
	Capital Cost	Annual O&M	NPC O&M[1]	Total NPC
A - ROD Remedy - Baseline Alternative	$0	$407,000	$5,805,000	$5,805,000
B - In-Stream Stabilization and Removal	$6,061,000	$152,000	$2,633,000	$8,694,000
C - In-Stream Stabilization and Removal with PCI Settling Basins	$8,817,000	$219,000	$3,274,000	$12,091,000
D - Single Large Dam	$43,074,000	$394,000	$5,619,000	$48,693,000
E - In-Stream Stabilization and Removal with Single Moderate Sized Dam	$11,267,000	$485,000	$7,046,000	$18,313,000

[1]NPC O&M = Net Present Cost of Annual O&M plus two monitoring and overbank removal activities for Alternative B and one monitoring and overbank removal activity for Alts C and E.

The costs developed for this report are for comparison purposes only, to allow a sense of the magnitude of the efforts necessary. These costs are not intended for use in budgeting. Historically, cost estimates developed for preliminary engineering studies have proven to be low estimates of actual costs after implementation.

The cost summary indicates that, among the action alternatives, Alternative B is the least cost alternative, with respect to capital cost, annual O&M cost and NPC.

6.3 Summary of Effectiveness of Stabilization and Removal, Reservoirs and Settling Basins on Control of COCs

Sediments and the associated COCs are controlled by various combinations of stabilization and removal and reservoirs or settling basins. The effectiveness of each of these approaches in controlling COCs is compared in this section, both individually and in the combinations included in the alternatives.

6.3.1 Effectiveness of In-Stream Stabilization and Removal of Sediment

The in-stream stabilization and removal action described in Sections 4.2.3 and 5.3 (Alternative B) will prevent nearly all of the potentially contaminated sediments in the stabilization areas from moving out of the Blackbird Creek basin and into Panther Creek. As described in Section 6.5 below, this remediation action will stabilize 90 to 96 percent of the sediments immediately. Following construction, Blackbird Creek flow will winnow *(flush out)* the finer grained components from the surface sediments located between the stabilization structures, continuing for approximately 6 years. Once the winnowing process is completed, in-stream stabilization is expected to be nearly 100 percent effective with respect to suspended sediments under most conditions. However, in-stream stabilization will do little if anything to control COCs contained in floc that is generated by future iron precipitation in the stream. In addition, very large floods may dislodge and release some overbank sediments not removed or stabilized in the areas not addressed by in-stream stabilization.

The effectiveness of in-stream stabilization was estimated by using the 90 to 96 percent control values above, combining this with the estimates of the COCs in floc, acknowledging that the effectiveness during typical hydrologic events beyond the first six years will improve as the winnowed fines move out of the system. In contrast, a very large flood may partially disturb the stabilization structures and mobilize some overbank materials containing COCs, which would reduce effectiveness. Floc composes less than about 10 percent of the flux of COCs off-site (Section 3.2.2). Therefore the effectiveness of in-stream stabilization during a *smaller runoff* event, such as the 2-year flood, will be approximately 80 percent to 86 percent (90 percent minus 10 percent; 96 percent minus 10 percent). For larger events like the peak flows from a 500-year thunderstorm, in-stream stabilization would likely be less effective, although the actual effectiveness for such events is uncertain. An effectiveness of 50 percent to 80 percent was assumed for the 500-year event. Using these estimates of effectiveness for the 2-year and 500-year events, the effectiveness of in-stream stabilization for intermediate flood magnitudes was interpolated and is shown in Table 6-2 below.

TABLE 6-2

EFFECTIVENESS OF IN-STREAM STABILIZATION AND REMOVAL FOR FLOOD EVENTS WITH VARIOUS MAGNITUDES

Flood Recurrance Interval													
2 year		5 year		10 year		25 year		50 year		100 year		500 year	
High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
86%	80%	85%	75%	84%	70%	83%	65%	82%	60%	81%	55%	80%	50%

6.3.2 *Reservoirs and Settling Basins*

Alternatives D and E each include an on-stream reservoir, while Alternative C includes off-stream settling basins. Alternatives C and E include in-stream stabilization while Alternative D does not. Suspended (fine-grained) sediment reaching the reservoir or settling basins would be at least partially captured depending on the magnitude of the flood event occurring. The effectiveness of the reservoir/basin, measured as the percent *capture* of inflowing COCs, was assumed to be independent of the total load of inflowing COCs, and therefore independent of in-stream stabilzation that may be present in the upstream reaches. This assumption allows evaluation of the effectiveness of the components of an alternative independently, with subsequent evaluation of the combined effectiveness.

The effectiveness of each reservoir alternative (Alternative D and Alternative E) with respect to *capture* of inflowing sediments was estimated using the Churchill Method. The Churchill method is the most widely accepted approach for estimating the effectiveness of an in-stream reservoir for sediment *capture* during a flood event. Details on the analyses are presented in Appendix B3. The effectiveness of the PCI

Settling Basins with respect to *capture* of suspended sediments and COCs in Blackbird Creek flow was estimated using a variety of methods presented in Appendix H4. These methods suggest that the settling basins are 90 to 98 percent (average 94 percent) effective in removing COCs from influent. Therefore, if suspended sediments can be diverted into the settling basins, the basins will be nearly 100 percent effective in removing fine-grained sediments and the associated COCs for flows up to 200 cfs. However, not all the flow can be diverted into the basins during large events. The settling basins can capture 100 percent of the flow for events as large as the 25 year *runoff event*. For larger events only a fraction of the event can be captured so the corresponding effectiveness is reduced. For the 500-year event only 39 percent of the volume of the runoff can be captured. Appendix H4 presents computations showing *capture* for events of various recurrence intervals.

The results of applying the *capture* estimates to the reservoirs (Churchill) and settling basins (percent capture) for various Alternatives are presented in the Table 6-3 below. These estimates assume uniform distribution of COCs in fine-grained sediments.

TABLE 6-3

EFFECTIVENESS OF DAMS AND/OR SETTLING BASINS FOR FLOOD EVENTS WITH VARIOUS MAGNITUDES

Feature	Sediment Trap Efficiency						
	2 year	5 year	10 year	25 year	50 year	100 year	500 year
Settling Basins (Alt C)	100%	100%	100%	100%	81%	67%	39%
Large Dam (Alt D)	99%	94%	92%	87%	73%	64%	43%
Medium Dam (Alt E)	94%	75%	64%	53%	35%	23%	0%

Table 6-3 shows that the best capture that can be expected by a reservoir during runoff events (99 percent) occurs with the single large dam during a two-year *event*. The settling basins are expected to be 100 percent effective for small *runoff events* and approximately 94 percent effective for the 25-year event. The least *capture* (0 percent) would occur during a 500-year flood through a single medium sized dam.

For the purpose of evaluating the effectiveness of in-stream stabilization, reservoirs and basins for capturing and retaining floc, the performance of these systems would be similar to their effectiveness in capturing and retaining suspended (fine-grained) sediments.

6.3.3 Combined Effectiveness of Stabilization, Removal of Sediment and Control of COCs

The alternatives combine the in-stream stabilization and removal with settling basins and reservoirs, in various combinations. The combined effectiveness for the combinations of control methods was computed using the expression $E_T = E_1+E_2-(E_1xE_2)$, where E_T is the combined effectiveness from the effectiveness of the two parts, E_1 and E_2. The resulting combined effectiveness is presented in Table 6-4 below.

TABLE 6-4

COMPARISON OF THE EFFECTIVENESS OF THE ACTION ALTERNATIVES FOR FLOOD EVENTS WITH VARIOUS MAGNITUDES

Alternative	Flood Recurrance Interval													
	2 year		5 year		10 year		25 year		50 year		100 year		500 year	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Alt B - ISS only	86%	80%	85%	75%	84%	70%	83%	65%	82%	60%	81%	55%	80%	50%
Alt C - ISS and Settling Basins	100%	100%	100%	100%	100%	100%	100%	100%	97%	92%	94%	85%	88%	69%
Alt D Large Dam	99%	99%	94%	94%	92%	92%	87%	87%	73%	73%	64%	64%	43%	43%
Alt E Medium Dam with ISS	99%	99%	96%	94%	94%	89%	92%	84%	88%	74%	85%	65%	80%	50%

This table indicates that the combined effectiveness of the alternatives that include in-stream stabilization and another capture method (Alternatives C, D, and E) would be similar during smaller runoff events. During larger runoff events, the combined effectiveness of all of the alternatives would be reduced. Alternative C is the most effective in controlling *fine-grained* sediments and the associated COCs for all *runoff* conditions. *During larger runoff events, none of the alternatives would be completely effective, and there would still be some risk that COCs would be transported downstream with deposition at overbank areas along Panther Creek. It is likely that there would be significant dilution of the COCs by clean sediments during a larger runoff event. Therefore, it is not known if the concentrations of COCs in the fine-grained sediments that would be deposited along Panther Creek during larger runoff events would be greater than the cleanup levels.*

6.4 Alternative A - Baseline Remedy

6.4.1 General Performance

The ROD (USEPA 2003) for the Blackbird Mine describes the selected remedy which includes selective removal of contaminated overbank soils along both Blackbird Creek and Panther Creek, as is provided by Alternative A. Recognizing the uncertainty of success, the ROD also defines contingent actions that include 1) additional removal of overbank deposits along Blackbird Creek and 2) additional removals along Panther Creek if monitoring following *large runoff* events *indicates* deposition of overbank deposits that exceed remediation goals (p. 12-16).

6.4.2 Effectiveness

Overall Protection of Human Health and the Environment: Under Alternative A there would continue to be potential for periodic releases of sediments from Blackbird Creek containing arsenic above cleanup levels and cobalt above PRGs that would be deposited on overbank areas *along* Panther Creek. Monitoring following flood events and periodic removals would be required to determine if exceedances of cleanup levels occurred. Natural *recovery* of in-stream sediments would be delayed because sediments containing elevated concentrations of arsenic, cobalt and copper would continue to be flushed into Panther Creek at concentrations exceeding cleanup levels. Dissolved copper concentrations would potentially continue to exceed cleanup levels in Panther Creek during high runoff periods when sediments in Blackbird Creek containing soluble copper are eroded.

Compliance with ARARs: This alternative would require no modification to ARARs identified in the ROD, which were presented in Section 2.3 and summarized in Table 6-10. A summary of the most significant ARARs relevant to this alternative is as follows:

- Idaho Water Quality Standards (IDAPA 58.01.02) - There would be ongoing potential to exceed the IWQS for dissolved copper *in Panther Creek* during *high* runoff events.
- *Clean Water Act Section 304 –The ROD established a total arsenic water quality cleanup level of 14 µg/L pursuant to Section 304. There would be ongoing potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events.*
- Clean Water Act Section 404 - Future high flow runoff events could erode materials which could impact wetlands *along* Panther Creek and require removal. Any action that results in a disruption or destruction of wetlands would be required to meet the substantive requirements of Section 404 of the Clean Water Act which requires that measures be taken to avoid or minimize impacts to wetlands or compensate for unavoidable impacts as a result of dredge or fill activities.
- Clean Water Act *NPDES Regulations and* Stormwater *Permit Requirements (40 CFR 122-125,* 40 CFR 122.26) – BMPs *would* be required to manage stormwater during *any future removals of contaminated sediments in overbank areas along Panther Creek.*

Long Term Effectiveness and Permanence: Pursuant to the ROD, Alternative A is expected to reduce potential human health risks in overbank deposits along Blackbird Creek and Panther Creek (p. 12-17). By definition, Alternative A contains no change from existing conditions. Bed load in Blackbird Creek would continue to be mobilized during high flow events, resulting in deposition of bed load sediments in downstream reaches and suspended (fine-grained) sediments containing arsenic in excess of EPA's cleanup level and cobalt in excess of EPA's PRG would continue to migrate downstream into Panther Creek. Oxyhydroxide floc formed from iron and arsenic discharging from the West Fork Tailings Impoundment would also continue to flow through the lower Blackbird Creek reach with the potential for deposition in overbank areas, especially during simultaneous significant flood events in both Blackbird and Panther Creeks. As required by the ROD, monitoring would continue to be conducted and sediments exceeding the arsenic cleanup levels and the cobalt PRG would be removed as needed.

Alternative A will do nothing to change the water quality in Panther Creek, nor the in-stream sediments, from conditions as they exist today.

Reduction of Toxicity, Mobility and Volume: Alternative A would not alter the toxicity, mobility or volume of sediments or floc containing arsenic or cobalt through treatment. However sediments exceeding arsenic cleanup level and the cobalt PRG would be removed, as provided in the ROD.

Short Term Effectiveness: Alternative A would not cause any significant short term disruption, nor any significant incremental risk to public or workers. Overbank deposits containing significant COCs would occur as they have in the past. To the extent these deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal will be required. If removal is required, there will be short-term potential impacts to the public associated with periodic cleanups of public and private properties along Panther Creek. These potential impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs there would also be increased potential short-term risks because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. *However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. Therefore, the comparatively small exposure areas and the comparatively brief time between deposition and cleanup are not likely to significantly increase the potential long-term risks associated with exposure to elevated concentrations of COCs*

6.4.3 Implementability

Ease of Construction: Alternative A *would not require any new construction.*

Suitability of the Proposed Technology: Not applicable.

Ease of Implementation: Since Alternative A is the Baseline remedy, implementation would not be an issue.

Administrative Constraints: This is an approved remedy under the ROD and there should be no administrative constraints.

6.4.4 Cost

All capital, O&M and NPC are summarized in Table 6-1, with detail provided in Appendix G.

There is no capital cost associated with this alternative.

The annual O&M cost associated with the baseline remedy includes annual inspection and testing of overbank materials when they are deposited. The O&M cost assumes that there would be one monitoring program and one major cleanup action required every 2 years, with some minor maintenance each year.

6.4.5 Sensitivity

Because Alternative A is the base-case, it is used as a basis for comparison when evaluating the action alternatives.

6.4.5.1 Flood Hydrology

If the magnitude and frequency of flood events is greater than the expected values used, the magnitude and frequency of sediment transport and erosion damage would be greater. Costs for O&M would increase. Conversely, if flood events are smaller and/or less frequent, sediment transport, flood damage and their associated costs would be smaller.

6.4.5.2 Annual and Event Sediment Transport Volumes

Alternative A would also be influenced by changes in annual sediment volume in a manner similar to flood hydrology, as explained above.

6.4.5.3 Reservoir Effectiveness

Reservoir effectiveness has no influence because Alternative A does not include a reservoir.

6.5 Alternative B – In-Stream Stabilization and Removal

6.5.1 General Performance

The sediments containing arsenic and cobalt that were deposited along Panther Creek in 2008 and 2009 originated from a few depositional reaches of Blackbird Creek between the PCI and the WTP. The arsenic and cobalt is *primarily* contained in the fine-grained, suspended sediments, not the coarser grained bed load. In-stream stabilization and selective removal would significantly reduce erosion, scour and transport of these contaminated sediments; however it may not eliminate movement of all the fine-grained sediments during very large flood events. Clean sediments from the small tributary sub-basins of Blackbird Creek would continue to move through the channel system in response to future flood events, covering the underlying sediments that contain arsenic and cobalt. This clean sediment would become the active sediment in the new natural sediment regime of the Blackbird Creek system, and would move through the system during large flood events, restoring natural stream function.

Alternative B would provide significant stabilization of the Blackbird Mine Site access road because the migration of sediments in the channel would be significantly reduced and because the road itself would be armored and protected in many areas.

During extreme events, there is some potential for migration of contaminated sediments that are located deep below the armor layer, as high flows plow and churn the surface sediments to depths not previously experienced. However, the volume of the contaminated migrating materials should be relatively small compared to the overall scale of the sediments moving during the event. There is little likelihood that there will be mass migration of contaminated sediments released as part of headcut erosion moving up the entire channel. These sediments would be protected behind grade control structures which are designed to be stable under the hydraulic loads of extreme events. Further, the channel has many locations where bed rock is exposed that serve to control and prevent the migration of headcut erosion. For these reasons there is little likelihood of a major failure of the in-stream stabilization system. After the first several years of armor development and winnowing of fines, large flow events in Blackbird Creek may occasionally result in some release of contaminated fine-grained sediments, but a major release of the stabilized sediments is very unlikely.

Once the in-stream stabilization measures are in place and the removal work is complete, some re-working of surface sediments in stabilized depositional areas is anticipated from the initial *runoff events* after installation. This erosion, transport and deposition would likely occur on the surface of the stabilization areas, and not at depth where the majority of the potentially fine-grained and contaminated sediments exist. After the first few flood events, the surface sediment would naturally "armor" and mobilization of sediments below the engineered structure elevations would be minimized or eliminated. New clean sediments would continue to be delivered to the Blackbird Creek channel, thereby maintaining the natural sediment transport processes of the system, mantling the stabilized sediments. A more detailed description of the effectiveness and time associated with becoming fully effective is included in Appendix D2.

The total contribution of COCs resulting from mobilization of fine-grained sediments (i.e. suspended sediment load with potentially elevated COC levels) from depositional reaches where in-stream stabilization and removal is conducted would be significantly reduced from current levels; however, during large *runoff* events there is potential for sediments containing arsenic and cobalt to be eroded. The removal actions are intended to reduce or eliminate the COCs from these potential erosion areas. To the extent these potential erosion areas are cleaned, the movement of contaminated sediments can be eliminated. Continued erosion and scour of bed load and suspended load from clean sediment areas, namely areas along Blackbird Creek where no in-stream stabilization is completed, would continue along the Blackbird Creek channel. These sediments would mantel the previously stabilized reaches.

Additional in-stream stabilization, beyond the initial implementation, may be completed in the future. Future stabilization work would be performed as needed for new reaches identified as arsenic and cobalt source areas, as well as for existing areas that may need maintenance. This would be part of the on-going monitoring and maintenance work, which should diminish over time.

6.5.2 Effectiveness

Overall Protection of Human Health and the Environment: Alternative B would greatly reduce the volume of sediments containing COCs that would be eroded out of Blackbird Creek into Panther Creek. This would reduce potential exceedances of EPA's human health-based cleanup levels in overbank deposition areas and reduce impacts to the natural recovery of in-stream sediments containing elevated concentrations of COCs. *This alternative would not be fully protective* until the surface sediments naturally armor with a mantle of clean sediments *(on the order of six years). Even after the natural armoring occurs, there may be some releases of sediments to downstream areas, especially during larger runoff events.* The reductions in erodible materials *associated with Alternative B* would reduce the disturbance of materials containing soluble copper that cause exceedances of *water quality* cleanup levels in Panther Creek. *However,* there would potentially be some contributions to water quality exceedances *until* the Blackbird Creek channel *becomes fully* stabilized.

Compliance with ARARs: A description of ARARs is provided in Section 2.3 and Table 6-10. A summary of the most *significant* ARARs for this alternative is as follows:

- Idaho Water Quality Standards (IDAPA 58.01.02) – This alternative would significantly reduce potential to exceed the IWQS for dissolved copper during spring runoff events by removing much of the erodible sediments containing soluble copper that occur along Blackbird Creek and through stabilizing the Blackbird Creek Channel. There will be some potential for exceedances for the first several years following construction as the system stabilizes, depending on hydrologic events. *Alternative B could result in release of a pollutant (such as turbidity) during construction. BMPs would be employed to minimize turbidity releases to comply with Idaho's water quality standards.*
- *Clean Water Act Section 304 –The ROD established a total arsenic water quality cleanup level of 14 μg/L pursuant to Section 304. Alternative B would reduce the potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events.*
- Clean Water Act Section 404 – *This alternative would be required to meet the substantive requirements of Section 404 in terms of impacts from fill activities associated with the in-stream stabilization. Alternative B would* reduce the potential for future high flow runoff events to erode materials which could impact wetlands along Panther Creek and require removal. However, there is some potential for this to occur during the first several years following construction, while the system stabilizes, depending on hydrologic events. Any action that results in a disruption or destruction of wetlands will be required to meet the substantive requirements of Section 404 of the Clean Water Act which requires that measures be taken to avoid or minimize impacts to wetlands or compensate for unavoidable impacts as a result of dredge or fill activities.
- *Clean Water Act NPDES Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26) – BMPs would be required to manage stormwater* during construction activities, *and to meet State water quality standards.*
- State of Idaho Stream Channel Alteration (IDAPA 37.03.07) - This alternative would be required to meet the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rules 56), Dumped Rock Riprap (Rules 57) and Drop Structures, Sills and Barbs (Rule 59).
- Endangered Species Act (16 USC 1531 *et seq)* – Consultation with the NMFS and USFWS *would be required* to determine whether remedial actions conducted for this alternative could affect threatened or endangered species.

Long Term Effectiveness and Permanence: Alternative B significantly reduces potential human health risk and protects the Blackbird Creek Road. It is anticipated to provide general compliance with EPA's action levels for arsenic along Blackbird and Panther Creeks. Achieving arsenic cleanup levels is expected to also result in meeting EPA's PRG for cobalt.

Alternative B would require annual maintenance, but it would provide an effective long-term solution with respect to stabilizing sediments containing arsenic and cobalt. As described above, it is possible that during large *runoff* events some of the existing in-stream sediments may be mobilized, but that volume would be significantly reduced compared to the ROD (USEPA, 2003) remedy and even this mobilization of contamination can be eliminated if removal actions are successful. In addition, the redundancy in the quantity of stabilization structures would reduce the likelihood of mobilization of sediments. If mobilized, these sediments could be deposited downstream, either in Blackbird Creek or along Panther Creek *at concentrations that pose a potential risk to human health* in overbank areas. However, the natural armoring layer does take some time to develop, as described in the short term effectiveness section below.

The Blackbird Creek basin may be subject to infrequent but large snowmelt or thunderstorm events in the future, such as those that occurred in lower Panther Creek in 2002 and 2003. These extreme hydrologic events would produce large quantities of incoming debris flows and sediments from the side drainages, most of which would be clean and free from COCs. Alternative B would allow these clean sediments to pass over the underlying stabilized sediments, restoring the natural geomorphic processes and natural stream function.

Alternative B will stabilize 90-96 percent of the potential contaminants of concern in place. This is expected to improve water quality in Panther Creek by eliminating substantial portions of the mobile arsenic and cobalt in the water column. Some reduction in dissolved copper is expected due to removal of contaminated sediments and stabilization, but the amount of reduction is unknown. The in-stream stabilization and removal is expected to significantly improve the quality of the in-stream sediments in Panther Creek by eliminating the source. The qualities of the in-stream sediments will improve as clean sediment replaces and/or covers those materials containing COCs.

Reduction of Toxicity, Mobility and Volume: Alternative B would not alter the toxicity, mobility or volume of sediments containing arsenic and cobalt through treatment. However, over time it would substantially reduce the mobility of the arsenic and cobalt contained in the existing stream sediments by preventing it from being transported by natural stream processes and by the buildup of a clean mantel. The removal action included with Alternative B would reduce the volume of toxic materials by removing tailings and other materials high in arsenic and cobalt in the channel, bank and road. Alternative B does not address the reduction of toxicity, mobility and volume of floc being transported down Blackbird Creek, but, as noted in Section 3.1.7 and Appendix F, the total load of COCs contained in the floc is a small percentage of the total load of COCs in all sediments.

Short Term Effectiveness: Construction of Alternative B is not expected to cause any significant short term disruption; however, some sediments with arsenic and cobalt contamination may be released during construction activities and there may be some short term disruption due to cleanup activities. This alternative could theoretically be designed and construction completed during 2010.

The proposed combination of grade control structures and bendway weirs would stabilize in-stream sediments below the invert elevations of the installed structures immediately following construction. The invert elevation is defined as the top elevation of any given structure. Sediments that are below the invert elevation are assumed to be stable, and would not be mobilized due to lateral channel migration or headcut erosion. Sediments on the surface of the targeted stabilization areas that may be subject to channel or overbank flood flows can be expected to potentially be eroded, until the elevation of the sediments matches the invert elevation of the nearest downstream structure, or until the sediments become armored.

Armoring of sediments is a natural process resulting in coarsening of the near surface bed, bank, and overbank materials. In this process, the fine-grained sediments are washed away, leaving the coarser grained sediments behind to accumulate on the surface. The continuation of this process over time results in degradation of well-graded sediment mixtures, and a layer of predominately coarse-grained sediments on the surface that resists further erosion.

Where sediments in the bed or overbank areas are disturbed through erosion or by man-made disturbance, the armoring process repeats until the armor layer develops again. The process of armoring results in a loss of sediment and a corresponding drop in bed or overbank elevations. This is likely to happen in in-stream stabilization areas until an armor layer develops or the elevation matches the invert elevation of the nearest downstream structure.

The time it takes to develop the armor layer in approximately the top one foot is also the time it takes for the in-stream stabilization structure to become fully effective. Furthermore, the nature of the sediments in the bed, banks, and overbank areas defines whether an armor layer can develop. The greater the percentage of coarse material the faster the armor layer can develop (Julien 2002). The armor layers observed and sampled along Blackbird Creek show a large percentage of coarse material (Figure 3-3B and Appendix D1, Figure D2) relative to the underlying substrate sediments (Figure 3-3A and Appendix D1, Figure D3), indicating that an armor layer should develop relatively quickly.

Estimates were made of the depth and extent of the armor layer, the time required for the armor layer to develop, and the amount of material that would be transported downstream as the armor layer develops. These computed estimates, together with the associated assumptions, are presented in Appendix D2. The computations indicate that 1.1 feet of material will be removed in the formation of the armor layer, and that it is likely to occur during the first approximately 6 years following completion of in-stream stabilization. This is an estimate and is dependent on the magnitude and timing of high flow events in Blackbird Creek. During this period, a portion of the potential COCs contained within these sediments may be mobilized and deposited in overbank deposits along Panther Creek

The probability and extent of future overbank deposits containing significant COCs depends on the amount, timing and duration of exposure prior to full development of an effective control methodology. To the extent these deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal will be required. If removal is required, there will be short-term impacts to the public associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs, there could also be potential short-term risks because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. Therefore, the comparatively small exposure areas and the comparatively brief time between deposition and cleanup are not likely to significantly increase the potential long-term risks associated with exposure to elevated concentrations of COCs.

6.5.3 *Implementability*

Ease of Construction: No major construction issues are anticipated. A riprap source for 2010 work is currently being evaluated. The construction materials are believed to be readily available and the activity is of a size that mobilizing a contractor to complete construction by the end of 2010 is manageable.

Suitability of the Proposed Technology: In-stream stabilization is well suited to the intended purpose. It is a simple, proven technology that would be effective once the system was implemented and adjusted as required. There is potential for some sediments at depth that contain arsenic and cobalt to be mobilized during large *runoff* flows; however the in-stream stabilization approach would significantly control these materials.

Ease of Implementation: No implementation issues are anticipated. A preliminary design has been completed and a source of riprap is currently being evaluated. Therefore, the design and construction can theoretically be completed by the end of 2010. Future adjustments to the in-stream stabilization can be easily completed.

Administrative Constraints: The substantive requirements of the USFS permitting process will be met with respect to riprap source approval on Forest Service land. No other administrative constraints to construction of Alternative B are anticipated. Demonstration stabilization features were put in place in 2004 and performed very well during the 2008 and 2009 flood events.

6.5.4 Cost

All capital, O&M and NPC are summarized in Table 6-1, with detail provided in Appendix G.

A capital cost was developed by approximating planning-level quantities and materials for major components of Alternative B. This value includes markups for mobilization, CQA, design and contingency. Cost details are included in Appendix G.

Annual O&M related costs were estimated to be 5 percent of the total capital cost every 2 years. In addition, a monitoring program and the cost for a major cleanup of COCs in Panther Creek overbank deposits after 2 and 4 years was included at $200,000.

6.5.5 Sensitivity

6.5.5.1 Flood Hydrology

If the design event (100-yr) and other *large runoff* events are larger than the expected values used herein, the size of the required riprap in the stabilization structures would be larger and the structures themselves would be larger. Capital and O&M costs would be greater. Conversely, if the size of the design event and other *large runoff* events are smaller than the values used, the size and cost of the alternative would be less. The effectiveness and implementability of Alternative C is unlikely to change.

6.5.5.2 Annual and Event Sediment Transport Volumes

Unlike hydrology, changes in the actual amounts of sediment moved annually or by storms would not significantly influence the performance of Alternative B. More sediment could move annually, or during major *runoff events,* but the effectiveness of the in-stream stabilization would not be significantly different. The same is true if less sediment moves annually, or during major *runoff events*.

6.5.5.3 Reservoir Effectiveness

Reservoir effectiveness has no influence on Alternative B because Alternative B does not include a reservoir.

6.6 Alternative C – In-Stream Stabilization and Removal with PCI Settling Basins

6.6.1 General Performance

The overall performance of Alternative C would be similar to Alternative B with respect to the control of in-stream sediments. See Sections 6.5.1 and 6.5.2 for a more complete description of the performance and effectiveness of Alternative C in stabilizing in-stream sediments. In addition, Alternative C includes settling basins at the PCI. The settling basins would capture most of the fine-grained sediments, including floc, being transported downstream during high flow events.

Alternative C would provide significant stabilization of the Blackbird Mine Site access road because the migration of sediments in the channel would be significantly reduced and because the road itself would be armored and protected in many areas.

In-stream stabilization and selective removal would significantly reduce erosion, scour and transport of potentially contaminated sediments; however it would not eliminate movement of all the fine-grained sediments during *large runoff* events. Clean sediments from the small tributary sub-basins of Blackbird Creek would continue to move through the channel system in response to future flood events, covering the underlying sediments that may contain arsenic and cobalt. This clean sediment would become the active sediment in the new natural sediment regime of the Blackbird Creek system, and would move through the system during large flood events, restoring natural stream function.

The diversion of Blackbird Creek flows into the PCI Settling Basins would divert nearly all water from approximately 570 feet of the existing Blackbird Creek channel between the diversion structure and the confluence with Panther Creek, resulting in loss of stream function in this reach of Blackbird Creek. The discharge of Blackbird Creek flows into Panther Creek would be moved approximately 700 feet or 1,500 feet downstream, depending on how the settling basins are operated. This would affect the mixing zone in Panther Creek downstream from the discharges.

6.6.2 Effectiveness

Overall Protection of Human Health and the Environment: *The in-stream stabilization would greatly reduce the volume of sediments containing COCs that would be eroded from Blackbird Creek with downstream deposition in and along Panther Creek.* The PCI Settling Basins *associated with Alternative C would* provide additional protectiveness by further reducing the potential for exceedances of EPA's human health-based cleanup levels in overbank deposition areas and reducing potential impacts to the natural recovery of in-stream sediments containing elevated concentrations of COCs. *During small and medium-sized runoff events in Blackbird Creek (less than approximately a 25-year event), this alternative is predicted to be completely protective of human health and the environment. During larger runoff events (greater than approximately a 25-year event), a minor amount of the Blackbird Creek materials could become mobilized and some of these mobilized materials would not be captured by the PCI Settling Basins. Thus, the protectiveness of Alternative C would be slightly reduced until the surface sediments naturally armor with a mantle of clean sediments (on the order of six years). However, there would likely be dilution of the COCs in the transported sediments by clean sediments in Panther Creek during a large runoff event, further reducing the risks of recontamination of overbank areas at concentrations higher than the cleanup levels.* The settling basins would reduce the potential for exceedances of dissolved copper *water quality* cleanup levels *in Panther Creek* by providing additional time for adsorption of copper to iron oxyhydroxides. *The change in location of the discharges from the settling basins to Panther Creek would impact the mixing zones in Panther Creek downstream from the discharges. However, this change would be likely to result in some minor quality improvement within the mixing zones because the discharges from the settling basins would be better quality water than the current discharge of Blackbird Creek to Panther Creek.*

Compliance with ARARs: A description of ARARs is provided in Section 2.3 and Table 6-10. A summary of the most *significant* ARARs for this alternative is as follows:

- Idaho Water Quality Standards (IDAPA 58.01.02) – This alternative would significantly reduce potential to exceed the IWQS for dissolved copper during spring runoff events by removing much of the erodible sediments containing soluble copper that occur along Blackbird Creek and through stabilizing the Blackbird Creek channel. As noted above, the settling basins provided with this alternative may further reduce the potential for exceedances. However, there will be some potential for exceedance for the first several years following construction as the system stabilizes, depending on hydrologic events. Alternative C could result in release of a regulated pollutant (such as turbidity) during construction. BMPs would be employed to minimize turbidity releases to comply with Idaho's water quality standards.
- *Clean Water Act Section 304 –The ROD established a total arsenic water quality cleanup level of 14 µg/L pursuant to Section 304. Alternative C would significantly reduce the potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events.*
- *Clean Water Act Section 404 – This remedy would significantly reduce the potential for future high flow runoff events to erode materials which could impact wetlands along Panther Creek and require removal. However, there is some potential for this to occur during the first several years following construction, while the system stabilizes, depending on hydrologic events. Construction of the settling basins at the PCI could also impact wetlands in that area. Any action that results in a disruption or destruction of wetlands will be required to meet the substantive requirements of Section 404 of the Clean Water Act that* may require *measures to avoid or minimize impacts to wetlands or loss of aquatic habitat or to compensate for unavoidable impacts as a result of dredge or fill activities. Alternative C would result in* diversion of nearly all water from Blackbird Creek for approximately 570 feet below the diversion structure, although some seepage through or below the diversion structure would likely resurface within this reach of Blackbird Creek. *The* diversion *of Blackbird Creek below the diversion structure would result in the elimination* or modification *of stream habitat in this reach of Blackbird Creek; however, the existing habitat has been significantly impacted by mining activities and previous cleanup actions, and is comparatively low quality habitat.* The need for and scope of any mitigation for affected wetlands or aquatic habitat to meet the substantive requirements of Section 404 would be evaluated during the design of this alternative.
- *Clean Water Act National Pollutant Discharge Elimination System (NPDES) (40 CFR 122-125, 40 CFR 440). The PCI Settling Basins would have two point source discharges to Panther Creek. The PCI Settling Basins would reduce the dissolved copper concentrations slightly in the waters of Blackbird Creek; however, the discharges from the basins would not meet the dissolved copper water quality standard during parts of the year, especially during high runoff events, due to the pre-existing impaired condition of Blackbird Creek. Mixing zones for dissolved copper would likely be required in Panther Creek during the times when the settling basin discharges do not meet the dissolved copper water quality standard. An evaluation of the mixing zone issue would be required to determine the extent of mixing zones and compliance with state water quality*

standards. It is anticipated that the discharges from the settling ponds can meet the water quality standard for arsenic and the cleanup level for cobalt in Panther Creek without the need for mixing zones.

- *Clean Water Act NPDES Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26) – BMPs would be required to manage stormwater* during construction activities *and to meet state water quality standards.*
- State of Idaho Stream Channel Alteration (IDAPA 37.03.07) - This alternative would be required to meet the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rules 56), Dumped Rock Riprap (Rules 57) and Drop Structures, Sills and Barbs (Rule 59).
- Endangered Species Act (16 USC 1531 *et seq)* – Consultation with the NMFS and USFWS *would be required* to determine whether remedial actions conducted for this alternative could affect threatened or endangered species.

Long Term Effectiveness and Permanence: Alternative C significantly reduces potential human health risks and protects the Blackbird Creek Road. It is anticipated to provide compliance with EPA's action levels for arsenic by stabilizing the existing in-stream sediments and capturing most suspended (fine-grained) sediment and floc that is not stabilized in place. Achieving arsenic cleanup levels is also expected to meet EPA's PRG for cobalt.

Alternative C would require annual maintenance, but it would provide an effective long-term solution with respect to stabilizing sediments containing arsenic and cobalt. As described previously, it is possible that during large *runoff* events some of the existing in-stream sediments may be mobilized; *however,* the redundancy in the quantity of stabilization structures would reduce the likelihood of mobilization of sediments. During *small and medium-sized runoff events (up to about the 25-year event),* the PCI Settling Basins will capture most of the suspended (fine-grained) sediments that are winnowed out of the surficial sediments during development of the armor layer, as well as *capturing much of the* floc generated by West Fork Tailings Impoundment seepage. *During large runoff events (greater than about the 25-year event) a* small percentage of the mobilized sediments may not be captured in the settling basins and could be deposited downstream along Panther Creek in overbank areas. *However, there would likely be dilution of the COCs in the transported sediments by clean sediments in Panther Creek during a large runoff event, further reducing the risks of recontamination of overbank areas at concentrations higher than the cleanup levels*

Alternative C will stabilize 90-96 percent of the potential contaminants of concern in place. Most of the remaining contaminants will be winnowed out of the surface sediments and then be captured by the PCI Settling Basins. This is expected to improve water quality in Panther Creek by eliminating *most of* the mobile arsenic, cobalt, *and copper* in the water column; *however,* the amount of reduction is unknown. In-stream stabilization and removal coupled with the PCI Settling Basins is expected to significantly improve the quality of the in-stream sediments in Panther Creek by eliminating the source. The qualities

Reduction of Toxicity, Mobility and Volume: The stabilization component of Alternative C would not alter the toxicity, mobility or volume of sediments containing arsenic and cobalt through treatment. However, over time it would substantially reduce the mobility of the arsenic and cobalt by preventing them from being transported by natural stream processes and by the buildup of a clean mantel. The removal action included with Alternative C would reduce the volume of toxic materials by removing tailings and other materials high in arsenic and cobalt in the channel, bank and road. Alternative C would include *capture* of suspended (fine-grained) sediment and floc by the PCI Settling Basins which would significantly reduce the mobility and volume of COCs being transported down Panther Creek.

Short Term Effectiveness: Construction of the stabilization component of Alternative C is not expected to cause any significant short term disruption; however, some sediments with arsenic and cobalt contamination may be released during construction activities. The short-term effectiveness of the PCI Settling Basins would be similar to the in-stream stabilization. The design and construction can theoretically be completed by the end of 2010, *but may extend into 2011.*

As described more fully in Section 6.5.2 above, the in-stream stabilization structures would immediately stabilize the materials below the invert elevations of the installed structures. Stabilization of the armor layer (the top approximate one foot of material) may take on the order of 6 years to fully stabilize. This time period is an estimate and is dependent on the magnitude and timing of future high flow events in Blackbird Creek. The PCI Settling Basins would capture most of this migrating suspended (fine-grained) sediment. Even with these settling basins in place, there would be some potential risk of COCs in Panther Creek overbank deposits during this period, however the potential for redeposition at concentrations that pose unacceptable risks would be substantially reduced.

The probability and extent of future overbank deposits containing significant COCs depends on the amount, timing and duration of exposure prior to full development of an effective control methodology. To the extent these deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal will be required. If removal is required, there will be short-term potential impacts to the public associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs there could also be potential short-term risks because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. Therefore, the comparatively small exposure areas and the comparatively brief time between exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. Therefore, the comparatively small exposure areas and the comparatively brief time between deposition and cleanup are not likely to significantly increase the potential long-term risks associated with exposure to elevated concentrations of COCs.

6.6.3 Implementability

Ease of Construction: No major construction issues are anticipated. A riprap source for 2010 work is currently being evaluated. The construction materials are believed to be readily available and the activity is of a size that mobilizing a contractor to complete construction of the in-stream stabilization components of this alternative by the end of 2010 is manageable.

Suitability of the Proposed Technology: In-stream stabilization and settling basins are well suited to the intended purpose. Both are simple, proven technologies that would be relatively effective once the systems are implemented and adjusted as required. There is potential for some sediments at depth that contain arsenic and cobalt to be mobilized during very large flood flows; however the in-stream stabilization approach would significantly control these materials.

Ease of Implementation: No implementation issues are anticipated for the in-stream stabilization. A preliminary design has been completed and a source of riprap is currently being evaluated. Therefore, the design and construction can theoretically be completed by the end of 2010, *but may extend into* 2011. Future adjustments to the in-stream stabilization can be easily completed.

Implementation of the PCI Settling Basins would be relatively straightforward. Some additional review and analysis would be required regarding the diversion dam and the distribution and collection piping systems.

Administrative Constraints: The substantive requirements of the USFS permitting process will be met with respect to riprap source approval on Forest Service land. No other administrative constraints to construction of Alternative C are anticipated. Demonstration stabilization features were put in place in 2004 and performed very well during the 2008 flood events. No administrative problems are expected.

6.6.4 Cost

All capital, O&M and NPC are summarized in Table 6-1, with detail provided in Appendix G.

The capital cost includes in-stream stabilization, hillside tailings removal, road restoration, a diversion dam, a conveyance and distribution system, settling basins and a collection and discharge system. The cost includes markups for mobilization, CQA, design and contingency. Cost details are included in Appendix G.

Alternative C, a monitoring program and a reduced cost for a cleanup during the armor development period is included at year 2.

6.6.5 Sensitivity

6.6.5.1 Flood Hydrology

If the design event (100-yr) and other *runoff event*s are larger than the expected values used herein, the size of the required riprap in the stabilization structures would be larger and the structures themselves would be larger. Capital and O&M costs would be greater. Conversely, if the size of the design event and other *runoff event*s are smaller than the values used, the size and cost of the alternative would be less. The effectiveness and implementability of Alternative C is unlikely to change.

Changes in flood hydrology would have only a small impact on the performance of the proposed PCI Settling Basins. Since their capacity is fixed, an increase in the size and/or frequency of peak flows would mean that overflows would occur more frequently and therefore the effectiveness would be slightly reduced. Conversely a reduction in the peak flows would decrease the spill frequency and increase the effectiveness of the basins.

6.6.5.2 Annual and Event Sediment Transport Volumes

Unlike hydrology, changes in the actual amounts of sediment moved annually or by storms would not significantly influence the performance of Alternative C. More sediment would move annually, or during major *runoff event*s, but the effectiveness of the in-stream stabilization and the PCI Settling Basins would not be significantly different.

6.6.5.3 Reservoir Effectiveness

Reservoir effectiveness has no influence on Alternative C because Alternative C does not include a reservoir.

6.7 Alternative D – Single Large In-Stream Dam

6.7.1 General Performance

The performance of Alternative D with respect to bedload and suspended (fine-grained) sediments would be substantially different from the other action alternatives because in-stream stabilization *and removal* is not included. Alternative D addresses suspended (fine-grained) sediment and floc by attempting to capture the total load in a large reservoir, by providing a long retention time and abundant storage volume. Potential arsenic and cobalt contamination would continue to be remobilized and transported from the depositional reaches of Blackbird Creek between the PCI and the WTP. A portion of these sediments would be captured in the reservoir of Alternative D. Because the reservoir is very large these contaminated sediments could be left in place for many years. Eventually these sediments would be removed and transported to a suitable disposal location.

sediments would be captured in the reservoir of Alternative D. Because the reservoir is very large these contaminated sediments could be left in place for many years. Eventually these sediments would be removed and transported to a suitable disposal location.

The reservoir included in Alternative D would be effective in retaining the total bedload even for extreme events. The reservoir provides 2,180,000 cubic yards of sediment storage whereas the average annual inflow of sediments is expected to be 4,000 cubic yards. The 100-year flood is estimated to produce 11,000 cubic yards of total load.

Actual settling data suggests that the dam *associated with Alternative D* would remove only 64 percent of the suspended (fine-grained) sediments entering the reservoir during the 100 year flood event.

Alternative D would not provide significant stabilization of the Blackbird Mine Site access road. However, construction of the dam would require portions of the Blackbird Mine Site access road to be relocated onto Forest Service land. Because of the large size of the dam and reservoir, the road relocation would be very significant as well.

6.7.2 Effectiveness

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and *the environment during smaller runoff events in Blackbird Creek (up to about the two-year event)* by containing and storing sediments eroded from Blackbird Creek in a large reservoir. *However, the protectiveness of Alternative D would decrease with larger runoff events because of the decreasing capture capacity of the fine-grained sediment in the reservoir as flows increase. In addition, during larger runoff events, the* sediments *mobilized along* Blackbird Creek *would* potentially *release* more soluble copper and *potentially contribute* to exceedances of *water quality* cleanup levels *in Panther Creek.* However, increased adsorption of copper to iron oxyhydroxides with the additional retention time in the reservoir would reduce *the* potential for exceedances compared to current conditions,

Compliance with ARARs: A description of ARARs is provided in Section 2.3 and Table 6-10. A summary of the most *significant* ARARs for this alternative is as follows:

- Safety of Dams, State of Idaho Rules and Regulations (Chapter 17, Section 42-1714, Idaho Code and provisions of Section 42-1709 through 42-1721, Idaho Code). These requirements are applicable to the large dam that would be constructed for this alternative.
- Idaho Water Quality Standards (IDAPA 58.01.02) – There would still be potential to exceed the IWQS for dissolved copper during spring runoff events since there would be no removal of the erodible sediments containing soluble copper that occur along Blackbird Creek under this alternative. The reservoir would provide additional potential for sorption of dissolved copper to iron oxyhydroxides, thus reducing potential for exceedances. *Alternative D could result in release of a pollutant (such as turbidity)*

- Clean Water Act Section 404 – This remedy would significantly reduce the potential for future high flow runoff events to erode materials which could impact wetlands in Panther Creek and require removal. Any action that results in a disruption or destruction of wetlands *or aquatic habitat would* be required to meet the substantive requirements of Section 404 of the Clean Water Act which requires that measures be taken to avoid or minimize impacts to wetlands or compensate for unavoidable impacts as a result of dredge or fill activities. *Construction of the large dam would result in change of the aquatic habitat along Blackbird Creek and may require mitigation for the impacts of that change.*
- *Clean Water Act NPDES Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26) – BMPs would be required to manage stormwater* during construction activities *and to meet State water quality standards.*
- State of Idaho Stream Channel Alteration (IDAPA 37.03.07) - This alternative would be required to meet the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rules 56), and Dumped Rock Riprap (Rules 57).
- Endangered Species Act (16 USC 1531 *et seq)* – EPA will be responsible for consultation with the NMFS and USFWS to determine whether remedial actions conducted for this alternative could affect threatened or endangered species.

Long Term Effectiveness and Permanence: Alternative D would reduce human health risk. It is expected to contain Blackbird Creek sediments and floc from Blackbird Creek, *especially during smaller runoff events (less than the two-year event). However, during larger runoff events. the sediment capture efficiency would be reduced, and there would be a greater risk of deposition of fine-grained sediments along Panther Creek at COC concentrations that exceed the cleanup levels.*

The Blackbird Creek basin may be subject to infrequent but large snowmelt or thunderstorm events in the future, such as those that occurred in lower Panther Creek in 2002 and 2003. These extreme hydrologic events would produce large quantities of incoming debris flows and sediments from the side drainages, most of which would be clean and free from COCs. Alternative D would store these clean sediments requiring periodic removal.

Alternative D would reduce the amount of arsenic and cobalt migrating downstream into Panther Creek by capturing much of the bed load and suspended load in a large reservoir. This is expected to improve water quality in Panther Creek by eliminating a significant portion of the mobile arsenic and cobalt in the water column. The reservoir will significantly improve the quality of the in-stream sediments in Panther Creek by eliminating most of the source. The qualities of the in-stream sediments will improve as clean sediment replaces and/or covers those materials containing contaminants.

Reduction of Toxicity, Mobility and Volume: Alternative D would not alter the toxicity, mobility or volume of sediments and floc containing arsenic and cobalt through treatment. However, it would reduce the transport of these materials out of Blackbird Creek.

Short Term Effectiveness: Construction of a dam on Blackbird Creek would cause significant short term disruption due to the magnitude of the construction effort and the number of people and equipment involved. Although the site access road would be realigned above the dam and reservoir, access to the Blackbird Mine Site would be disrupted during the construction period. The work can be completed without significant incremental risk to public or workers. The work would require two to three years to complete and possibly longer because of the size of the dam.

The probability and extent of future overbank deposits containing significant COCs depends on the amount, timing and duration of exposure prior to full development of an effective control methodology. The large dam would take several years to design and construct and after construction the reservoir would be less than 100 percent effective. To the extent the overbank deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal would be required. If removal is required, there would be short-term impacts to the public associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs there could also be potential short-term risks because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. Therefore, the comparatively small exposure areas and the comparatively brief time between deposition and cleanup are not likely to significantly increase the long-term risks associated with excess exposure to COCs.

6.7.3 Implementability

Ease of Construction: There are many unknowns regarding the geologic conditions along Blackbird Creek which may result in challenges for the construction of a large dam.

Suitability of the Proposed Technology: Construction of a dam is well suited to the intended purpose. It is a proven technology that would be partially effective at reducing the migration of sediment and floc into Panther Creek.

Ease of Implementation: Construction of a single large dam along Blackbird Creek would be complex with respect to site access, schedule, new access roads being required and general disturbance. The work would require two to three years to complete and possibly longer because of the size of the dam. Once in place, the dam would require minimum O&M. However, large amounts of sediment removal would be required at infrequent intervals.

Administrative Constraints: The substantive requirements of the USFS permitting process will be met with respect to riprap source approval on Forest Service land. Regulatory barriers to implementation are likely due to the size, complexity and permanence of the required facility. Administrative constraints may stem from the *potential* need for *mitigation for* the disruption of the natural stream function resulting from the dam, the borrowing of large amounts of material for the dam and the relocation of the Blackbird Mine Site access road onto Forest Service land.

6.7.4 Cost

All capital, O&M and NPC are summarized in Table 6-1, with detail provided in Appendix G.

The capital cost estimates include major components of the dam, diversion during construction and new access road. The costs include markups for mobilization, CQA, design and contingency. Cost details are included in Appendix G.

Annual O&M costs associated with Alternative D includes one dam operator part time throughout each year, as well as sediment removal once every 25 years. A downstream sediment monitoring program is not included for this alternative.

6.7.5 Sensitivity

6.7.5.1 Flood Hydrology

The size of the large dam used in Alternative D is essentially fixed. If the design event (100-yr) and other *runoff events* are larger than the expected values used herein, the size of the spillway would be larger. Capital and O&M costs would be greater. Conversely, if the size of the design event and other *runoff events* are smaller than the values used, the size and cost of the spillway would be less. The implementability of Alternative D is unlikely to change significantly.

6.7.5.2 Annual and Event Sediment Transport Volumes

Because the size of the Alternative D dam is fixed, more incoming sediment annually, or during major *runoff events*, would require more frequent clean outs and therefore higher O&M costs. However the frequency of removal is very low so the potential impact would be minor. Similarly a decrease in the sediment flux would also have little potential impact.

6.7.5.3 Reservoir Effectiveness

Reservoir effectiveness has a direct impact on the effectiveness of the alternative. The best estimate of effectiveness during a 100 year event is 64 percent. The range is estimated to be 55 percent to 75 percent.

6.7.5.3 Reservoir Effectiveness

Reservoir effectiveness has a direct impact on the effectiveness of the alternative. The best estimate of effectiveness during a 100 year event is 64 percent. The range is estimated to be 55 percent to 75 percent.

6.8 Alternative E – In-Stream Stabilization and Removal with a Single Moderately Sized In-Stream Dam

6.8.1 General Performance

As with Alternative B, the in-stream stabilization structures and removal actions in Alternative E would significantly reduce erosion, scour and transport of contaminated sediments from Blackbird Creek to downstream locations along Blackbird and Panther Creeks. Alternative E would also include a moderately sized dam and reservoir near the mouth of Blackbird Creek to capture virtually all bedload, most suspended (fine-grained) sediments and some floc. These sediments would be removed periodically as part of scheduled maintenance and would be transported to a suitable disposal location.

Alternative E would provide significant stabilization of the Blackbird Mine Site access road because the migration of sediments in the channel would be significantly reduced and because the road itself would be armored and protected in many areas. Construction of the dam would require portions of the Blackbird Mine Site access road to be relocated onto Forest Service land.

Once the in-stream stabilization measures are in place, some re-working of surface sediments in stabilized depositional areas is anticipated *during* the initial *runoff events* after installation. This erosion, transport and deposition would likely occur on the surface of the stabilization areas, and not at depth where the majority of the potentially fine-grained and contaminated sediments exist. After the first few *runoff* events, the surface sediment would naturally armor and mobilization of sediments below the engineered structure elevations would be minimized or eliminated. Once the in-stream stabilization structures become fully effective, the in-stream dam may be considered for removal. Removal of the dam would allow new clean sediments to continue to be transported through the Blackbird Creek system, thereby maintaining the natural sediment transport processes of the system and mantling over the stabilized sediments. A more detailed description of the effectiveness and time associated with becoming fully effective is included in Section 6.4.2.

Additional in-stream stabilization, beyond the initial implementation, may be completed in the future. Future stabilization work would be performed as needed for new reaches identified as arsenic and cobalt source areas, as well as for existing areas that may need maintenance. This would be part of the on-going monitoring and maintenance work, which should diminish over time.

Performance of the reservoir included in Alternative E would be *significantly less effective than Alternative D, especially during large runoff* events, in terms of its ability to capture a percentage of the incoming sediment load. However, the total sediment load entering the Alternative E reservoir would be substantially lower than the load entering the Alternative D reservoir because of the in-stream stabilization and removal features included with Alternative E. It is likely that the net effect of the smaller reservoir coupled with in-stream stabilization would produce less COCs in the suspended (fine-grained) sediment being transported out of Blackbird Creek. Alternative E would be effective in retaining the total bedload. The reservoir provides 33,000 cubic yards of sediment storage whereas the average annual inflow of sediments is expected to be 4,000 cubic yards. The 100-year flood is estimated to produce 11,000 cubic yards of total load.

As described in Section 6.3.2, the reservoir included in Alternative E would remove approximately 23 percent of the incoming suspended (fine-grained) sediment and floc occurring during the 100 year flood. Although the effectiveness of the reservoir at capturing and retaining suspended sediment (fine-grained) and floc appears low, this occurs only during very infrequent *runoff events.* During more normal conditions, which exist most of the time, the reservoir would be more effective.

6.8.2 Effectiveness

Overall Protection of Human Health and the Environment: *The in-stream stabilization associated with Alternative E would greatly reduce the volume of sediments containing COCs that would be eroded from Blackbird Creek with downstream deposition in and along Panther Creek. The dam and reservoir would provide additional protectiveness by further reducing the potential for exceedances of EPA's human health-based cleanup levels in overbank deposition areas and reducing potential impacts to the natural recovery of in-stream sediments containing elevated concentrations of COCs. During smaller runoff events in Blackbird Creek (less than the two-year event), this alternative is predicted to be protective of human health and the environment. During larger runoff events, some of the Blackbird Creek fine-grained materials would not be captured by the reservoir, and could be deposited along Panther Creek at concentrations that exceed the cleanup levels. Thus, the protectiveness of Alternative E would be significantly reduced during larger runoff events until the surface sediments naturally armor with a mantle of clean sediments (on the order of six years). The reservoir would reduce the potential for exceedances of dissolved copper water quality cleanup levels in Panther Creek by providing additional time for adsorption of copper to iron oxyhydroxides.*

Compliance with ARARs: A description of ARARs is provided in Section 2.3 and Table 6-10. A summary of the most *significant* ARARs for this alternative is as follows:

- Safety of Dams, State of Idaho Rules and Regulations (Chapter 17, Section 42-1714, Idaho Code and provisions of Section 42-1709 through 42-1721, Idaho Code). These requirements are applicable to the moderate sized dam that would be constructed for this alternative.

Alternative E could result in release of a pollutant (such as turbidity) during construction. BMPs would be employed to minimize turbidity releases to comply with Idaho's water quality standards.

- *Clean Water Act Section 304 –The ROD established a total arsenic water quality cleanup level of 14 µg/L pursuant to Section 304. Alternative E would significantly reduce the potential to exceed the total arsenic cleanup level in Panther Creek during high runoff events.*
- Clean Water Act Section 404 – This *alternative would* significantly reduce the potential for future high flow runoff events to erode materials which could impact wetlands in Panther Creek and require removal. Any action that results in a disruption or destruction of wetlands *would* be required to meet the substantive requirements of Section 404 of the Clean Water Act, which requires that measures be taken to avoid or minimize impacts to wetlands *or loss of aquatic habitat,* or compensate for unavoidable impacts as a result of dredge or fill activities. *Construction of the moderate-sized dam would result in change of the aquatic habitat along Blackbird Creek and may require mitigation for the impacts of that change.*
- *Clean Water Act NPDES Regulations and Stormwater Permit Requirements (40 CFR 122-125, 40 CFR 122.26) – BMPs would be required to manage stormwater* during construction activities *and to meet State water quality standards.*
- State of Idaho Stream Channel Alteration (IDAPA 37.03.07) - This alternative would be required to meet the substantive requirements of IDAPA 37.03.07, which includes the State of Idaho's requirements for stream channel alterations. Applicable sections of IDAPA 37.03.07 include Minimum Standards (Rule 55), Construction Procedures (Rules 56), Dumped Rock Riprap (Rules 57) and Drop Structures, Sills and Barbs (Rule 59).
- Endangered Species Act (16 USC 1531 *et seq)* – EPA will be responsible for consultation with the NMFS and USFWS to determine whether remedial actions conducted for this alternative could affect threatened or endangered species.

Long Term Effectiveness and Permanence: Alternative E significantly reduces human health risk and protects the Blackbird Creek Road. It is expected to provide compliance with EPA's *cleanup* levels for arsenic and cobalt under most conditions by stabilizing Blackbird Creek sediments and providing for a downstream dam to capture sediments that may be mobilized during the time the in-stream stabilization is becoming fully effective. The dam also contributes to the partial *capture* of floc.

Alternative E would require annual maintenance, but it would provide an effective long-term solution with respect to stabilizing sediments containing arsenic and cobalt. The in-stream structures would immediately stabilize materials below the invert of the structures, but would take several years to become fully effective in the upper approximately one foot of the stabilized area. The dam and reservoir, intended as a short term part of the solution, would require annual maintenance, but would provide an effective solution to capturing sediments and to some extent floc, that travels down Blackbird Creek. See Section 6.4.2.

The Blackbird Creek basin may be subject to infrequent but large snowmelt or thunderstorm events in the future, such as those that occurred in lower Panther Creek in 2002 and 2003. These extreme hydrologic events would produce large quantities of incoming debris flows and sediments from the side drainages, most of which would be clean and free from COCs. Alternative E would *capture and* store *much of* these clean sediments, requiring their removal.

Alternative C will stabilize 90-96 percent of the potential contaminates of concern in place. A portion of the remaining contaminants will be captured by the moderate sized reservoir. This is expected to improve water quality in Panther Creek by eliminating a large portion of the mobile arsenic and cobalt in the water column. Some reduction in dissolved copper is expected due to *capture* of contaminated sediments and stabilization, but the amount of reduction is unknown. In-stream stabilization and removal coupled with a medium dam is expected to significantly improve the quality of the in-stream sediments in Panther Creek by eliminating the source in the long term. The qualities of the in-stream sediments will improve as clean sediment replaces and/or covers those materials containing contaminants.

Reduction of Toxicity, Mobility and Volume: Alternative E would not alter the toxicity, mobility, or volume of sediments containing arsenic and cobalt through treatment. However, over time the stabilization aspects of the alternative would substantially reduce the mobility of the arsenic and cobalt contained in the existing stream sediments by preventing them from being transported by natural stream processes and by the buildup of a clean mantel. The removal action included with Alternative E would reduce the volume of toxic materials by removing tailings and other materials high in arsenic and cobalt in the channel, bank and road. The reservoir would capture sediments and a portion of the floc that was transported downstream.

Short Term Effectiveness: Construction of a dam on Blackbird Creek in addition to in-stream structures would cause significant short term disruption. Access to the Blackbird Mine Site would be disrupted during the construction period. The work can be completed without significant incremental risk to public or workers. Design and construction of the in-stream stabilization structures could be completed by the end of 2010. The construction of a dam on Blackbird Creek would take two to three years to complete.

As described in detail in Section 6.5.2, the in-stream stabilization structures would provide immediate stabilization of materials below the invert elevations of the structures. Over the course of approximately 6 years, the armor layer would develop to provide effectiveness in stabilizing sediments above the invert elevation of the structures. This time period is an estimate and is dependent on the magnitude and timing of future high flow events in Blackbird Creek. Inclusion of a dam in Alternative E would provide a downstream reservoir to catch material that may be transported during the period the structures take to become fully effective. Even with the reservoir in place there is some risk of COCs in Panther Creek overbank deposits until the armor layer develops.

The probability and extent of future overbank deposits containing significant COCs depends on the amount, timing and duration of exposure prior to full development of an effective control methodology. The medium-*sized* dam would take several years to design and construct and after construction the reservoir would be less than 100 percent effective, *especially during larger runoff events.* To the extent the overbank deposits exceed cleanup levels for arsenic and/or PRGs for cobalt, removal would be required. If removal is required, there would be short-term impacts to the public associated with periodic cleanups of public and private properties along Panther Creek. These impacts would include disruption to the land owners associated with sampling and cleanups, additional construction traffic along the Panther Creek Road, disruption of vegetation and/or crops, and the time required to re-establish vegetation following cleanups. If re-contamination occurs there could also be potential short-term risks because of the lag periods between the depositional events and cleanups. These lag periods arise because of the time required for flows to recede and the time required to prepare and review sampling and analysis plans, to conduct sampling, to prepare and review work plans, and to conduct removals at each of the properties. However, the depositional areas are typically a small portion of the overall exposure area at each site, and EPA's arsenic cleanup levels and cobalt PRGs are based on long-term exposure. Therefore, the comparatively small exposure areas and the comparatively brief time between deposition and cleanup are not likely to significantly increase the long-term risks associated with excess exposure to COCs.

6.8.3 Implementability

Ease of Construction: No major construction issues are anticipated associated with the in-stream stabilization structures. A riprap source for 2010 work is currently being evaluated. The construction materials are believed to be readily available and the in-stream stabilization activity is of a size that mobilizing a contractor to complete construction in 2010 is manageable. However, there are many unknowns regarding the geologic conditions along Blackbird Creek which may result in construction challenges associated with dam construction and access road relocation.

Suitability of the Proposed Technology: In-stream stabilization is well suited to the intended purpose. It is a simple, proven technology that would be relatively effective once the system was implemented and adjusted as required. There is potential for some sediments at depth that contain arsenic and cobalt to be mobilized during very large flood flows; however the downstream reservoir is provided for capture of those mobilized sediments. Construction of a dam is suited to the intended purpose. It is a proven technology that would be effective at reducing the mobilization of sediment and floc from Blackbird Creek.

Ease of Implementation: The design and construction of the in-stream stabilization structures can occur relatively quickly. A preliminary design has been completed and a source of riprap is currently being evaluated; therefore design and construction of the in-stream stabilization structures should be completed by the end of 2010. The construction of a dam on Blackbird Creek would take two to three years to complete. Once in place, the dam would require minimum O&M and the in-stream stabilization structures can be easily maintained and adjusted if necessary. Sediment removal from the dam reservoir would be required periodically.

Administrative Constraints: Regulatory barriers to implementation are likely due to the size, complexity and permanence of the required facility. The substantive requirements of the USFS permitting process will be met with respect to riprap source approval on Forest Service land. No administrative constraints are anticipated with respect to construction of the in-stream stabilization structures. Administrative constraints may result from the *potential* need for *mitigation* of the disruption of the natural stream function resulting from the dam, the borrowing of large amounts of material for the dam and the relocation the Blackbird Mine Site access road onto Forest Service land.

6.8.4 Cost

All capital, O&M and NPC are summarized in Table 6-1, with detail provided in Appendix G.

The capital cost estimates include major components of the in-stream structures, dam, diversion during construction and new access road. The costs include markups for mobilization, CQA, design and contingency. Cost details are included in Appendix G.

Annual O&M costs associated with Alternative E includes an estimated annual cost of 5 percent of the total capital cost of the in-stream structures every 2 years, as well as one part time laborer each year, one monitoring program and a reduced level cleanup at year 2, and sediment removal every 8 years for the dam and reservoir.

6.8.5 Sensitivity

6.8.5.1 Flood Hydrology

If the design event (100-yr) and other *runoff events* are larger than the expected values used herein, the size of the required riprap in the stabilization structures would be larger and the structures themselves would be larger. Capital and O&M costs would be greater. Conversely, if the size of the design event and other *runoff events* are smaller than the values used, the size and cost of the alternative would be less. The effectiveness and implementability of in-stream stabilization portion of Alternative E is unlikely to change.

The size of the dam used in Alternative E is essentially fixed. If the design event (100-yr) and other *runoff events* are larger than the expected values used herein, the size of the spillway would be larger. Capital and O&M costs would be greater. Conversely, if the size of the design event and other *runoff events* are smaller than the values used, the size and cost of the spillway would be less. The implementability of Alternative E is unlikely to change significantly.

6.8.5.2 Annual and Event Sediment Transport Volumes

Changes in the actual amounts of sediment moved annually or by storms would not significantly influence the performance of Alternative E. If more sediment would move annually, or during major *runoff events*, the effectiveness of the in-stream stabilization would not be significantly different. The same is true if less sediment moves annually, or during major *runoff events*.

Because the size of the Alternative E dam is fixed, more incoming sediment annually, or during major *runoff events*, would require more frequent clean outs and therefore higher O&M costs. However the frequency of removal is low so the potential impact would be minor. Similarly a decrease in the sediment flux would also have little potential impact.

6.8.5.3 Reservoir Effectiveness

Reservoir effectiveness has a direct impact on the effectiveness of the alternative. The best estimate of effectiveness during a 100 year event is 23 percent. The range of uncertainty is estimated to be 0 percent to 40 percent.

6.9 Summary of Comparison of Alternatives

6.9.1 General Comparison

An evaluation of the performance of the alternatives in achieving the project criteria was presented previously in Section 6 and is summarized in Table 6-5. This comparison table summarizes the effectiveness, implementability and costs of the various alternatives.

6.9.2 Effectiveness

Overall Protection of Human Health and the Environment: Alternative A, the Baseline Remedy, is the least effective of the alternatives at protecting human health and the environment *because Blackbird Creek sediments would be periodically transported down Panther Creek with redeposition at overbank areas. In addition, the natural recovery of Panther Creek sediments would be delayed, and there would continue to be exceedances of water quality cleanup levels during high runoff events in Blackbird Creek.*

Alternatives B and D would be somewhat more protective than Alternative A. Both alternatives would reduce the transport of fine-grained sediments, either through the in-stream stabilization of Alternative B or the large dam of Alternative D. However, there would still be releases of some fine-grained sediments during larger runoff events, with associated releases of COCs to the water column. Both Alternatives B and D would speed up the natural recovery of the in-stream sediments in Panther Creek. The large dam of Alternative D would result in the greatest long-term impacts to the existing environment in Blackbird Creek.

Alternative E would be more protective than Alternatives B or D through the in-stream stabilization combined with the moderate-sized dam. Alternative E is anticipated to eliminate the risk of mobilization and re-deposition of fine-grained sediments along Panther Creek during smaller runoff events and reduce that risk during larger runoff events. Alternative E would have a similar reduction in the risk of water *quality exceedances and improvement in the natural recovery of in-stream sediments in Panther Creek. The moderate-sized dam of Alternative E would result in some long-term impacts to the existing environment in Blackbird Creek.*

Alternative C is the highest rated alternative in terms of protection of human health and the environment through the use of in-stream stabilization combined with the PCI Settling Basins. Alternative C is predicted to significantly reduce *the risk of mobilization of Blackbird Creek fine-grained sediments with re-deposition along Panther Creek during small and medium-sized runoff events and significantly reduce the re-mobilization risk during large runoff events. In addition, there would likely be dilution of the COCs in the transported sediments by clean sediments in Panther Creek during a large event, further reducing the risks of recontamination of overbank areas at concentrations higher than the cleanup levels. Alternative C would also significantly reduce the risk of water quality exceedances and it would speed up the natural recovery of in-stream sediments in Panther Creek. Alternative C would have moderate impacts to the Blackbird Creek aquatic environment because of the diversion of Blackbird Creek* from about 570 *feet of the existing channel. However, the impacts to the aquatic environment would be less than the dams associated with Alternatives D and E.*

Compliance with ARARs: *All of the alternatives would be able to meet the substantive requirements of the Action-Specific ARARs. Alternative A would not reduce the risk of exceeding water quality standards in Panther Creek during runoff events, whereas Alternative B would reduce the exceedance risk somewhat, especially after the first few years. Alternatives D and E would reduce the risk of water quality exceedances during smaller runoff events through capture of most of the contaminated sediments. However, these alternatives would still have the risk of exceedances during medium and larger runoff events. Alternative C would have the lowest risk of exceedances of water quality standards and may be able to meet the standards in all but the largest runoff events.*

Long-Term Effectiveness and Permanence: *Alternative A would have the lowest long-term effectiveness in terms of sediment transport and re-deposition along Panther Creek. Fine-grained sediments along Blackbird Creek would continue to be mobilized during large runoff events and deposited downstream along Panther Creek. The long-term effectiveness of the action alternatives is summarized in Table 6-4. As can be seen from Table 6-4, with the exception of Alternative B, the action alternatives are all very effective at eliminating the mobilization and redeposition of fine-grained sediments during smaller runoff events. As runoff events in Blackbird Creek become larger, Alternative C is the most effective, followed by Alternative E, then Alternative D.*

Alternatives A and B do little to capture or treat floc from upstream sources and prevent movement of floc into Panther Creek. Alternatives C, D, and E would capture varying proportions of the floc in reservoirs or settling basins under typical conditions, but would pass a portion of the incoming floc during infrequent flood conditions. Although Alternatives C and D are the most effective in removing floc, none of the alternatives would remove all of the floc under all conditions.

All of the alternatives, with the exception of Alternative A, are expected to improve water quality in Panther Creek by detaining a portion of the mobile arsenic that is suspended (i.e., the total concentration fraction) in the water column. The potential for contributions to exceedances of dissolved copper cleanup levels due to mobilization of sediments containing dissolvable copper would be reduced for Alternatives B, C, and E due to removal of contaminated sediments and stabilization along Blackbird Creek. There could be some additional removal of dissolved copper in the settling basins of Alternative C or the dams of Alternatives D and E. Alternatives C and E are expected to be more effective than Alternative D at reducing dissolved copper releases from sediments, however, the degree of reduction in dissolved copper cannot be quantitatively predicted for any of the alternatives.

All of the alternatives, with the exception of Alternative A, would reduce potential impacts to the natural recovery of in-stream sediments in Panther Creek. Alternatives C and E, would be most effective by eliminating the source in the long term through removal and in-stream stabilization, coupled with either the settling ponds or a medium dam. The large dam provided in Alternative D would be slightly more effective than Alternative B in terms of natural recovery of Panther Creek sediments.

All of the action alternatives are essentially comparable in terms of permanence. All of the action alternatives would be designed to withstand or pass flows up to the 500-year event in Blackbird Creek without sustaining substantial damage.

Reduction of Toxicity, Mobility, and Volume. *Alternative A would not reduce the toxicity, mobility or volume of COCs being transported down Blackbird Creek and redeposited along Panther Creek and therefore is rated lowest for this criteria. Alternative B would reduce the mobility of the COCs through in-stream stabilization and overbank removals along Blackbird Creek, but Alternative B would not address the toxicity or volume of COCs. Alternatives C, D, and E would reduce the mobility of the COCs, with Alternative C having the greatest mobility reduction, followed by Alternative E then D. Alternatives C, D, and E would all add a small amount of treatment for removal of dissolved copper by allowing additional time for co-precipitation of copper with the oxyhydroxides in either the reservoirs or settling ponds. None of the alternatives would reduce the toxicity of the COCs.*

Short-Term Effectiveness: The in-stream stabilization components of Alternatives B, C and E can likely be implemented by the end of 2010. Alternatives B, C and E would be immediately effective in *reducing* the movement of COCs from the sediments within and along the Blackbird Creek channel by stabilization or removal. The portion of sediments located above the invert elevation of grade control structures would be available for transport for the period of time it would take for these sediments to be reworked by the stream and an armor layer of coarse materials to form and/or clean sediments to move into the stabilized reaches. It may take several years (on the order of six years) for the clean sediments and bedload to fully mantel the stabilized depositional areas, but *most* of the COC mass currently available for transport within Blackbird Creek would be controlled immediately. However this is an estimate and time required will be dependent on magnitude and timing of high flow events in Blackbird Creek. Material below the invert of the in-stream stabilization structures would be fully stabilized at the time of construction.

Alternatives C and E, which include in-stream stabilization and a supplemental feature for capture and storage of sediments near the confluence of Blackbird Creek and Panther Creek, would capture most of those sediments that may be transported downstream during the time it would take for the clean mantel layer to form in the stabilized reaches. Construction of these supplemental features might not be completed until 2011 *for Alternative C or 2013 for Alternative E. Therefore,* the benefits of the dam or settling basins *would* not be realized *until construction was completed. The large dam associated with Alternative D could require as much as three years or more to complete.*

6.9.3 Implementability

Alternative A, is the most easily implemented followed in order by Alternatives B, C, E, and D, based on the relative amount of construction and complexity involved. The removal and in-stream stabilization components of Alternatives B, C, and E could be implemented by the end of 2010 with few construction related issues envisioned. Alternatives D and E both involve construction of dams that would be disruptive and take several years to design and construct, with the large dam associated with Alternative D taking the longest and being most disruptive.

6.9.4 Cost

A comparison of costs of the alternatives is provided in Table 6-1.

Alternative A, the baseline remedy, has the lowest total NPC. The baseline remedy alternative has no capital cost; however, the contaminated sediments and floc that would be transported out of Blackbird Creek and deposited along Panther Creek must be recovered and the downstream overbank areas cleaned every few years, following *runoff* events that cause migration of the contamination. The average annual O&M cost for cleanup is estimated to be $407,000, which is equivalent to a NPC of $5.8 million.

Alternative B is the next lowest cost with a total NPC of $8.7 million, followed by Alternative C at a NPC of $12.1 million and Alternative E at $18.3 million. Alternative D is the most costly alternative with a capital cost of $48.7 million due to the size of the dam required.

6.9.5 Monitoring

All of the alternatives will include continuing monitoring of sediments in Blackbird Creek and Panther Creek. The results of this monitoring will alert the site operators to the need for sediment removal if it occurs. It is assumed the monitoring is required every 2 years for Alternative A, at 2 and 4 years after construction for Alternative B, 2 years after construction for Alternatives C and E. It is assumed that no sediment monitoring is required for Alternative D.

TABLE 6-5
SUMMARY COMPARISON OF ALTERNATIVES

ALTERNATIVE		EFFECTIVENESS					IMPLEMENTABILITY				COST		
		Protective of Human Health & the Environment	Compliance w/ARARs	Long Term Effectiveness	Reduction in Toxicity, Mobility and Volume	Short Term Effectiveness	Constructability	Suitability *of Technology*	Ease of Implementation	Administrative Constraints	Capital	Annual O&M	Total NPC
A	Baseline Remedy	*Not protective. Continued risks to HH&E due to periodic re-deposition of COCs at overbank and in-stream areas along Panther Creek. Continued risk of exceedances of WQ standards during runoff events*	No change from *current conditions.* Potential to continue to exceed IWQS during future high flow events in Blackbird Creek.	*Least effective alternative. Sediments with COCs would continue to move downstream. Would require repeated disruption of properties along Panther Creek for cleanups. No road protection. There would be no improvement in the WQ and in-stream sediments in Panther Creek.*	No change from existing conditions. Natural processes continue to *slowly* reduce mobility.	No incremental short term impacts.	No issues	Highly suitable. Simple, and reliable technology.	No barriers to implementation.	No constraints likely.	$0	$407,000	$5,805,000
B	In-Stream Stabilization and Removal	*Least protective of action alternatives. Continued risk of re-deposition of COCs at overbank and in-stream areas along Panther Creek and exceedances of WQ standards during the first few years after implementation. Ongoing potential risk of releases during larger runoff events even after first few years.*	*Would* reduce potential to exceed IWQS. *Would be able to meet substantive requirements of other ARARs*	*Least effective of action alternatives. Potentially effective in the long-term but requires clean sediment armoring for full effectiveness. Road protection provided. WQ and in-stream sediments in Panther Creek would be improved over current conditions..*	Sediment mobility reduced. Floc mobility: unchanged. Sediment volume reduced through removal.	May release some COCs during and after construction; *likely* limited to first few years. Can be completed sooner than other alternatives.	No issues envisioned. Most constructible of the action alternatives.	Highly suitable. Simple, and reliable technology.	No major barriers to implementation.	Expected to offer the least administrative constraints other than Alternative A.	$6,061,000	$152,000	$8,694,000
C	In-Stream Stabilization and Removal with PCI Settling Basins	*Most protective alternative. Protective of HH&E for small and medium-sized runoff events (up to 25-year event). Potential small risk of re-deposition of COCs in overbank and in-stream areas and exceedances of WQ standards along Panther Creek during large runoff events (larger than 25-year event)*	*Would substantially reduce potential to exceed IWQS. Would be able to meet substantive requirements of other ARARs*	*Most effective alternative in the long-term by stabilizing sediments in place plus capturing residuals with settling basins. Road protection provided. WQ and in-stream sediments in Panther Creek would be substantially improved.*	Sediment mobility significantly reduced. Floc mobility reduced by settling basins. Sediment volume reduced through *removal.*	May release some COCs during construction. Most COCs not stabilized are captured by settling ponds. Can be constructed during 2010 or 2011.	*Settling basins likely more easily* constructible *than dams of Alts D and E.*	Highly suitable. Simple, and reliable technology.	Minor difficulty implementation due to construction near Panther Creek.	Minor administrative constraints expected due to diversion dam and PCI Settling Basins.	$8,817,000	$219,000	$12,091,000
D	Single Large Dam	*Less protective than Alternatives C and E. Protective of HH&E for small runoff events (up to 5-year event). Potential risk of re-deposition of COCs in overbank and in-stream areas and exceedances of WQ standards along Panther Creek during medium and large runoff events (larger than 5-year event)*	*Would reduce potential to exceed IWQS. Would be able to meet substantive requirements of other ARARs*	*Less effective than Alternative C. Traps most sediments during smaller runoff events, but effectiveness diminishes during larger runoff events. No road protection provided. WQ and in-stream sediments in Panther Creek would be substantially improved during smaller runoff events; less improvement during larger runoff events.*	Sediment and floc mobility reduced *through settlement behind large dam. No reduction in sediment volume.*	May release some COCs during construction; highly disruptive for two to three years of construction. Releases of *some* COCs during high flow events will continue indefinitely.	*Potential* problems due to need for large dam foundation investigations and preparation.	Highly Suitable. Simple, and reliable technology for sediments.	Difficulty with implementation due to very large dam. Construction period of 3 or 4 years likely.	The greatest administrative constraints expected due to disruption of stream function caused by a large dam, dam safety issues, extensive road relocation, and large volumes of borrow materials.	$43,074,000	$394,000	$48,693,000

ALTERNATIVE		EFFECTIVENESS					IMPLEMENTABILITY				COST		
E	In-Stream Stabilization and Removal with Single Moderately Sized Dam	*Less protective than Alternative C. Protective of HH&E for small runoff events (up to 5-year event). Potential risk of re-deposition of COCs in overbank and in-stream areas and exceedances of WQ standards along Panther Creek during medium and large runoff events (larger than 5-year event). More protective than Alternative D during larger events (greater than 10-year events)*	*Would substantially reduce potential to exceed IWQS. Would be able to meet substantive requirements of other ARARs*	*Less effective than Alternative C. Traps most sediments during smaller runoff events. Effectiveness greater than Alternative D during larger runoff events; however, effectiveness during larger events less than Alternative C. Road protection provided. WQ and in-stream sediments in Panther Creek would be substantially improved during smaller runoff events; less improvement during larger runoff events.*	*Sediment mobility significantly reduced. Floc mobility reduced by medium dam. Sediment volume reduced through removal*	May release some COCs during construction; highly disruptive for two to three years of anticipated construction.	*Potential problems due to need for medium dam foundation investigations and preparation.*	Highly suitable. Simple, and reliable technology for sediments.	Difficulty with implementation because of dam. Construction period of 3 to 4 years likely.	Administrative constraints expected due to disruption of stream function caused by dam, road relocation, and borrowing of materials.	$11,267,000	$485,000	$18,313,000

6.9.6 Sensitivity of the Alternatives Comparison to Uncertainty

This section discusses the potential impact of uncertainty in estimating key parameters on the comparison of the effectiveness, implementability and cost of the five alternatives. Each of the key parameters is discussed sequentially in the following sections.

6.9.6.1 Flood Hydrology

The estimates of the peak flood flows in Blackbird Creek for various recurrence intervals involve uncertainty. The ranges of the standard errors were estimated, providing a maximum and minimum value for each estimated peak flow. The ranges of peak flows for Blackbird Creek at its mouth are presented for the two recurrence intervals used in the design of the in-stream stabilization structures, the dams and the diversions structure. These are presented in Table 6-6 below.

TABLE 6-6
RANGE OF UNCERTAINTY OF PEAK FLOOD FLOWS AT MOUTH OF BLACKBIRD CREEK

Flood Event	Unit	Min	Expected Value	Max
100 Year	*Flow in* cfs	475	588	726
	Percent difference from Expected Value	19%	0%	23%
500 Year	*Flow in cfs*	1263	1510	1809
	Percent difference from Expected Value	16%	0%	20%

If these upper or lower values are used as a basis for the designs, the resulting configurations of the alternatives sometimes change. In other cases the structures remain the same but the effectiveness of the alternative is modified. For example, if the design event (100-yr) and other *runoff event*s are larger than the expected values used herein, the size of the required riprap in the stabilization structures would be larger and the structures themselves would be larger. Capital and O&M costs would be greater. Conversely, if the size of the design event and other *runoff event*s are smaller than the values used, the size and cost of the alternative would be less.

Because none of the alternatives *would be* 100 percent effective, increases or decreases in the magnitude and frequency of floods in Blackbird Creek would have a corresponding effect on the frequency of release of COCs to the Blackbird Creek channel and to Panther Creek. Changes in the effectiveness and implementability of in-stream stabilization due to changes in the design storms are likely to be modest. The costs of the alternatives are also affected by the size of the design storms. All the alternatives that include in-stream stabilization would have increased or decreased capital costs due to larger or smaller design storms. This would be expressed primarily in increased costs for the volume and size of the rock required for riprap. The increases and decreases would be similar for all the action alternatives except Alternative D, which does not include in-stream stabilization.

The dam embankments that are part of Alternatives D and E would not change in size or cost, but the associated spillways would be larger or smaller and more or less costly. As a percentage of total costs these increases or decreases would be modest because of the relatively high base cost of the dam alternatives.

Alternative C would be more or less costly with a larger/smaller design storm because of the need for a change in the overflow spillway. Because of the constrained width of the valley, the spillway crest width would remain the same and the flood surcharge would increases or decrease by 1 foot or less. The potential impact on cost would be modest. The diversion system and settling basins would not change.

The qualitative potential impacts of modified peak flood flow estimates on each of the alternatives are summarized in Table 6-7 below.

TABLE 6-7
RANGE OF UNCERTAINTY OF PEAK FLOOD FLOWS AT MOUTH OF BLACKBIRD CREEK

ALT	Effect of Higher Flood flows	Effect of Lower Flood flows
A	1. More frequent releases of COCs	1. Less COC discharge
B	1. More frequent releases of COCs	1. Less COC discharge
	2. Larger riprap and structures required.	2. Smaller riprap and structures required.
	3. Higher Capital and O&M Costs.	3. Lower Capital and O&M Costs
C	1. More frequent releases of COCs	1. Less COC discharge
	2. Larger riprap and structures required.	2. Smaller riprap and structures required.
	3. Larger emergency spillway	3. Smaller emergency spillway
	4. Higher Capital and O&M Costs.	4. Lower Capital and O&M Costs
D	1. More frequent releases of COCs	1. Less COC discharge
	2. Larger spillway	2. Smaller spillway
	3. Higher Capital and O&M Costs.	3. Lower Capital and O&M Costs
E	1. More frequent releases of COCs	1. Less COC discharge
	2. Larger riprap and structures required.	2. Smaller riprap and structures required.
	3. Larger spillway	3. Smaller spillway
	4. Higher Capital and O&M Costs.	4. Lower Capital and O&M Costs

6.9.6.2 Annual and Event Sediment Transport Volumes

As discussed in Section 3.1.3.2, the estimated average annual volume of bedload moving down Blackbird Creek is approximately 400 cubic yards, but there is uncertainty in this estimate. The range of the estimate is from 200 cubic yards to 800 cubic yards. Similarly the bedload fraction of the total sediment load is used to estimate the total sediment load of Blackbird Creek but this value is uncertain as well. Our best estimate of this fraction is 10 percent but it may range from 26 percent to as low as 5 percent. Based on the variability of the bedload fraction, and the best estimate of bed load, the estimate of the total sediment load ranges from a low of 1,600 cubic yards to a high of 8,000 cubic yards.

If the sediment load during normal years and during *runoff events* is higher or lower than the expected values, all of the alternatives will have a lower or higher (respectively) effectiveness in containing COCs. In general, more sediment flux means more COCs are transported and potentially deposited in overbank areas along Panther Creek and the remedy is less effective. Conversely, a lower flux means less deposition of COCs and greater effectiveness.

Among the action alternatives, those that include on-stream dams (Alternatives D and E) would also be affected by a change in the amount of sediment load during normal years and during *runoff events* through a change in the necessary O&M. The volumes reserved for sediment storage would need to be cleaned more or less frequently, increasing or decreasing O&M costs. No change to the capital costs is anticipated.

Alternative B would not be changed except for the change in effectiveness described above.

Alternative C would have a small increase/decrease in O&M, similar to the dam alternatives, due to the need for increased/decreased O&M at the diversion dam. The frequency of clean out of the settling basins would also change and would be reflected in the O&M costs. The capital costs of Alternative C are unlikely to change.

The effects of a change in the sediment transport volumes are summarized in Table 6-8 below.

TABLE 6-8
RANGE OF UNCERTAINTY OF ANNUAL AND EVENT SEDIMENT TRANSPORT VOLUMES

ALT	Effect of Larger Sediment Volumes	Effect of Smaller Sediment Volumes
A	1. More frequent releases of COCs	1. Less COC discharge
	2. Higher O&M Costs.	2. Lower O&M Costs
B	1. More frequent releases of COCs	1. Less COC discharge
	2. Higher O&M Costs.	2. Lower O&M Costs
C	1. More frequent releases of COCs	1. Less COC discharge
	2. Higher O&M Costs.	2. Lower O&M Costs
D	1. More frequent releases of COCs	1. Less COC discharge
	2. Higher O&M Costs.	2. Lower O&M Costs
E	1. More frequent releases of COCs	1. Less COC discharge
	2. Higher O&M Costs.	2. Lower O&M Costs

6.9.6.3 Reservoir Effectiveness

Changes in reservoir effectiveness would have a direct impact on the effectiveness of Alternatives D and E, see Table 6-9 below. The best estimate of effectiveness of the Alternative D reservoir during a 100-year event is 64 percent. The range is estimated to be 59 percent to 69 percent. The effectiveness of the Alternative E reservoir in retaining suspended (fine-grained) sediments *during a 100-year event* is estimated to be 23 percent, and ranges from a minimum of 17 percent to a maximum of 29 percent. Since reservoir effectiveness is directly related to the overall effectiveness of the alternatives, the two values are essentially the same because most of the COCs are associated with the suspended (fine-grained) sediments being described.

Changes in the effectiveness of the settling ponds of Alternative C due to changes in the design storm would likely be small. A larger or smaller storm would mean more or less sediment laden flow would pass over the spillway without settling, but the base 200 cfs would continue to be captured and sediment retained. Because of the lack of turbulence in the settling basins the percent change in effectiveness is likely to be less than that for the dam alternatives.

TABLE 6-9
RANGE OF UNCERTAINTY OF RESERVOIR EFFECTIVENESS FOR THE 100-YR EVENT

ALT	Effect of Greater Reservoir Effectiveness	Effect of Less Reservoir Effectiveness
A	1. No effect	1. No effect
B	1. No effect	1. No effect
C	1. No effect	1. No effect
D	1. 7% lower release of Suspended (fine-grained) Sediment and COCs during major flood events	1. 7% greater release of suspended (fine-grained) sediment and COCs during major flood events
	2. Slightly lower release of suspended (fine-grained) sediments and COCs during typical years.	2. Slightly greater release of suspended (fine-grained) sediments and COCs during typical years.
E	1. 26% lower release of Suspended (fine-grained) Sediment and COCs during major flood events	1. 26% greater release of suspended (fine-grained) sediment and COCs during major flood events
	2. Slightly lower release of suspended (fine-grained) sediments and COCs during typical years.	2. Slightly greater release of suspended (fine-grained) sediments and COCs during typical years.

6.9.6.4 Summary of Sensitivity of Changes in Key Parameters Evaluation of Best Alternatives

In summary there is some uncertainty regarding various parameters used in this comparison of alternatives. The variations generally do not change the relative merits of the alternatives. The key parameters include the magnitude and frequency of flood events, the amount of sediment moving downstream, in both normal years and in major flood events, and finally the effectiveness of on-stream reservoirs in removing suspended (fine-grained) sediments. The last parameter considered, West Fork Seepage reporting to Blackbird Creek as groundwater, has no impact because treatment was not included in any of the alternatives.

In general all of the alternatives are affected similarly by changes in the key parameters. If floods are larger than estimated, all the alternatives would be more costly and less effective, by approximately equal amounts. The converse is also true. The impact of sediment transport volumes is similar. Only reservoir effectiveness is different because those alternatives that do not include a dam and reservoir (Alternatives A, B and C) do not have the associated uncertainty.

7.0 RECOMMENDED ALTERNATIVE

Alternative C is recommended for implementation because:

1. Alternative C would be *the alternative most protective of human health and the environment because it would be best at* controlling exposures to COCs in the long term. Contaminated fine-grained sediments within the Blackbird Creek channel would be stabilized in place or removed through in-stream stabilization of sediments, coupled with aggressive supplemental *capture in the PCI Settling Basins.* The majority of the *potentially mobile* sediments *along Blackbird Creek* (90 – 96 percent) would be stabilized by the end of 2010.
2. Alternative C would provide additional *capture* of the winnowed sediments and floc *through construction of* the PCI Settling Basins. The basins would be operated so that nearly all of the flow of Blackbird Creek would pass through them. The sediments released during the winnowing process would flow into the settling basins thus allowing control of COCs included with those sediments. Most of the floc from West Fork Tailings Impoundment seepage would also be captured by the PCI Settling Basins. *Alternative C would significantly reduce the risk of water quality exceedances and would speed up the natural recovery of in-stream sediments in Panther Creek.*
3. *Alternative C would be the most effective alternative, and is predicted to be fully protective for small and medium-sized runoff events (up to about the 25-year event), During large runoff events (greater than about the 25-year event), there would be a slight risk of transport of COCs with deposition along Panther Creek; however, Alternative C would be the most effective alternative at reducing the risks of downstream transport during large events. In addition, there would likely be dilution of the COCs in the transported sediments by clean sediments in Panther Creek during a large event, further reducing the risks of recontamination of overbank areas at concentrations higher than the cleanup levels.*
4. Alternative C would be more easily implemented than the alternatives that include dams (Alternatives D and E). Construction of the *removal and* in-stream stabilization could be reasonably completed by the end of 2010, *and the settling basins could be completed by the end of 2010 or 2011.*
5. Alternative C would be fully effective in protecting the Blackbird Creek Road from erosion.
6. *The estimated present worth cost of Alternative C is $12.1 million. Alternative C would be higher in cost than Alternatives A or B, but significantly less costly than Alternatives D or E. Alternative C is the lowest cost alternative that would provide adequate protectiveness of human health and the environment.*

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TABLES

TABLE 2-1

REMEDIAL ACTION OBJECTIVES FOR BLACKBIRD CREEK SEDIMENTS AND OVERBANK DEPOSITS

Media	Receptors of Concern	Remedial Action Objectives
Surface Soils	Human Receptors	Reduce migration of surface soils and overbank deposits to downstream areas that would deposit concentrations of contaminants of concern in excess of the cleanup levels established at those downstream areas.
	Aquatic Receptors	Reduce migration of metals into the water column of the streams so that the cleanup levels established for the streams are not exceeded. Reduce migration of the surface soils to in-stream sediments so that the cleanup levels for the contaminants of concern established for in-stream sediments are not exceeded.
Surface Water	*Human Receptors*	*Maintain water quality for protection of human health.*
	Aquatic Receptors	*Reduce direct contact with surface water containing contaminants of concern in excess of the cleanup levels.* *Restore and maintain water quality and aquatic biota conditions capable of supporting all life stages of resident and anadromous salmonids and other fishes in Panther Creek.* *Reduce concentrations of contaminants of concern in Blackbird Creek to improve water quality such that cleanup levels are not exceeded in Panther Creek and to support some aquatic life in Blackbird Creek.*
Sediments	Aquatic Receptors	Reduce direct contact with in-stream sediments containing contaminants of concern in excess of the cleanup level. Reduce migration of in-stream sediments to downstream areas so that the cleanup levels for the contaminants of concern established for in-stream sediments at those downstream areas are not exceeded. Restore and maintain sediment quality and aquatic biota conditions capable of supporting all life stages of resident and anadramous salmonids and other fishes in Panther Creek. Reduce concentrations of contaminants of concern in Blackbird Creek to improve sediment quality such that the cleanup levels are not exceeded in Panther Creek and to support some aquatic life in Blackbird Creek.

TABLE 2-2

SUMMARY OF RELEVANT BLACKBIRD SITE CLEANUP LEVELS AND PRELIMINARY REMEDIATION GOALS

Drainage	Media	Arsenic	Cobalt	Copper	Risk Driver
Blackbird Creek	Soil – Upper Blackbird	8,500 mg/kg[1]	None	None	HHRA
	Soil – Lower Blackbird	4,300 mg/kg[1]	None	None	HHRA
Panther Creek Residential	Soil	100 mg/kg	97 mg/kg[2]	None	HHRA
USFS Campground	Soil	280	180[2]	None	HHRA
Undeveloped Campground Areas	Soil	400	200[2]	None	HHRA
Recreational Day Users	Soil	590	390[2]	None	HHRA
	Instream Sediment	35 mg/kg	80 mg/kg	149 mg/kg	Aquatics
	Surface Water	*0.014*[3] mg/L	0.086[4] mg/l	IWQC[5]	Aquatics

Notes:

1. While these are the specified cleanup levels for soils along Blackbird Creek to protect human receptors from incidental exposure in these locations, during remedial actions conducted during 2009, erodible soils containing >500 mg/kg were removed and in some locations soils >300 mg/kg were removed to prevent the possibility of causing recontamination of downstream areas along Panther Creek.
2. EPA's Preliminary Remediation Goals for cobalt.
3. *In March 2010, Idaho changed its surface water quality standard for dissolved arsenic from 0.050 mg/L to 0.010 mg/L. The surface water quality cleanup level established in the ROD was 0.014 mg/L total arsenic. There have been exceedances of the ROD's total arsenic cleanup level of 0.014 mg/L in Panther Creek during high runoff events in Blackbird Creek. However, there have been no measured exceedances of the State's revised dissolved arsenic standard of 0.010 mg/L in Panther Creek, even during high runoff events in Blackbird Creek. Therefore, the ROD's cleanup level of 0.014 mg/L total arsenic is the standard listed in this table.*
4. EPA's proposed cleanup level for dissolved cobalt
5. The equation for the dissolved copper cleanup level is based on total hardness and is the Idaho Water Quality Standard.

TABLE 3-4
BLACKBIRD FLOC CHEMISTRY RESULTS (OCTOBER 2008)

		Arsenic	Total Organic Carbon	Cobalt	Copper	Iron	Manganese	Paste pH	Sulfate	
	Units	mg/kg	wt%	mg/kg	mg/kg	mg/kg	mg/kg	s.u.	mg/kg	
	Reporting Limit	5 to 30	0.01	5	5	10 to 100	5	0.1	1 to 20	
WFIDSW-01	6-Oct-08	4,710	2.60	296	799	421,000	34	3.2	1,930	West Fork Area
WFTTSW-01	6-Oct-08	1,350	2.06	76	151	375,000	56	2.8	9,700	West Fork Area
WFCSW-01	6-Oct-08	556	2.34	1,040	662	558,000	502	6.6	318	West Fork Area
SETTIING POND A	6-Oct-08	1,450	5.26	83	412	364,000	96	2.9	23,700	West Fork Area
SETTLING POND B	6-Oct-08	1,120	2.82	198	894	247,000	201	5.0	496	West Fork Area
SETTLING POND DISCHARGE	7-Oct-08	954	2.89	203	818	236,000	233	5.0	583	West Fork Area
BBSW-02	7-Oct-08	884	3.72	123	1,210	374,000	190	5.3	513	Downstream of West Fork
BBSW-01.7	7-Oct-08	698	2.82	202	1,080	421,000	212	5.8	443	Downstream of West Fork
BBSW-01.3	7-Oct-08	940	3.90	379	1,500	272,000	595	5.8	518	Downstream of West Fork
BBSW-01A	7-Oct-08	1,280	4.69	642	2,040	335,000	630	6.1	638	Downstream of West Fork
LOWER PCI POND	7-Oct-08	1,360	4.65	936	1,990	273,000	672	6.2	799	Downstream of West Fork
PCI POND II	7-Oct-08	1,390	4.53	1,170	2,170	293,000	801	6.3	756	Downstream of West Fork
BLACKBIRD C (upstream of footbridge)	7-Oct-08	1,410	3.71	1,160	2,050	260,000	884	6.3	742	Downstream of West Fork
BLACKBIRD D (downstream of footbridge)	7-Oct-08	1,700	3.28	1,460	2,440	312,000	916	6.3	232	Downstream of West Fork
PANTHER A	7-Oct-08	1,300	4.00	803	1,570	181,000	752	6.5	363	Downstream of West Fork
PANTHER B	7-Oct-08	473	5.50	779	515	63,300	876	6.5	245	Downstream of West Fork

Notes:

Paste pH and sulfate determined for a 1:5 solid to solution ratio.

Concentrations reported as wet weight.

Golder Associates

TABLE 3-5
WEST FORK TAILINGS IMPOUNDMENT - SURFACE SEEPAGE FLOWS

		Flow (cfs)		
		WFTTSW-01	WFINTDITCH	Total
7-May-99	Spring 1999	-	0.18	-
26-Apr-00	Spring 2000	-	0.27	-
22-May-03	Spring 2003	0.11	0.17	0.28
4-May-04	Spring 2004	0.17	0.13	0.30
17-May-05	Spring 2005	0.13	0.12	0.25
16-May-06	Spring 2006	0.13	0.18	0.31
2-May-07	Spring 2007	0.13	0.22	0.35
6-Jun-08	Spring 2008	0.13	0.30	0.43
21-May-09	Spring 2009	0.12	0.23	0.35
20-Sep-00	Fall 2000	-	0.25	-
18-Sep-02	Fall 2002	-	0.05	-
23-Sep-04	Fall 2004	0.11	0.12	0.23
20-Sep-06	Fall 2006	0.13	0.19	0.32
6-Oct-08	Fall 2008	0.13	0.23	0.36
	Average (cfs)	0.13	0.19	0.32
	Max (cfs)	0.17	0.30	0.43
	Min (cfs)	0.11	0.05	0.23
	Average (gpm)	58	84	142
	Max (gpm)	76	134	192
	Min (gpm)	49	20	105

TABLE 3-6
BLACKBIRD CREEK WATER QUALITY MODEL - INPUT WATER QUALITIES

Parameter	Units	West Fork Tailings Impoundment Seepage			West Fork Clean Water Diversion		Blackbird Creek BBSW-03	
		Groundwater	Surface					
		WFMW-01S	WFINTDITCH	WFTTSW-01	WFSW-03, WFSW-02.5 and WFSW-02		BBSW-03	
		2004 to 2007	2002 to 2008	2003 to 2008	Fall 2000 to 2002	Spring 2000 to 2007	Fall Synoptic 2005 to 2008	Spring Synotic 2005 to 2008
pH	s.u.	5.6	4.5	4.9	7.8	7.3	7.2	7.1
Alkalinity	mg/L as $CaCO_3$	***10***	3	1	38	15	5	16
SO_4	mg/L	458	341	354	7.3	4.0	57	20
Cl	mg/L	***11***	-	-	-	-	-	-
Ca	mg/L	40	36	43	10	5.0	18	8
Mg	mg/L	18	16	17	3.0	1.7	3.8	3.1
K	mg/L	***12***	-	-	-	-	-	-
Na	mg/L	***4***	-	-	-	-	-	-
As	mg/L	0.056	0.10	0.034	0.010	0.003	0.010	0.012
Co	mg/L	5.0	3.2	3.1	0.006	0.005	0.16	0.067
Cu	mg/L	0.002	0.059	0.027	0.002	0.002	0.031	0.033
Fe	mg/L	173	95	83	0.020	0.066	0.030	0.12
Mn	mg/L	***3.7***	2.2	2.7	0.003	0.004	0.010	0.033
Temp.	°C	6.5	8.7	9.7	8.4	5.4	9.1	6.5

Notes:

Bold italics identify concentrations that were estimated based on a longer data record (no data available for recent monitoring).

Period of record used to calculate average concentrations shown in table header.

Non-detect concentrations assumed equal to the detection limit in calculation of average concentrations.

Non-detect concentrations with elevated reporting limits omitted from the calculation of average concentrations.

Solutions charged balanced by the addition of chloride (anion deficient) or potassium (cation deficient). Adjusted concentrations not shown in table.

Dissolved metal concentrations (As, Co, Cu, Fe and Mn) used in model simulations.

An initial Eh of 500 mV (at 25 °C) was assumed for all surface waters (including WFTTSW-01 and WFINTDITCH).

An initial Eh of 200 mV (at 25 °C) was assumed for groundwater (WFMW-01S).

TABLE 3-7
BLACKBIRD CREEK WATER QUALITY MODEL - INPUT WATER FLOWS

		Flow (gpm)				Description of Data Source
		Average		Maximum		
		Spring	Fall	Spring	Fall	
West Fork Tailings Impoundment Seepage						
Groundwater	WFMW-01S	10		10		Feasibility Study (Golder, 2002)
Surface	WFINTDITCH	83		134		Average and maximum measured flows (see Table 3-5).
	WFTTSW-01	58		76		Average and maximum measured flows (see Table 3-5).
West Fork Clean Water Diversion						
WFSW-03 WFSW-02.5 WFSW-02		13,382	655	13,382	655	Clean water diversion flow was calculated for each synoptic event as the increase in flow between BBSW-03 and BBSW-02 minus the contribution from surface seeps (WFINTDITCH and WFTTSW-01). the average flow was then calculated for all synoptic events (2005 to 2008) for use in the model simulations.
Blackbird Creek						
BBSW-03/03A		11,744	404	11,744	404	Average of measured synoptic sampling flows (2005 to 2008).

TABLE 3-8
BLACKBIRD CREEK WATER QUALITY MODEL RESULTS - SPRING

		Spring - Average Flow Conditions						Spring - Maximum Flow Conditions					
		Current Conditions		Capture 50% Surface Seepage		Capture 90% Surface Seepage		Current Conditions		Capture 50% Surface Seepage		Capture 90% Surface Seepage	
		Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls
pH	s.u.	7.2	7.7	7.2	7.7	7.2	7.7	7.2	7.7	7.2	7.7	7.2	7.7
pe	s.u.	4.8	1.4	5.0	1.6	5.3	2.0	4.6	1.2	4.8	1.5	5.3	1.9
Alkalinity	mg/L as $CaCO_3$	15	15	15	15	15	15	15	15	15	15	15	15
As	mg/L	0.008	0.003	0.007	0.003	0.007	0.003	0.008	0.004	0.008	0.003	0.007	0.003
Ca	mg/L	6.6	6.6	6.6	6.6	6.5	6.5	6.7	6.7	6.6	6.6	6.5	6.5
Cl	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Co	mg/L	0.053	0.053	0.045	0.045	0.038	0.037	0.062	0.062	0.049	0.049	0.038	0.038
Cu	mg/L	0.017	0.008	0.017	0.007	0.016	0.006	0.017	0.008	0.017	0.008	0.017	0.006
Fe	mg/L	0.67	0.54	0.41	0.30	0.21	0.11	0.91	0.77	0.54	0.42	0.23	0.13
K	mg/L	1.4	1.4	1.4	1.4	1.3	1.3	1.5	1.5	1.4	1.4	1.3	1.3
Mg	mg/L	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.4	2.4	2.4	2.4
Mn	mg/L	0.032	0.032	0.026	0.026	0.020	0.020	0.038	0.038	0.029	0.029	0.021	0.021
SO_4	mg/L	14	14	13	13	12	12	14	14	13	13	12	12

Notes:
Con. Mix - conservative mix
Geo. Controls - geochemical controls
Geochemical Controls - precipitation of ferrihydrite, adsorption onto ferrihydrite and equilibrium with atmospheric carbon dioxide.
Solutions charge balanced by the addition of K or Cl.

TABLE 3-9
BLACKBIRD CREEK WATER QUALITY MODEL RESULTS - FALL

		Fall - Average Flow Conditions						Fall - Maximum Flow Conditions					
		Current Conditions		Capture 50% Surface Seepage		Capture 90% Surface Seepage		Current Conditions		Capture 50% Surface Seepage		Capture 90% Surface Seepage	
		Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls
pH	s.u.	7.6	7.8	7.7	7.8	7.7	7.9	7.6	7.8	7.7	7.8	7.7	7.9
pe	s.u.	3.0	-0.8	2.8	-0.7	2.6	-0.4	3.0	-0.8	2.9	-0.8	2.6	-0.5
Alkalinity	mg/L as $CaCO_3$	22	21	24	23	25	25	21	20	23	22	25	25
As	mg/L	0.018	0.013	0.014	0.011	0.011	0.010	0.021	0.014	0.016	0.013	0.012	0.010
Ca	mg/L	17	17	15	15	14	14	18	18	16	16	14	14
Cl	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Co	mg/L	0.47	0.46	0.30	0.30	0.15	0.15	0.61	0.60	0.39	0.38	0.17	0.17
Cu	mg/L	0.017	0.016	0.015	0.014	0.013	0.013	0.019	0.017	0.016	0.015	0.014	0.013
Fe	mg/L	12	11	7.1	6.8	2.8	2.7	16	15	9.6	9.2	3.4	3.2
K	mg/L	3.7	3.7	2.5	2.5	1.4	1.4	7.2	7.2	5.8	5.8	4.5	4.5
Mg	mg/L	4.9	4.9	4.2	4.2	3.6	3.6	5.5	5.5	4.6	4.6	3.7	3.7
Mn	mg/L	0.31	0.31	0.18	0.18	0.071	0.071	0.42	0.42	0.25	0.25	0.085	0.085
SO_4	mg/L	67	67	50	50	34	34	82	82	58	58	36	36

Notes:
Con. Mix - conservative mix
Geo. Controls - geochemical controls
Geochemical Controls - precipitation of ferrihydrite, adsorption onto ferrihydrite and equilibrium with atmospheric carbon dioxide.
Solutions charge balanced by the addition of K or Cl.

TABLE 3-10
BLACKBIRD CREEK WATER QUALITY MODEL RESULTS - FALL REDOX SENSITIVITY ANALYSIS

		Fall - Average Flow Conditions						Fall - Average Flow Conditions Redox Sensitivity Analysis					
		Current Conditions		Capture 50% Surface Seepage		Capture 90% Surface Seepage		Current Conditions		Capture 50% Surface Seepage		Capture 90% Surface Seepage	
		Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls	Con. Mix	Geo. Controls
pH	s.u.	7.6	7.8	7.7	7.8	7.7	7.9	7.5	7.7	7.6	7.8	7.7	7.9
pe	s.u.	3.0	-0.8	2.8	-0.7	2.6	-0.4	4.5	-0.1	4.3	-0.3	3.7	-0.3
Alkalinity	mg/L as $CaCO_3$	22	21	24	23	25	25	22	16	24	20	25	24
As	mg/L	0.018	0.013	0.014	0.011	0.011	0.010	0.018	0.002	0.014	0.003	0.011	0.005
Ca	mg/L	17	17	15	15	14	14	17	17	15	15	14	14
Cl	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Co	mg/L	0.47	0.46	0.30	0.30	0.15	0.15	0.47	0.38	0.30	0.26	0.15	0.14
Cu	mg/L	0.017	0.016	0.015	0.014	0.013	0.013	0.017	0.004	0.015	0.006	0.013	0.009
Fe	mg/L	12	11	7.1	6.8	2.8	2.7	12	5.4	7.1	3.6	2.8	2.0
K	mg/L	3.7	3.7	2.5	2.5	1.4	1.4	7.9	7.9	4.7	4.7	1.9	1.9
Mg	mg/L	4.9	4.9	4.2	4.2	3.6	3.6	4.9	4.9	4.2	4.2	3.6	3.6
Mn	mg/L	0.31	0.31	0.18	0.18	0.071	0.071	0.31	0.31	0.18	0.18	0.071	0.071
SO_4	mg/L	67	67	50	50	34	34	67	67	50	50	34	34

Notes:
Con. Mix - conservative mix
Geo. Controls - geochemical controls
Geochemical Controls - precipitation of ferrihydrite, adsorption onto ferrihydrite and equilibrium with atmospheric carbon dioxide.
Solutions charge balanced by the addition of K or Cl.
Base Case Simulation
An initial Eh of 500 mV (at 25 °C) was assumed for all surface waters (including WFTTSW-01 and WFINTDITCH).
An initial Eh of 200 mV (at 25 °C) was assumed for groundwater (WFMW-01S).
Redox Sensitivity Analysis Simulation
An initial Eh of 600 mV (at 25 °C) was assumed for all surface waters (including WFTTSW-01 and WFINTDITCH).
An initial Eh of 300 mV (at 25 °C) was assumed for groundwater (WFMW-01S).

TABLE 6-10

COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

ARARs & To Be Considered Requirements	Alternative A – Baseline Alternative	Alternative B – In-Stream Stabilization & Removal	Alternative C – In-Stream Stabilization & Removal with PCI Settling Basins	Alternative D – Large Dam	Alternative E – In-Steam Stabilization & Removal with Moderate Dam
Idaho Water Quality Standards (IDAPA 58.01.02)	Applicable – Potential *would remain* to exceed *IWQS* for dissolved copper during *large* runoff events	Applicable – *Would* reduce potential to exceed *IWQS* for dissolved copper *during large runoff events. Remedial actions may result in discharges to waters of the state. BMPs to reduce turbidity and comply with other WQS would be employed.*	Applicable – *Would* significantly reduce potential to exceed *IWQS for* dissolved copper *during large runoff events. Remedial actions may result in discharges to waters of the state. BMPs to reduce turbidity and comply with other WQS would be employed.*	Applicable – *Would reduce potential to exceed IWQS for dissolved copper during large runoff events. Remedial actions may result in discharges to waters of the state. BMPs to reduce turbidity and comply with other WQS would be employed.*	Applicable – *Would* significantly reduce potential to exceed *IWQS* for dissolved copper *during large runoff events. Remedial actions may result in discharges to waters of the state. BMPs to reduce turbidity and comply with other WQS would be employed.*
Clean Water Act Section 304	Relevant and Appropriate - *AWQC-based total arsenic standard of 14 µg/L in Panther Creek would continue to be exceeded during large runoff events.*	*Relevant and Appropriate - would reduce the risk of exceedances of the AWQC-based total arsenic standard of 14 µg/L in Panther Creek during large runoff events.*	Relevant and Appropriate *- would significantly reduce the risk of exceedances of the AWQC-based total arsenic standard of 14 µg/L in Panther Creek during large runoff events.*	Relevant and Appropriate - *would reduce the risk of exceedances of the AWQC-based total arsenic standard of 14 µg/L in Panther Creek during large runoff events. .*	Relevant and Appropriate - *would significantly reduce the risk of exceedances of the AWQC-based total arsenic standard of 14 µg/L in Panther Creek during large runoff events.*
Clean Water Act NPDES (40 CFR 122-125, 40 CFR 440)	*Relevant and Appropriate – this alternative does not include any changes to point source discharges*	*Relevant and Appropriate – this alternative does not include any changes to point source discharges*	*Relevant and Appropriate– PCI settling basins would result in change of location of Blackbird Creek discharges to Panther Creek and associated mixing zones in Panther Creek.*	*Relevant and Appropriate – this alternative does not include any changes to point source discharges*	*Relevant and Appropriate – this alternative does not include any changes to point source discharges*

TABLE 6-10

COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

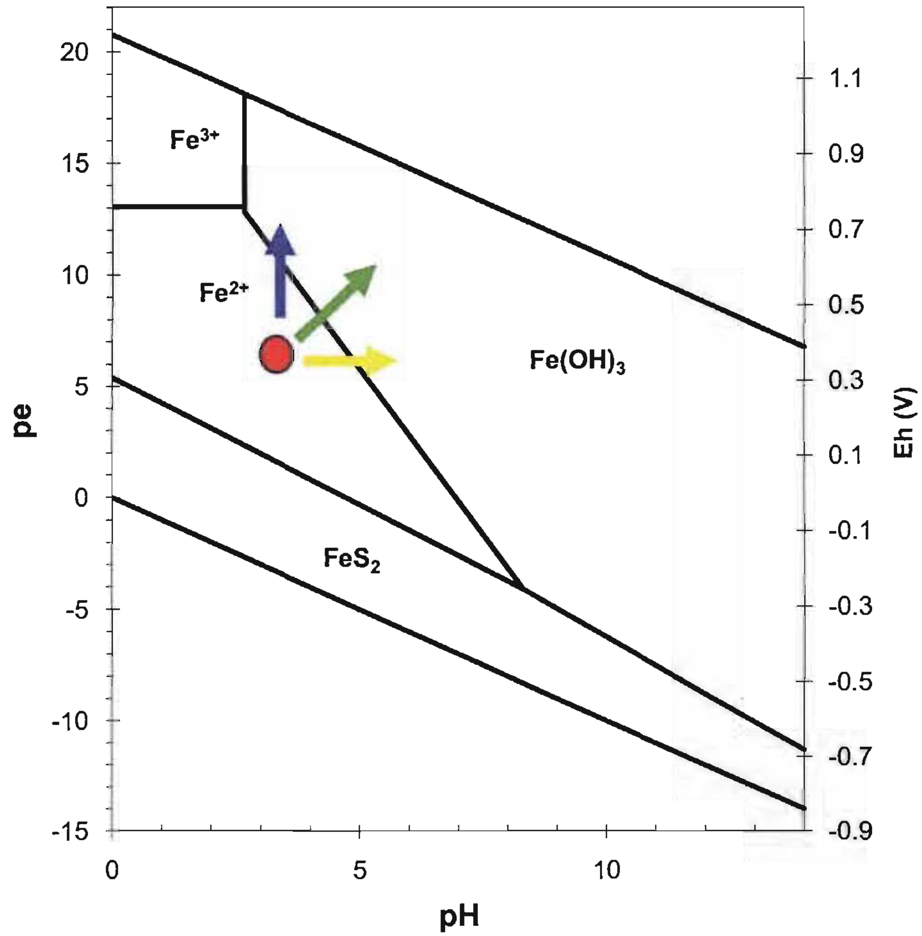
ARARs & To Be Considered Requirements	Alternative A – Baseline Alternative	Alternative B – In-Stream Stabilization & Removal	Alternative C – In-Stream Stabilization & Removal with PCI Settling Basins	Alternative D – Large Dam	Alternative E – In-Steam Stabilization & Removal with Moderate Dam
Clean Water Stormwater *(40 CFR 122-125 and* 40 CFR 122.26)	Applicable - BMPs *would* be required to manage stormwater during construction activities for any future removals.	Applicable - BMPs *would* be required to manage stormwater during construction activities.	Applicable - BMPs *would* be required to manage stormwater during construction activities.	Applicable - BMPs *would* be required to manage stormwater during construction activities.	Applicable - BMPs *would* be required to manage stormwater during construction activities.
Safety of Dams (*IDAPA* Chapter 17, Section 42-1714, and provisions of Section 42-1709 through 42-1721)	*Does not apply to this Alternative*	*Does not apply to this Alternative*	*Does not apply to this Alternative*	Applicable for the large dam included with this Alternative	Applicable for the *moderate-sized* dam included with this Alternative.
State of Idaho Stream Channel Alteration (IDAPA 37, Title 03, Chapter 07)	Does not apply to this Alternative	Applicable to remedial actions in Blackbird Creek to stabilize the channel and remove sediments	Applicable to remedial actions in Blackbird Creek to stabilize the channel and remove sediments and to alteration of lower Blackbird Creek to discharge to PCI settling basins..	Applicable due to large dam that would be constructed in Blackbird Creek	Applicable to remedial actions in Blackbird Creek to stabilize the channel and remove sediments and due to construction of moderate dam in Blackbird Creek.
Endangered Species Act (16 USC 1531 *et seq*)	*Does not apply to this Alternative .*	Applicable – *would require* Section 7 consultation with NMFS and USFWS.	Applicable – *would require* Section 7 consultation with NMFS and USFWS.	Applicable – *would require* Section 7 consultation with NMFS and USFWS.	Applicable – *would require Section 7* consultation with NMFS and USFWS.
Clean Water Act, Section 404 (40 CFR 230, 33 CFR 320-330)	Applicable to any future remedial actions *along Panther Creek*	Applicable to remedial actions involving wetlands *and placement of fill materials.* This	*Applicable to remedial actions involving wetlands and placement of fill materials. This alternative*	*Applicable to remedial actions involving wetlands and placement of fill materials. This*	*Applicable to remedial actions involving wetlands and placement of fill materials. This*

TABLE 6-10

COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

ARARs & To Be Considered Requirements	Alternative A – Baseline Alternative	Alternative B – In-Stream Stabilization & Removal	Alternative C – In-Stream Stabilization & Removal with PCI Settling Basins	Alternative D – Large Dam	Alternative E – In-Steam Stabilization & Removal with Moderate Dam
	involving wetlands.	alternative *would* reduce potential for future impacts to wetlands.	*would significantly reduce potential for future impacts to wetlands..*	*alternative would reduce potential for future impacts to wetlands..*	*alternative would significantly reduce potential for future impacts to wetlands.*
Executive Order 11990, Protection of Wetlands	*Applicable* to any future remedial actions involving wetlands.	Applicable to remedial actions involving wetlands.	Applicable to remedial actions involving wetlands. Wetlands at PCI will need to be delineated and mitigation for any loss of wetlands may be required.	Applicable to remedial actions involving wetlands.	Applicable to remedial actions involving wetlands.
Executive Order 11988, Floodplain Management	*Applicable* to any future remedial actions in floodplains.	Applicable to remedial actions in floodplains.	Applicable to remedial actions in floodplains.	Applicable to remedial actions in floodplains.	Applicable to remedial actions in floodplains.
Fish and Wildlife Coordination Act (16 USC 661 *et seq)*	*Applicable to any future* remedial actions that may have effect on fish and wildlife.	Applicable to remedial actions that may have effect on fish and wildlife.	Applicable to remedial actions that may have effect on fish and wildlife.	Applicable to remedial actions that may have effect on fish and wildlife.	Applicable to remedial actions that may have effect on fish and wildlife.
USFS Policies (FSM 7400 and 7500).	To be Considered during design and implementation of remedial actions on National Forest Service Land/	To be Considered during design and implementation of remedial actions on National Forest Service Land/	To be Considered during design and implementation of remedial actions on National Forest Service Land/	To be Considered during design and implementation of remedial actions on National Forest Service Land/	To be Considered during design and implementation of remedial actions on National Forest Service Land/

FIGURES



LEGEND

Cause of Ferrihydrite Precipitation

1. Change to more oxidizing conditions.

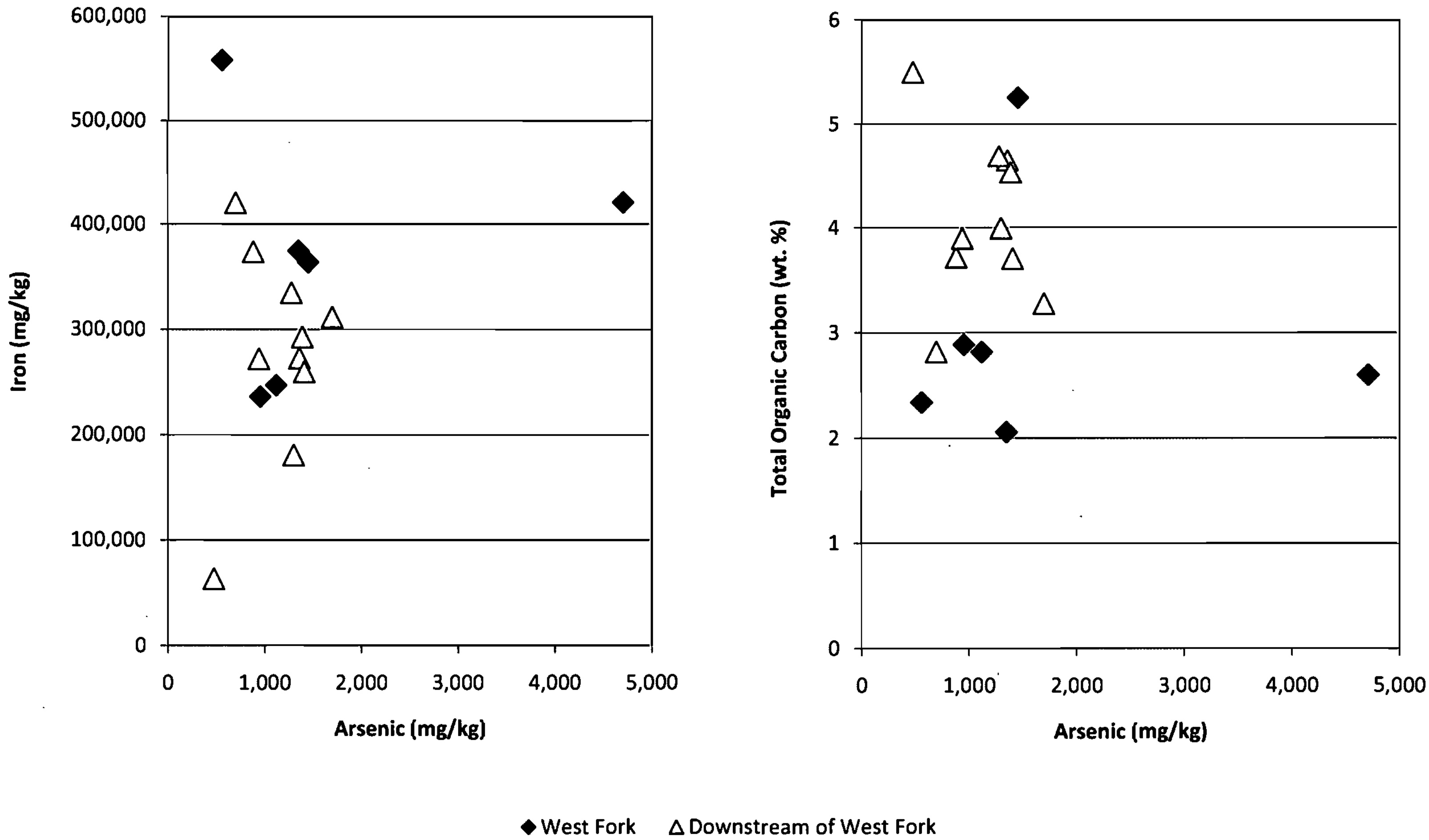
2. Change to more basic conditions.

3. Change to more oxidizing and basic conditions.

Total Fe = 1.8×10^{-3} M
Total S = 2.6×10^{-3} M
Temperature = 25 ^{oC}

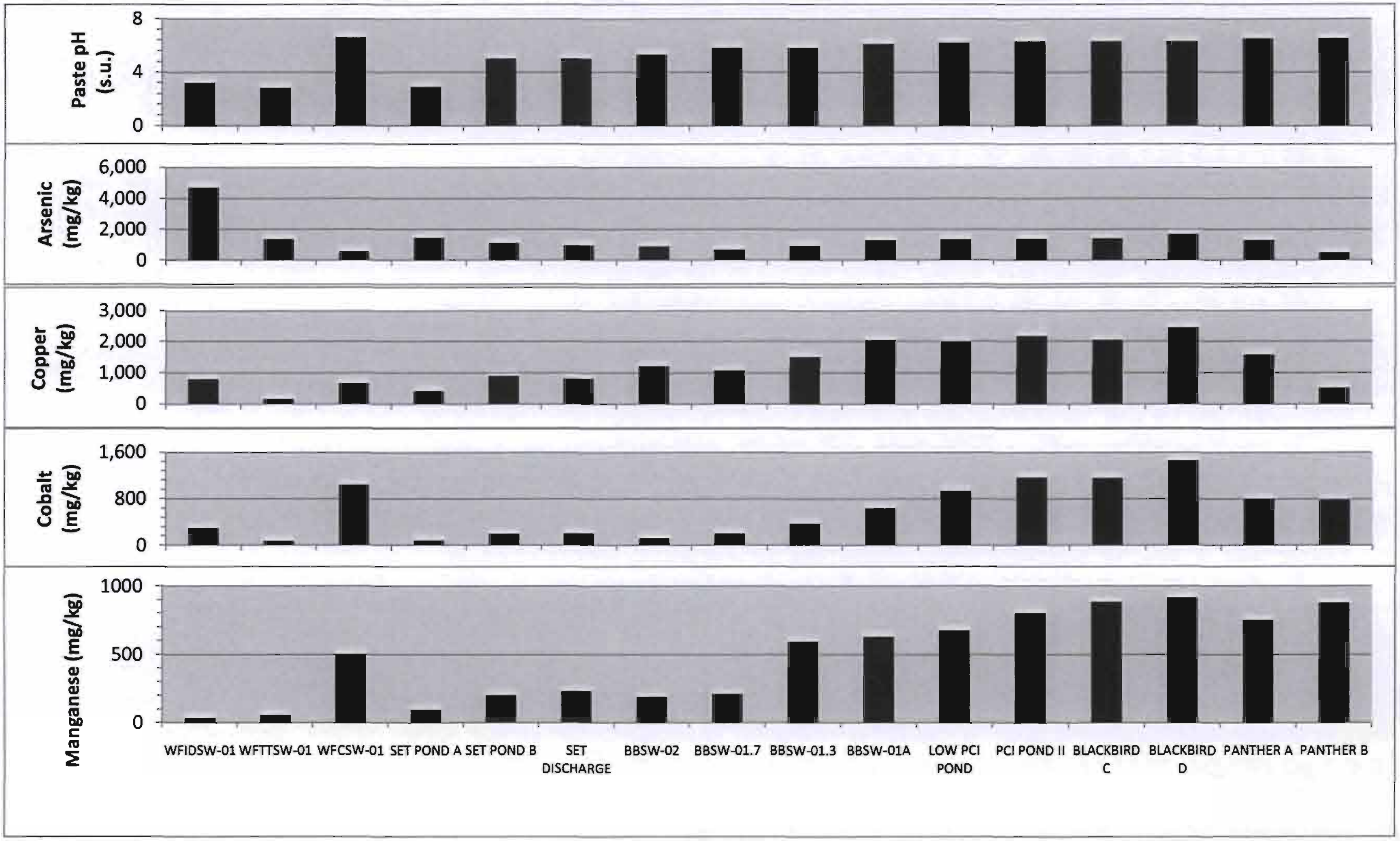
Golder Associates	Title: Eh-pH diagram for the Fe-S-H2O System		Drawn: CR
			Checked: RV
	Project Name: Blackbird Mine	Project No.: 943-1595-400.1280	Reviewed: RV
	Client Name: Blackbird Mine Site Group	Date: February 2010	FIGURE 3-5

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\Ferrihydrite Stability (Feb 2009).xlsx



Golder Associates	Title	Blackbird Floc Chemistry Results - As vs. Fe / TOC		Drawn	CR
	Project Name	Blackbird Mine	Project No. 943-1595-400.1280	Checked	RV
				Reviewed	RV
	Client Name	Blackbird Mine Site Group	Date February 2010	FIGURE	3-6

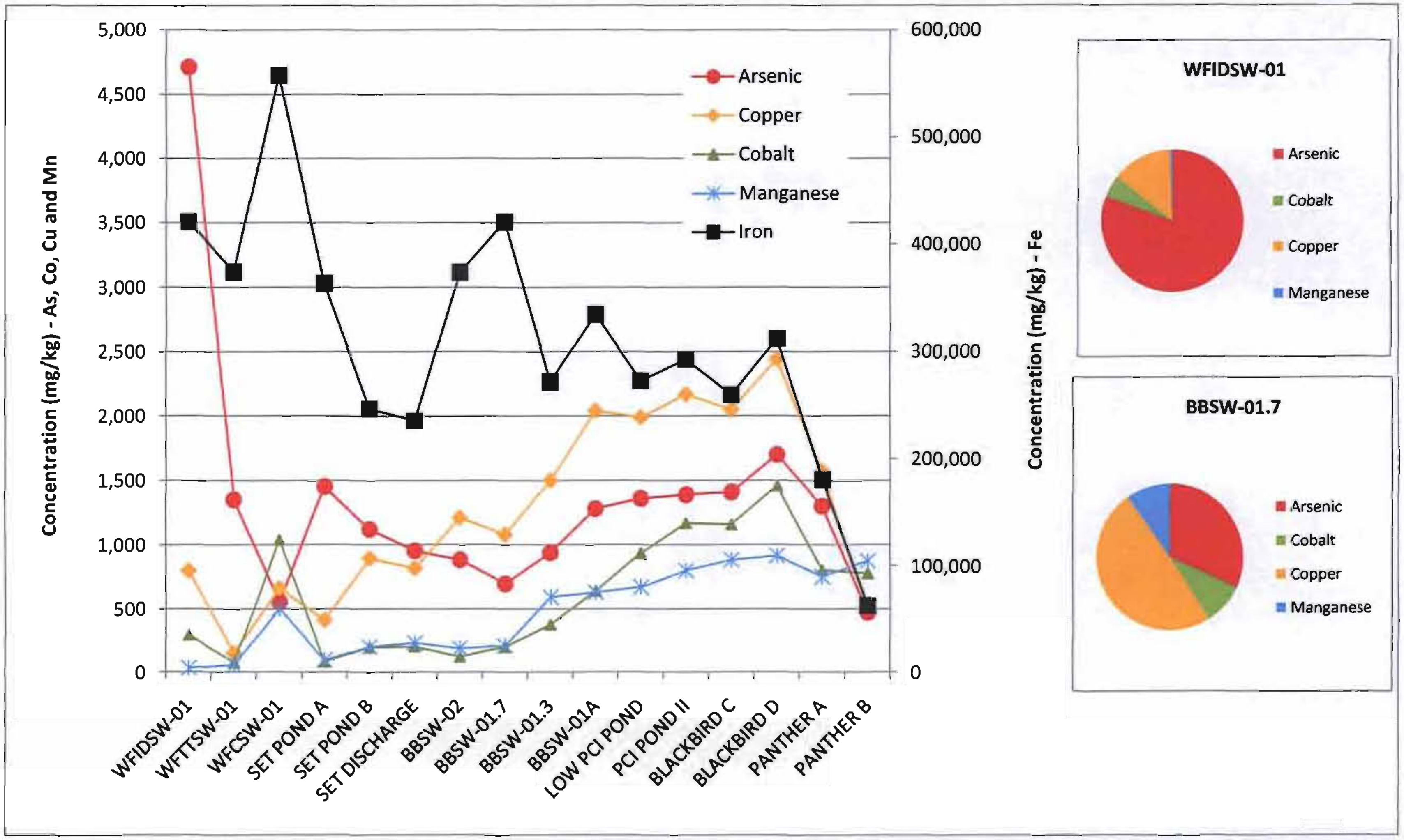
P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\Floc Data (Feb 2009).xlsx



Golder Associates

Title	Blackbird Floc Chemistry Results - pH, As, Co, Cu and Mn	Drawn	CR
		Checked	RV
Project Name: Blackbird Mine	Project No. 943-1595-400.1280	Reviewed	RV
Client Name: Blackbird Mine Site Group	Date: February 2010	FIGURE	3-7

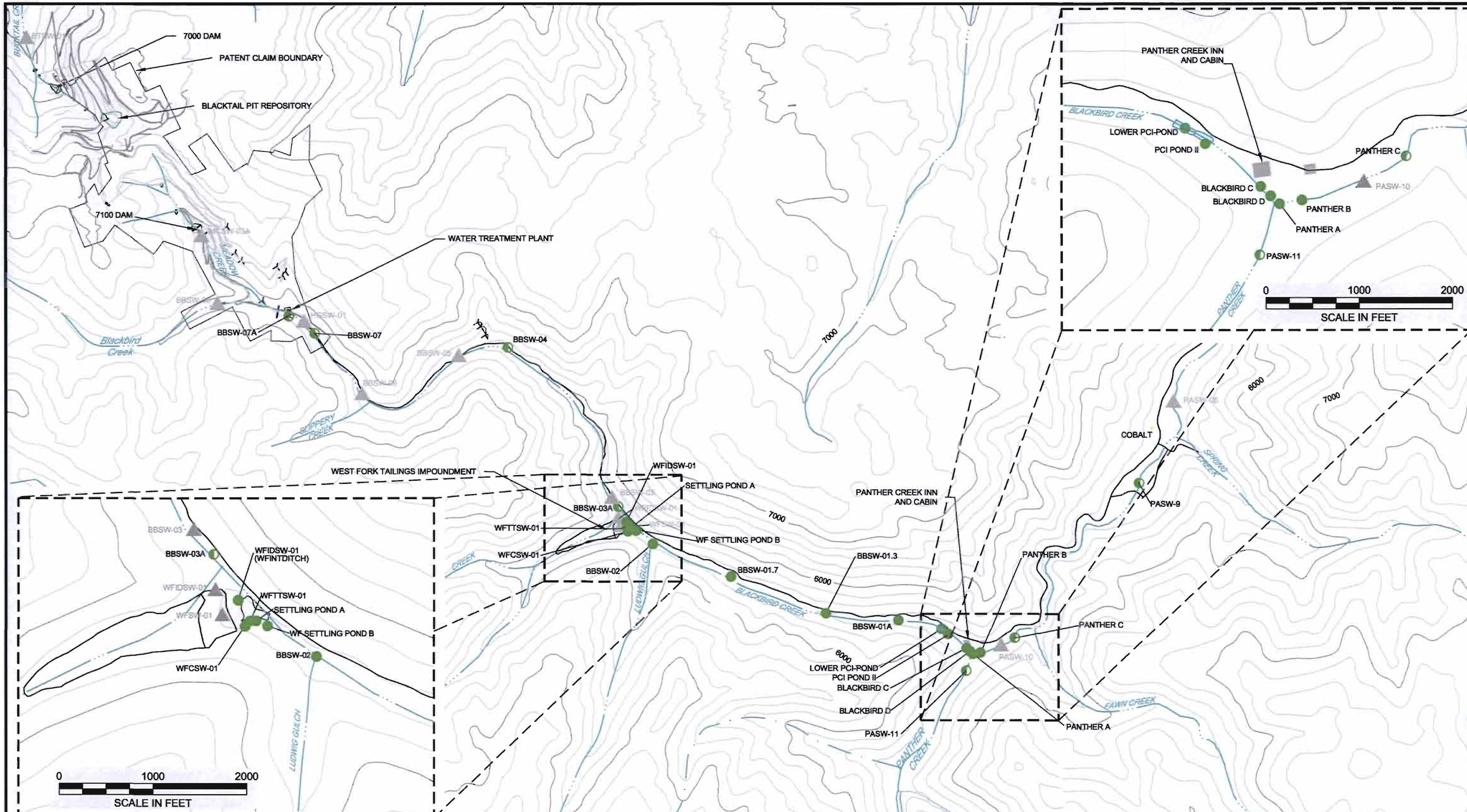
P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\Floc Data (Feb 2010).xlsx



Golder Associates

Title	Blackbird Floc Chemistry Results - Fe, As, Co, Cu and Mn			Drawn	CR
				Checked	RV
Project Name	Blackbird Mine	Project No.	943-1595-400.1280	Reviewed	RV
Client Name	Blackbird Mine Site Group	Date	February 2010	FIGURE	3-8

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\Floc Data (Feb 2010).xlsx



LEGEND

- FLOC MONITORING LOCATION (SAMPLE NOT COLLECTED)
- FLOC MONITORING LOCATION (SUFFICIENT FLOC COLLECTED FOR ANALYSIS)
- SURFACE WATER SAMPLE MONITORING LOCATION

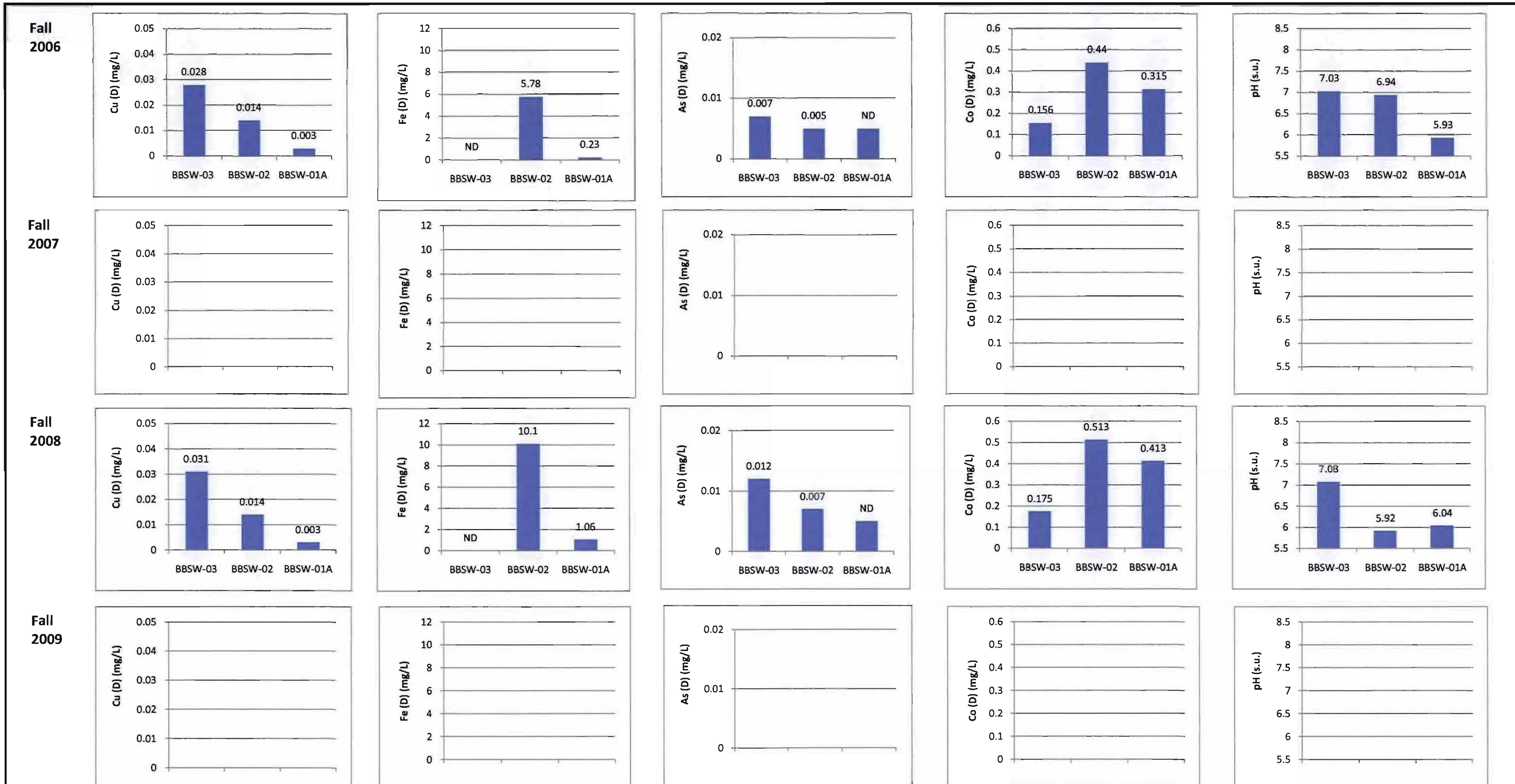
FIGURE **3-9**

BLACKBIRD MINE SAMPLING LOCATIONS

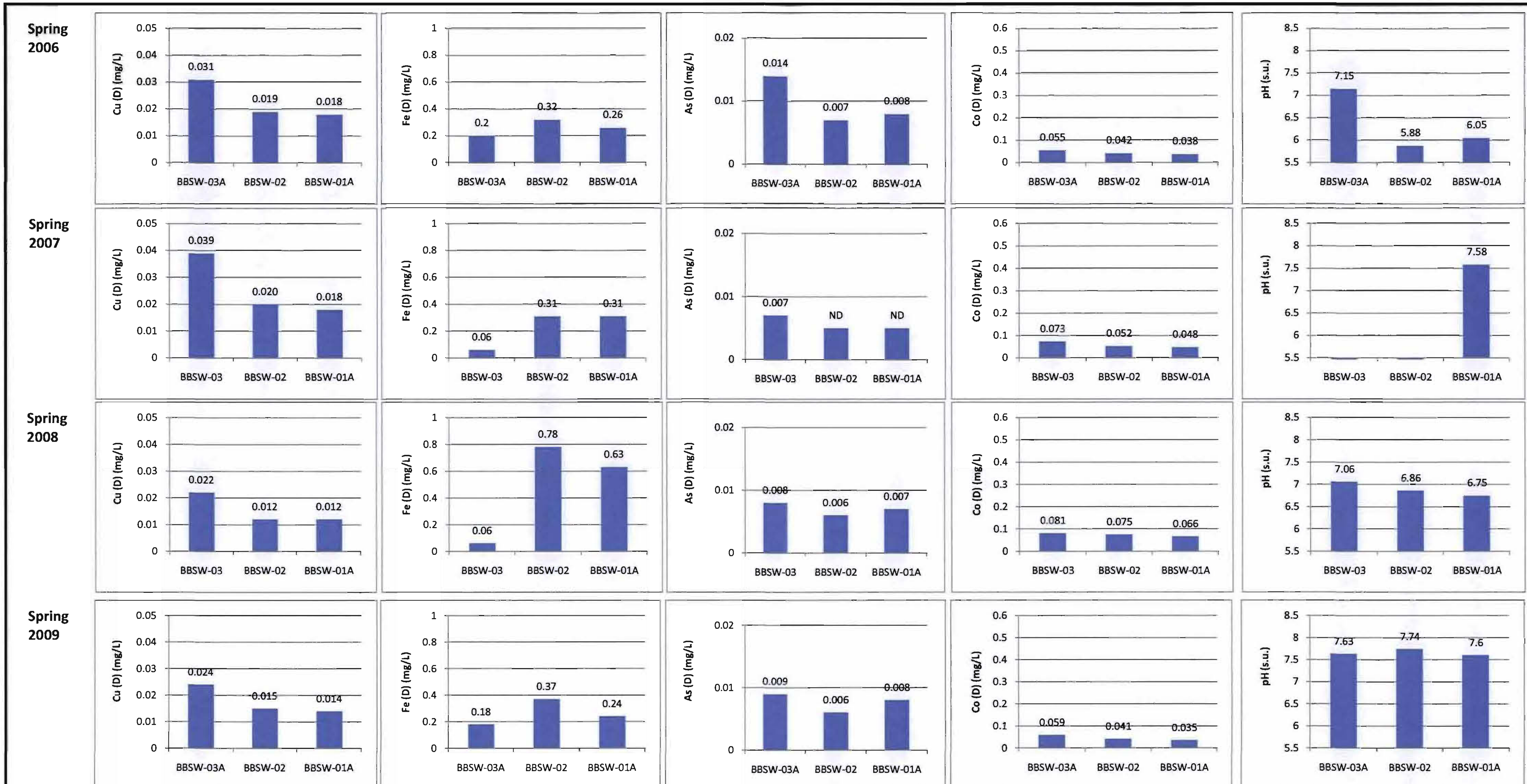
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\943-1595-004_1280_F3_9.dwg | F3-9 | Mod: 02/16/2010, 11:08 | Plotted: 02/22/2010, 15:13 | SSimmons

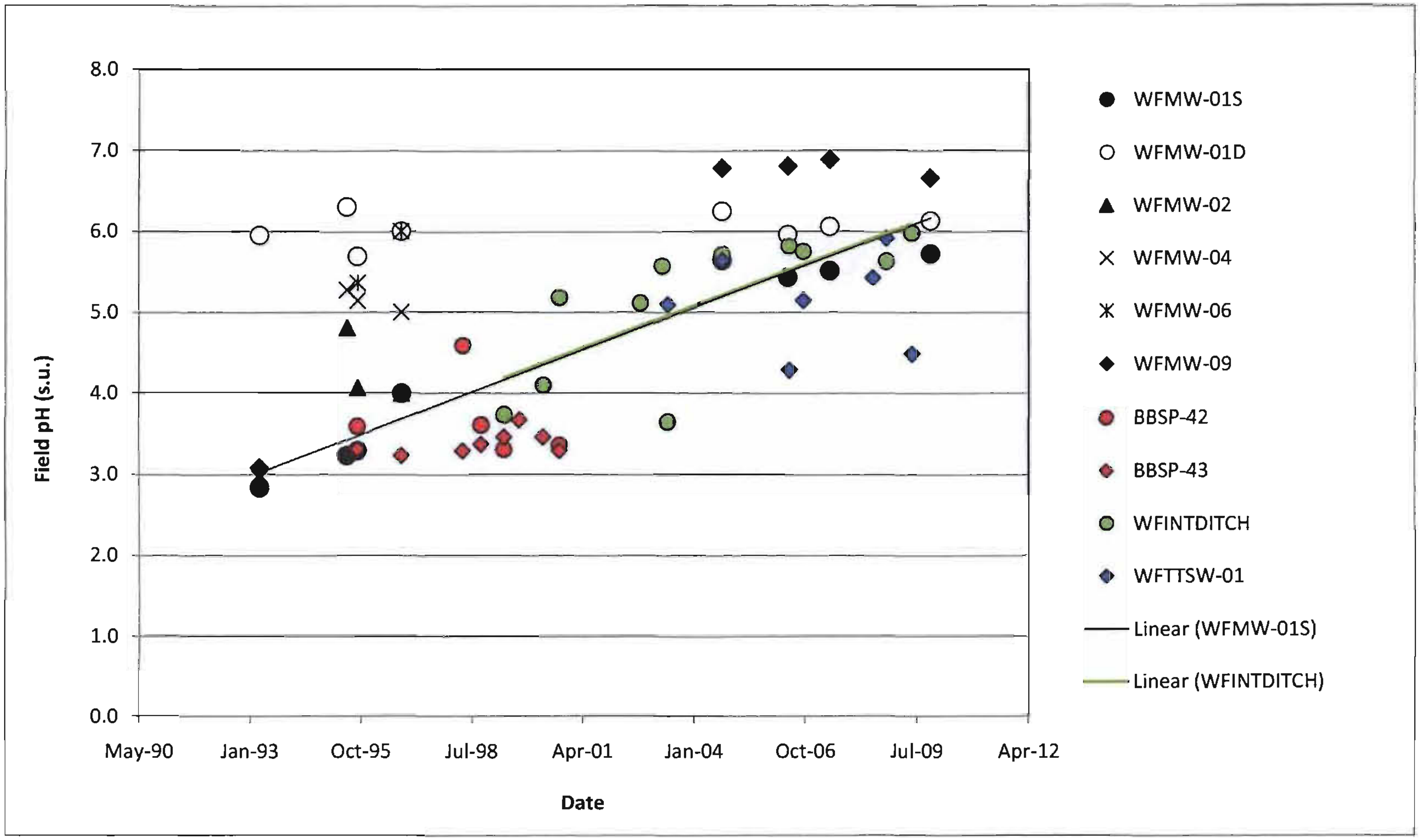
Golder Associates



Golder Associates	Title: Blackbird Creek Synoptic Data - Fall		Drawn: CR
	Project Name: Blackbird	Project No.: 943-1595-004-1280	Checked: AR
			Reviewed: CS
	Client Name: BMSG	Date: February 2010	FIGURE 3-10

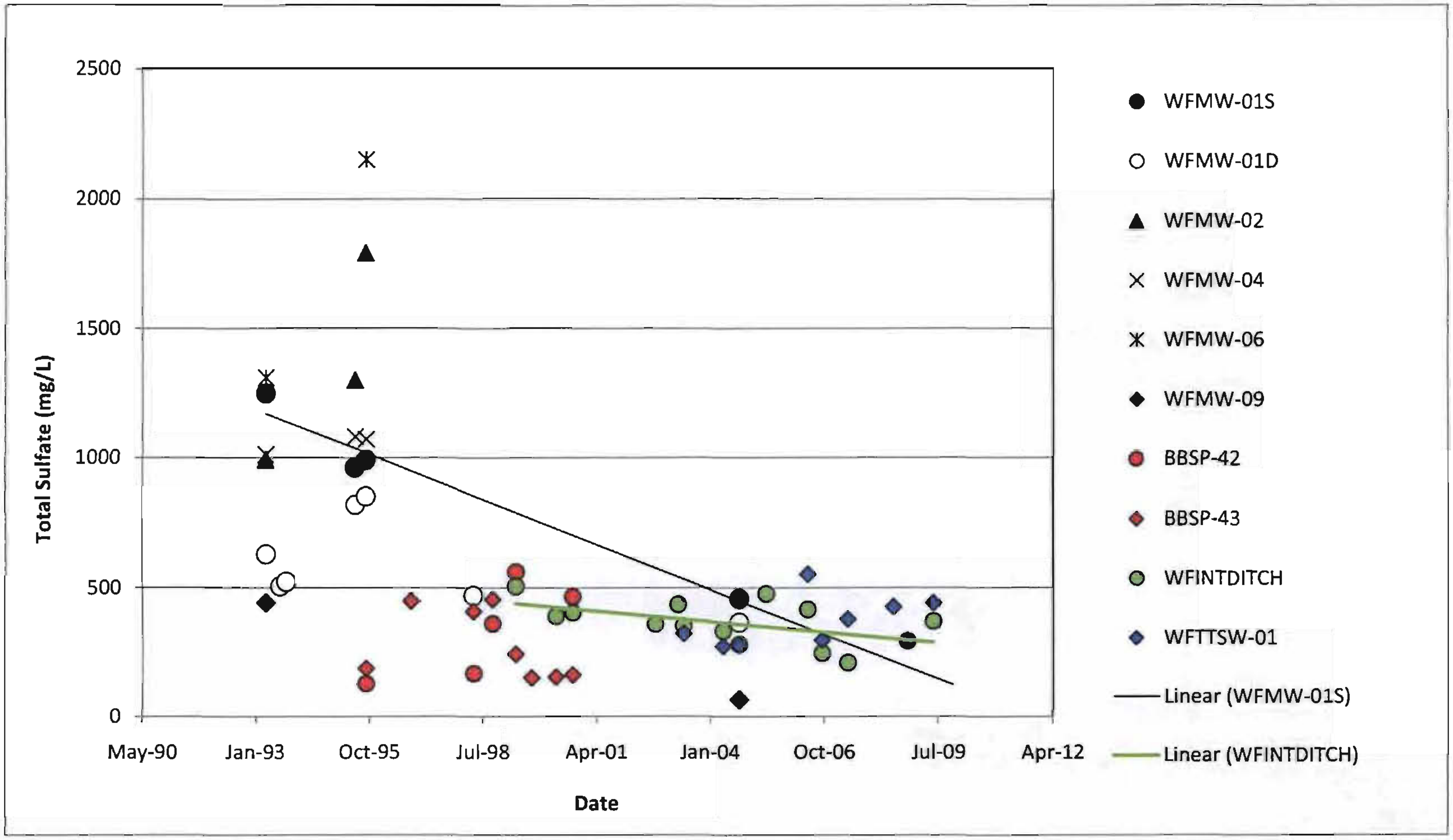


Golder Associates	Title	Blackbird Creek Synoptic Data - Spring		Drawn	CR
				Checked	AR
	Project Name	Blackbird	Project No. 943-1595-004-1280	Reviewed	CS
	Client Name	BMSG	Date February 2010	FIGURE	3-11



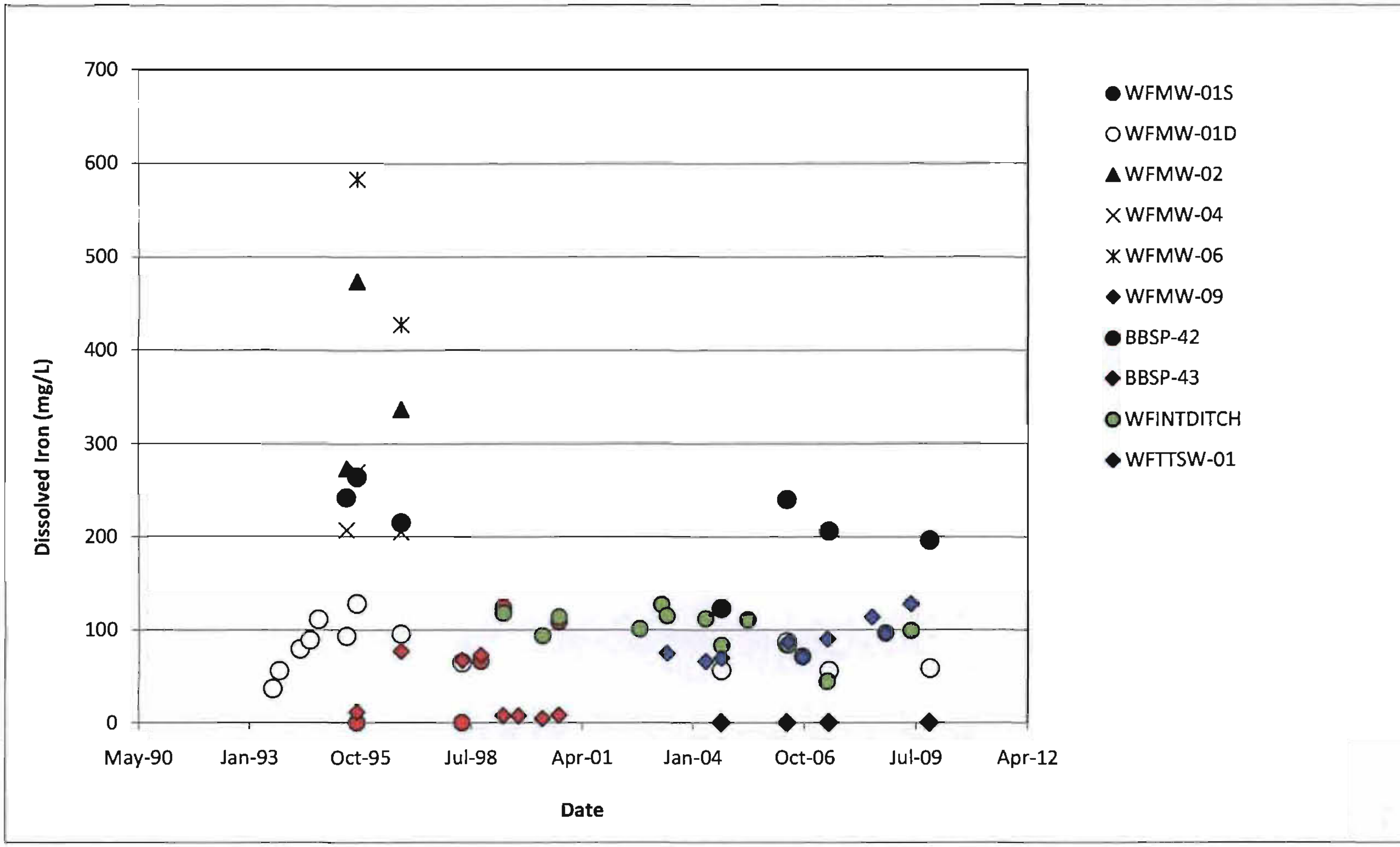
Golder Associates	Title: West Fork Groundwater and Seepage Quality - pH		Drawn	CR
	Project Name: Blackbird Mine	Project No. 943-1595-004.1280	Checked	RV
			Reviewed	RV
	Client Name: Blackbird Mine Site Group	Date: February 2010	FIGURE 3-12	

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\WF Treatment Evaluation (Feb 2010).xlsx



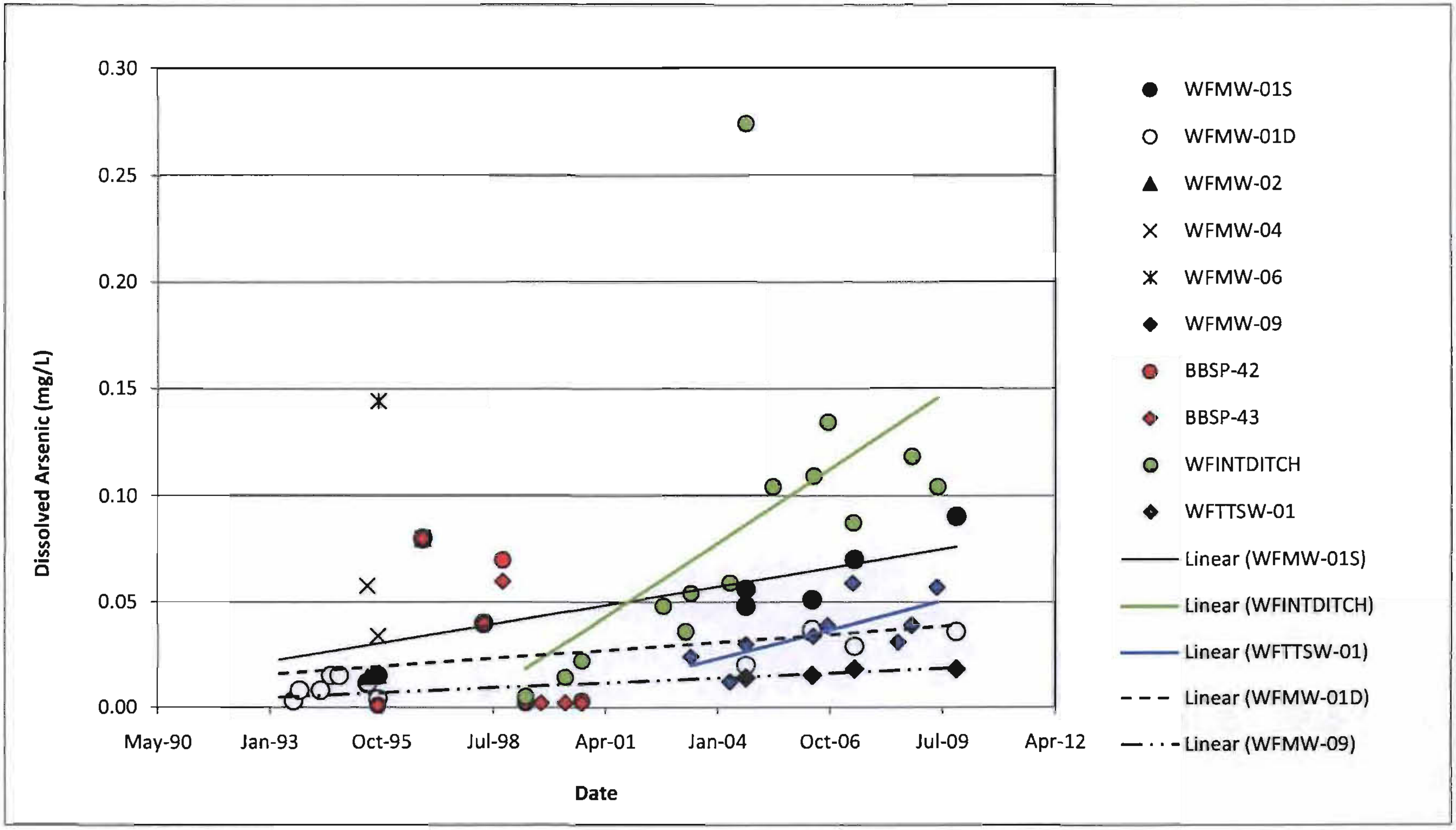
Golder Associates	Title	West Fork Groundwater and Seepage Quality - Total Sulfate		Drawn	CR
				Checked	RV
	Project Name	Blackbird Mine	Project No. 943-1595-004.1280	Reviewed	RV
	Client Name	Blackbird Mine Site Group	Date February 2010	FIGURE 3-13	

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\WF Treatment Evaluation (Feb 2010).xlsx



Non-detect constituents plotted at the detection limit.

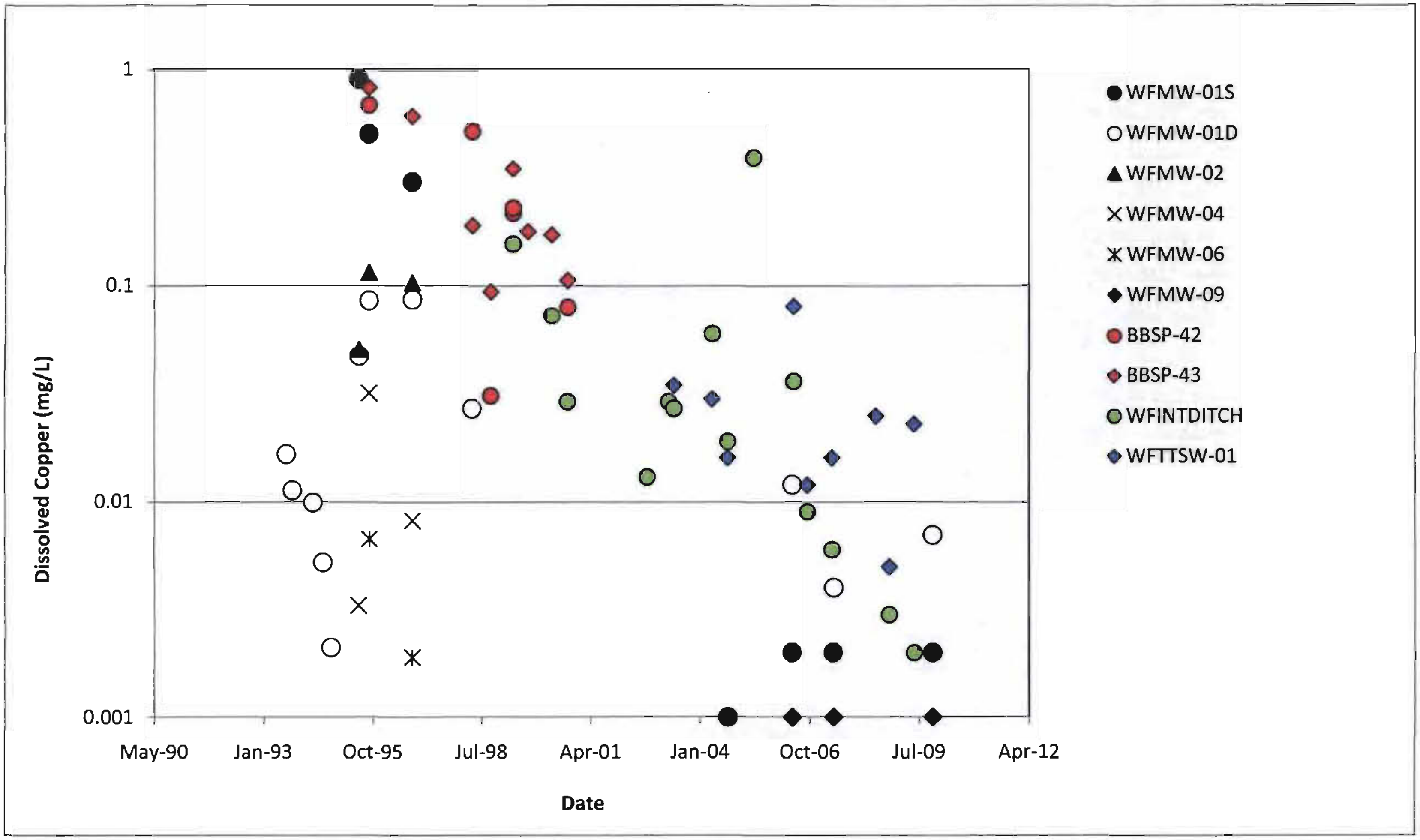
Golder Associates	Title: West Fork Groundwater and Seepage Quality - Dissolved Iron		Drawn	CR
	Project Name: Blackbird Mine	Project No. 943-1595-004.1280	Checked	RV
	Client Name: Blackbird Mine Site Group	Date: February 2010	Reviewed	RV
			FIGURE 3-14	



Non-detect constituents plotted at the detection limit.

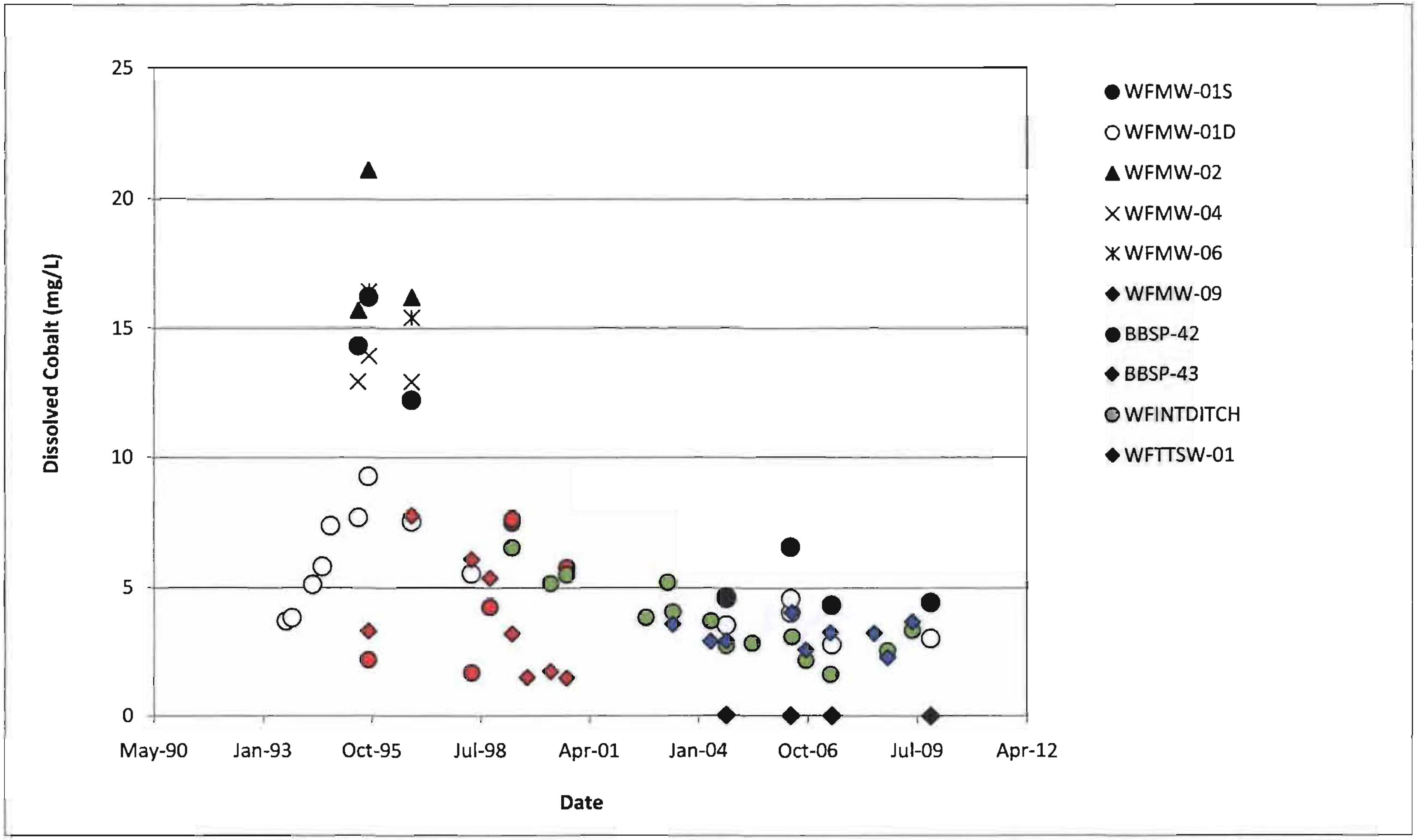
Golder Associates	Title	West Fork Groundwater and Seepage Quality - Dissolved Arsenic	Drawn	CR
			Checked	RV
	Project Name	Blackbird Mine	Project No. 943-1595-004.1280	Reviewed RV
	Client Name	Blackbird Mine Site Group	Date May 2010	FIGURE 3-15

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\WF Treatment Evaluation (May 2010).xlsx



Non-detect constituents plotted at the detection limit.

Golder Associates	Title	West Fork Groundwater and Seepage Quality - Dissolved Copper		Drawn	CR
				Checked	RV
	Project Name	Blackbird Mine	Project No. 943-1595-004.1280	Reviewed	RV
	Client Name	Blackbird Mine Site Group	Date February 2010	FIGURE 3-16	



Non-detect constituents plotted at the detection limit.

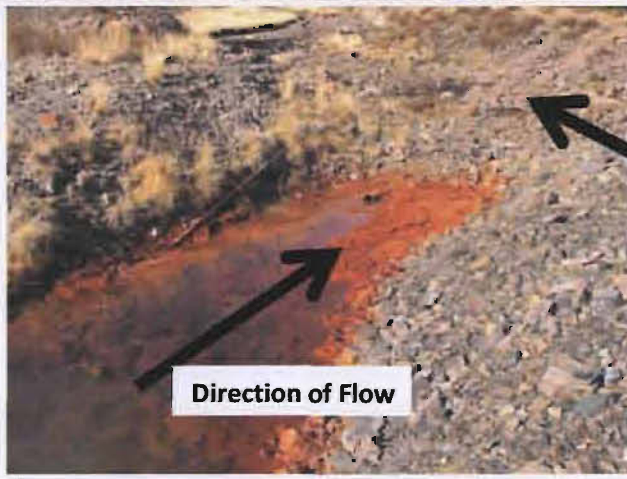
Golder Associates	Title	West Fork Groundwater and Seepage Quality - Dissolved Cobalt		Drawn	CR
				Checked	RV
	Project Name	Blackbird Mine	Project No. 943-1595-004.1280	Reviewed	RV
	Client Name	Blackbird Mine Site Group	Date February 2010	FIGURE 3-17	

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\WF Treatment Evaluation (Feb 2010).xlsx

WFTTSW-01

WFINTDITCH
Photo A

Photo B

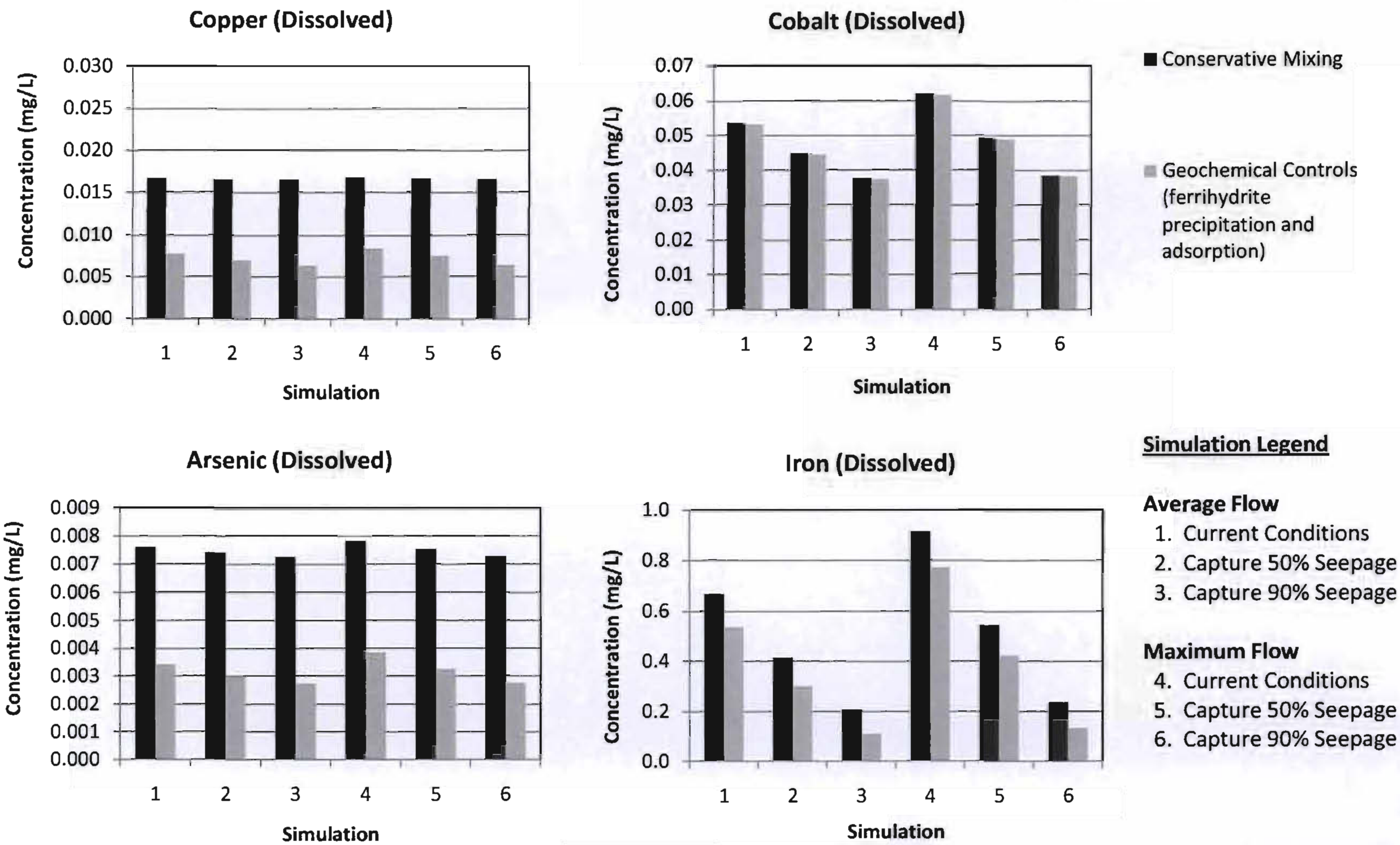


WFINTDITCH
Photo B

Sampling Location

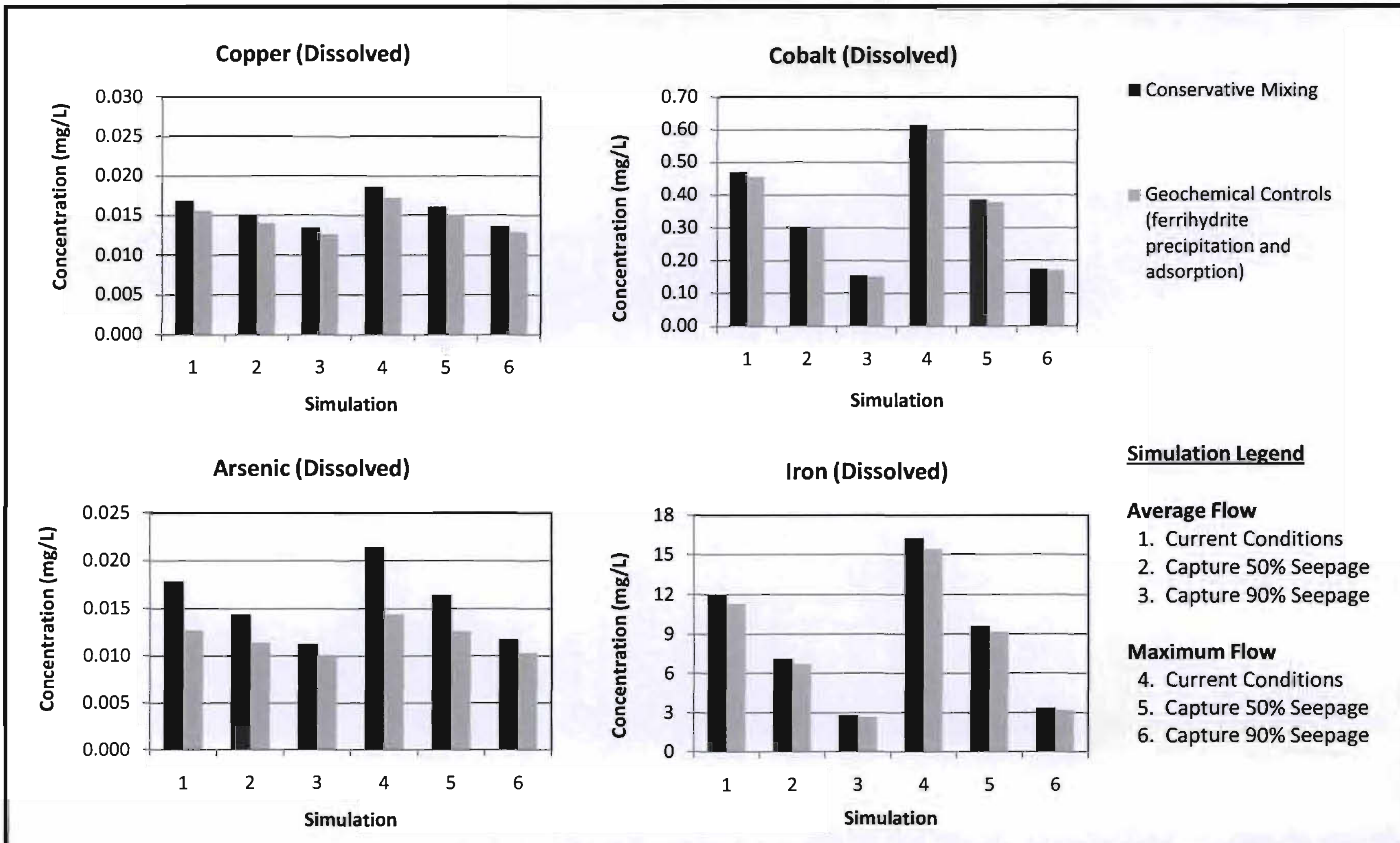
Golder Associates	Title	West Fork - Surface Seepage Monitoring Locations	Drawn	CR
			Checked	RV
	Project Name	Blackbird Mine	Project No. 943-1595-004.1280	Reviewed RV
	Client Name	Blackbird Mine Site Group	Date February 2010	FIGURE 3-18

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\WF Treatment Evaluation (Feb 2009).xlsx



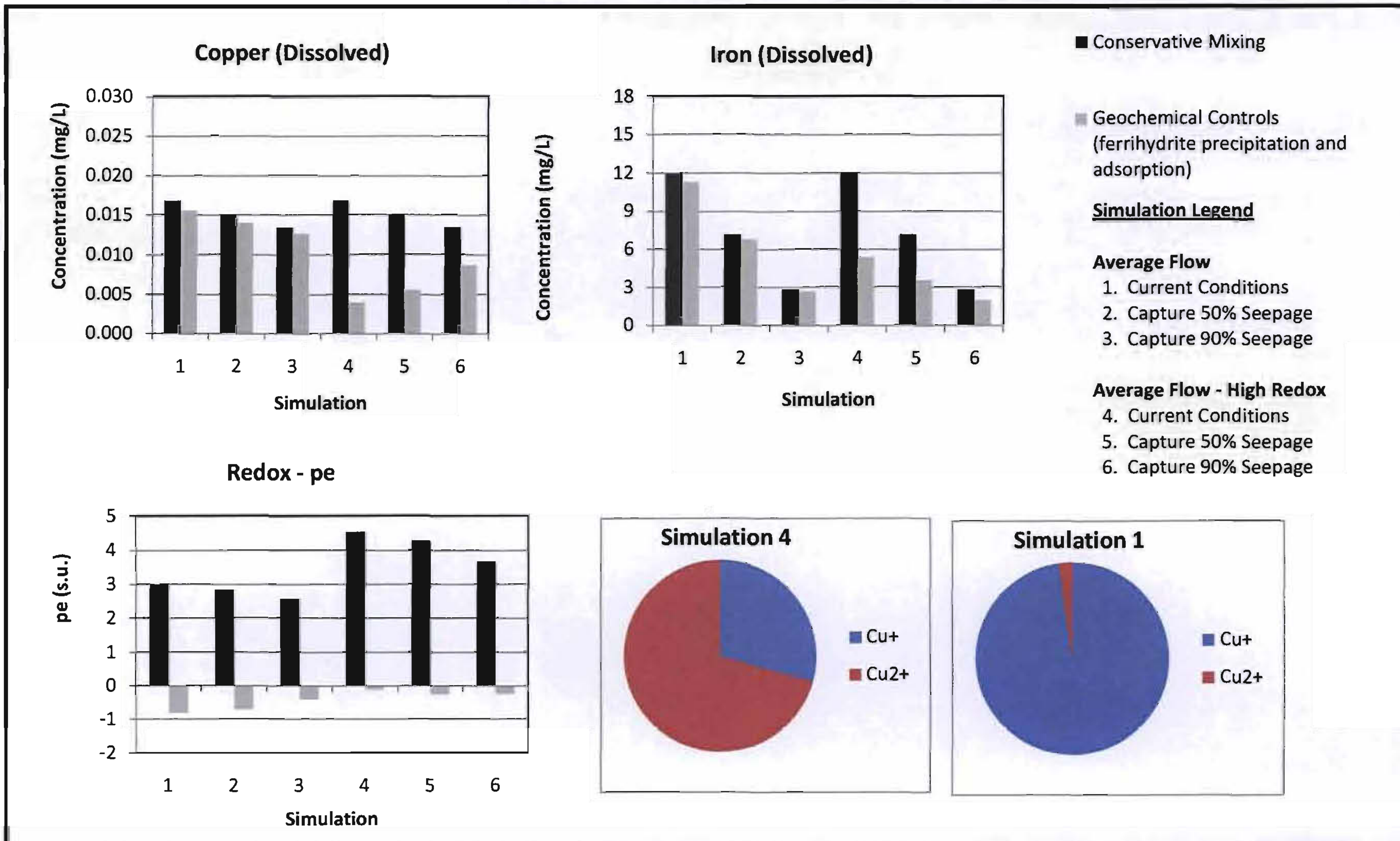
Golder Associates	Title: Blackbird Creek Water Quality Model Results (Cu, Co, As and Fe) - Spring		Drawn	CR
			Checked	RV
	Project Name: Blackbird Mine	Project No.: 943-1595-400.1280	Reviewed	RV
	Client Name: Blackbird Mine Site Group	Date: February 2010	FIGURE 3-19	

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\West Fork Model (Feb 2009).xlsx



Golder Associates	Title: Blackbird Creek Water Quality Model Results (Cu, Co, As and Fe) - Fall		Drawn: CR Checked: RV Reviewed: RV
	Project Name: Blackbird Mine	Project No.: 943-1595-400.1280	
	Client Name: Blackbird Mine Site Group	Date: February 2010	FIGURE 3-20

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\West Fork Model (Feb 2009).xlsx



Golder Associates	Title	Blackbird Creek Water Quality Model Results - Fall Redox Sensitivity Analysis		Drawn	CR
				Checked	RV
	Project Name	Blackbird Mine	Project No. 943-1595-400.1280	Reviewed	RV
	Client Name	Blackbird Mine Site Group	Date February 2010	FIGURE 3-21	

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochemistry\West Fork Model (Feb 2009).xlsx

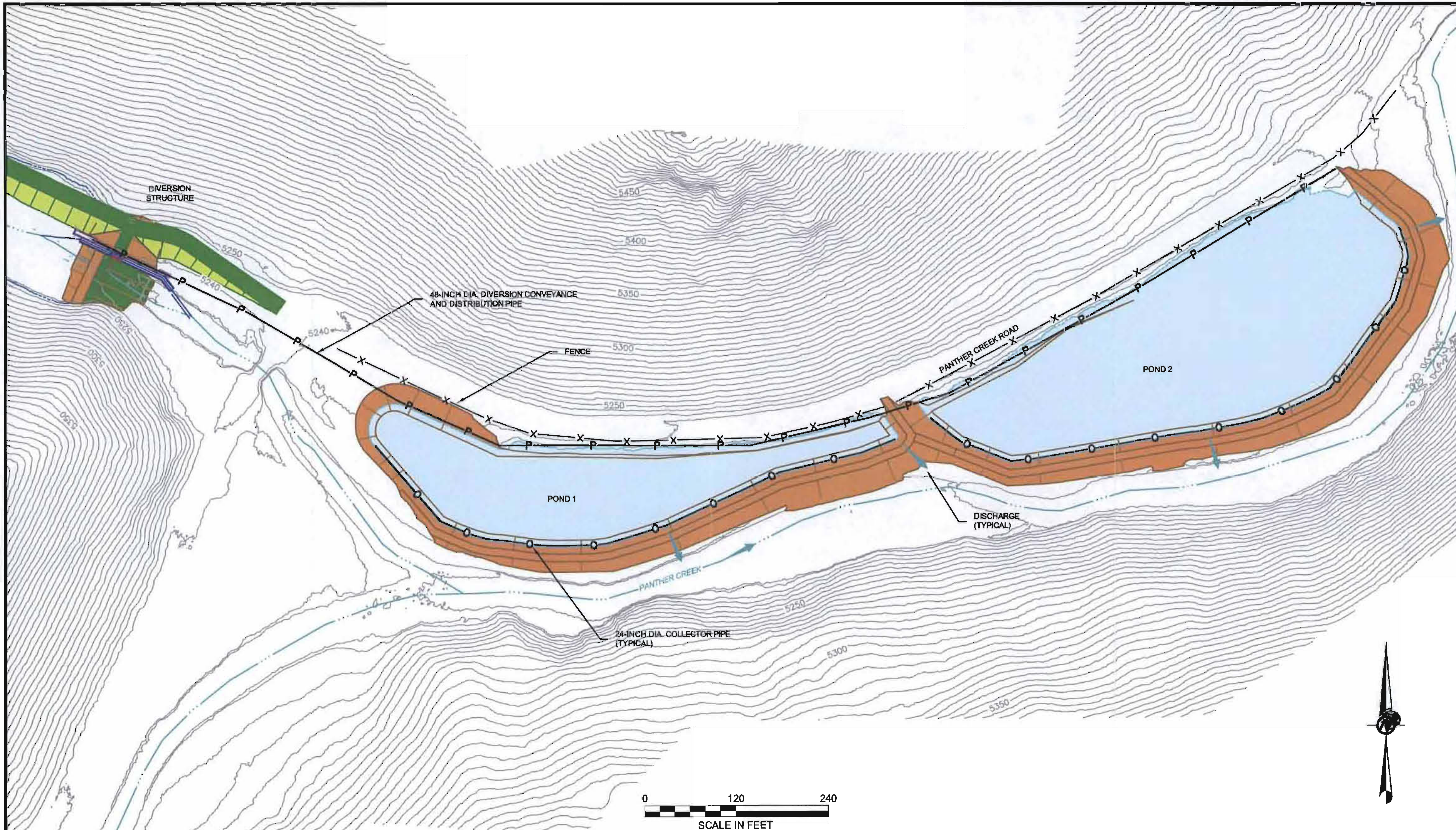


FIGURE **4-2**
PCI DIVERSION STRUCTURE AND SETTLING BASINS PLAN
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\Appendices\943-1595-004_1280_F4_2Thru4_5.dwg | Fig 4-2 | Mod: 02/23/2010, 13:04 | Plotted: 02/23/2010, 13:05 | SSimmons

Golder Associates

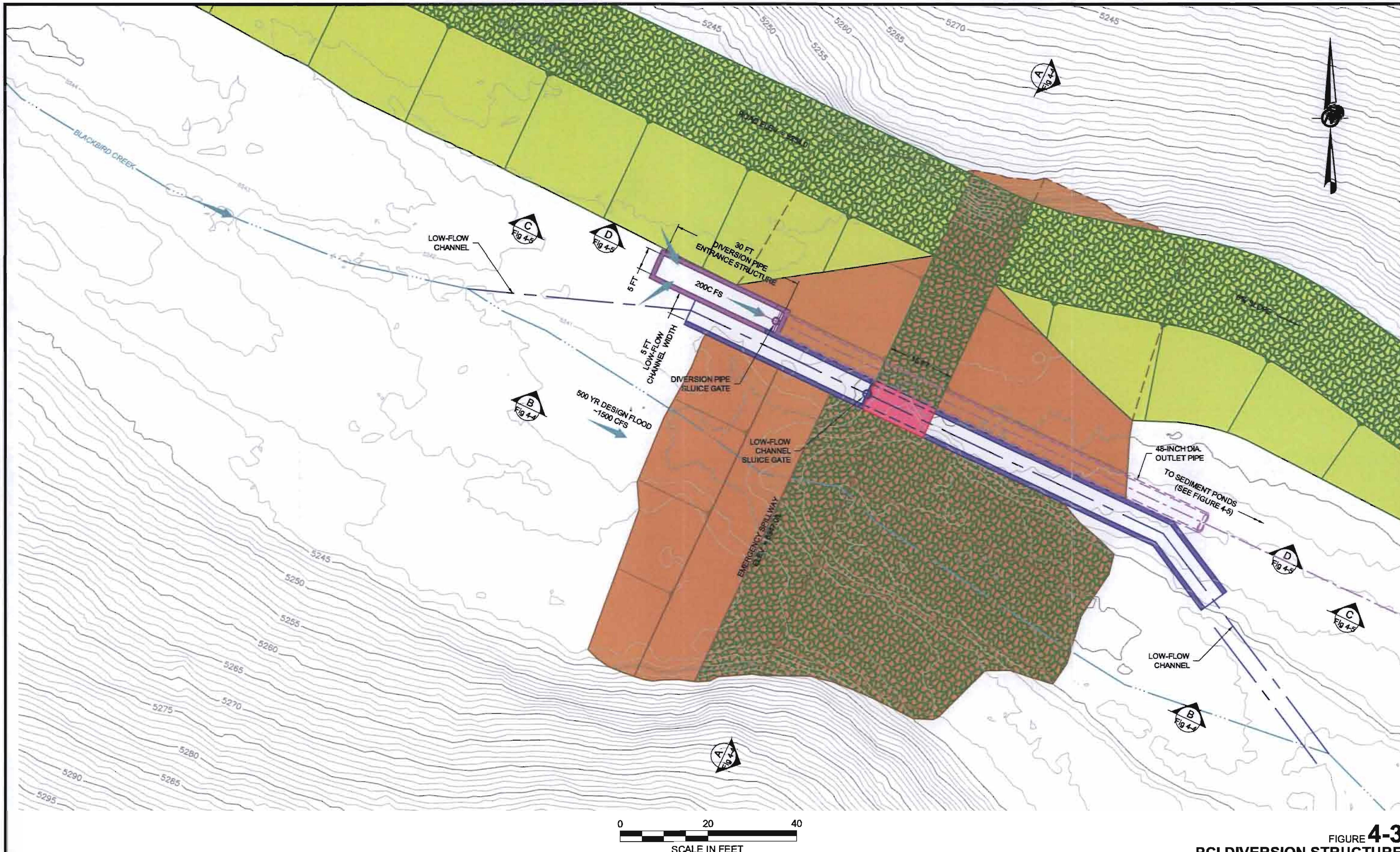


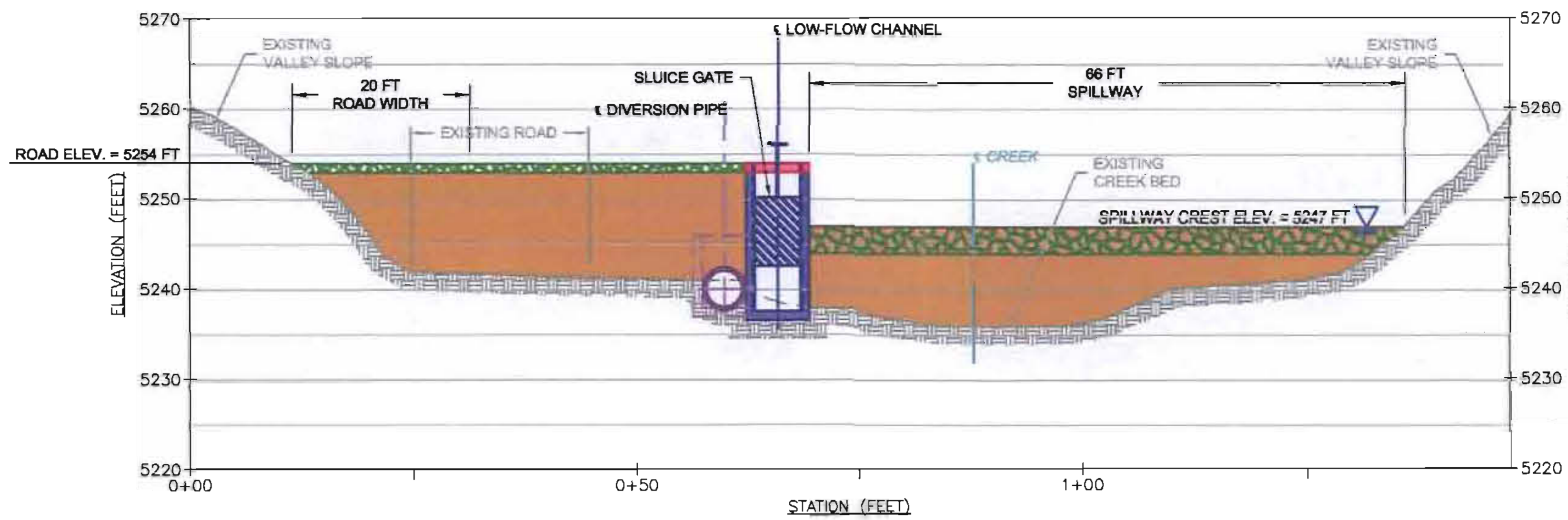
FIGURE **4-3**

PCI DIVERSION STRUCTURE SITE PLAN

BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\Appendices\943-1595-004_1280_F4_2Thru4_5.dwg | Fig 4-3 | Mod: 02/23/2010, 13:13 | Plotted: 02/23/2010, 14:06 | SSimmons

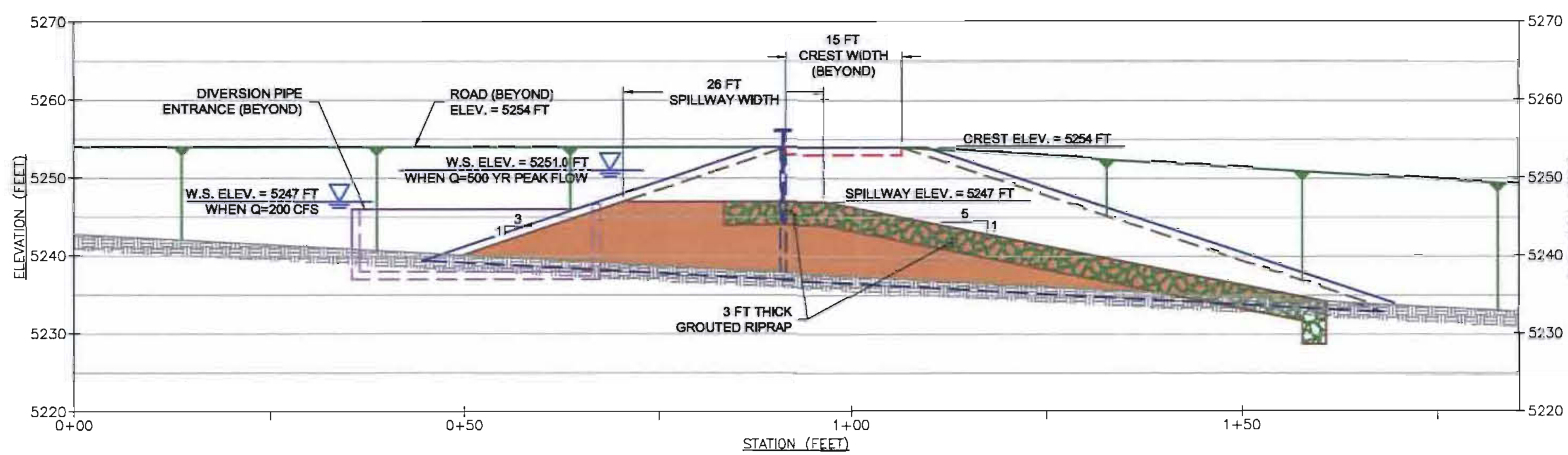
Golder Associates



A
Fig 4-3

EMBANKMENT PROFILE

0 20 40
SCALE IN FEET



B
Fig 4-3

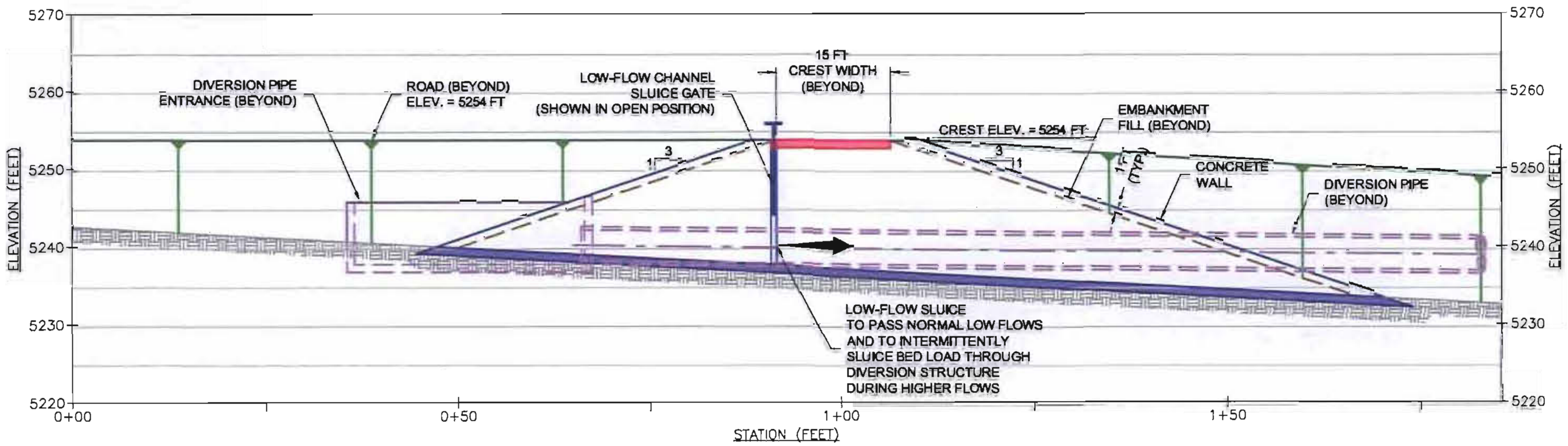
EMERGENCY SPILLWAY SECTION

0 20 40
SCALE IN FEET

FIGURE **4-4**

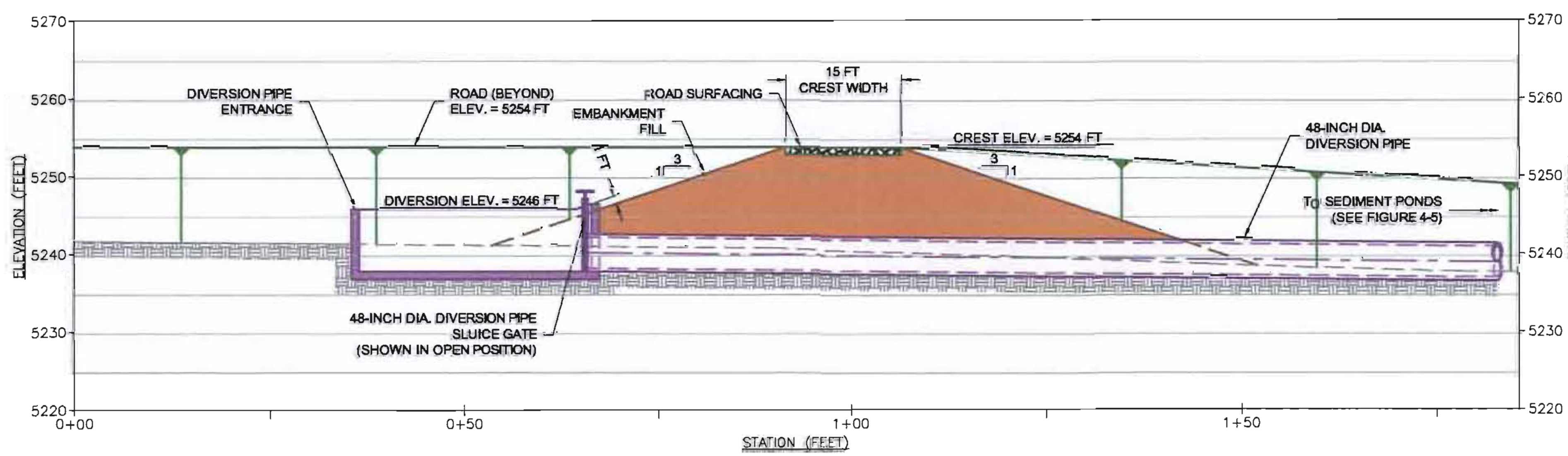
PCI DIVERSION STRUCTURE SECTION AND PROFILE

BMSG/BLACKBIRD MINE/ID



C (Fig 4-3) **LOW-FLOW CHANNEL PROFILE**

0 20 40
SCALE IN FEET



D (Fig 4-3) **DIVERSION PIPE PROFILE**

0 20 40
SCALE IN FEET

FIGURE **4-5**
PCI DIVERSION STRUCTURE PROFILES
BMSG/BLACKBIRD MINE/ID

Golder Associates

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\Appendices\943-1595-004_1280_F4_2Thru4_5.dwg | Fig 4-5 | Mod: 02/23/2010, 13:13 | Plotted: 02/23/2010, 14:03 | SSimmons

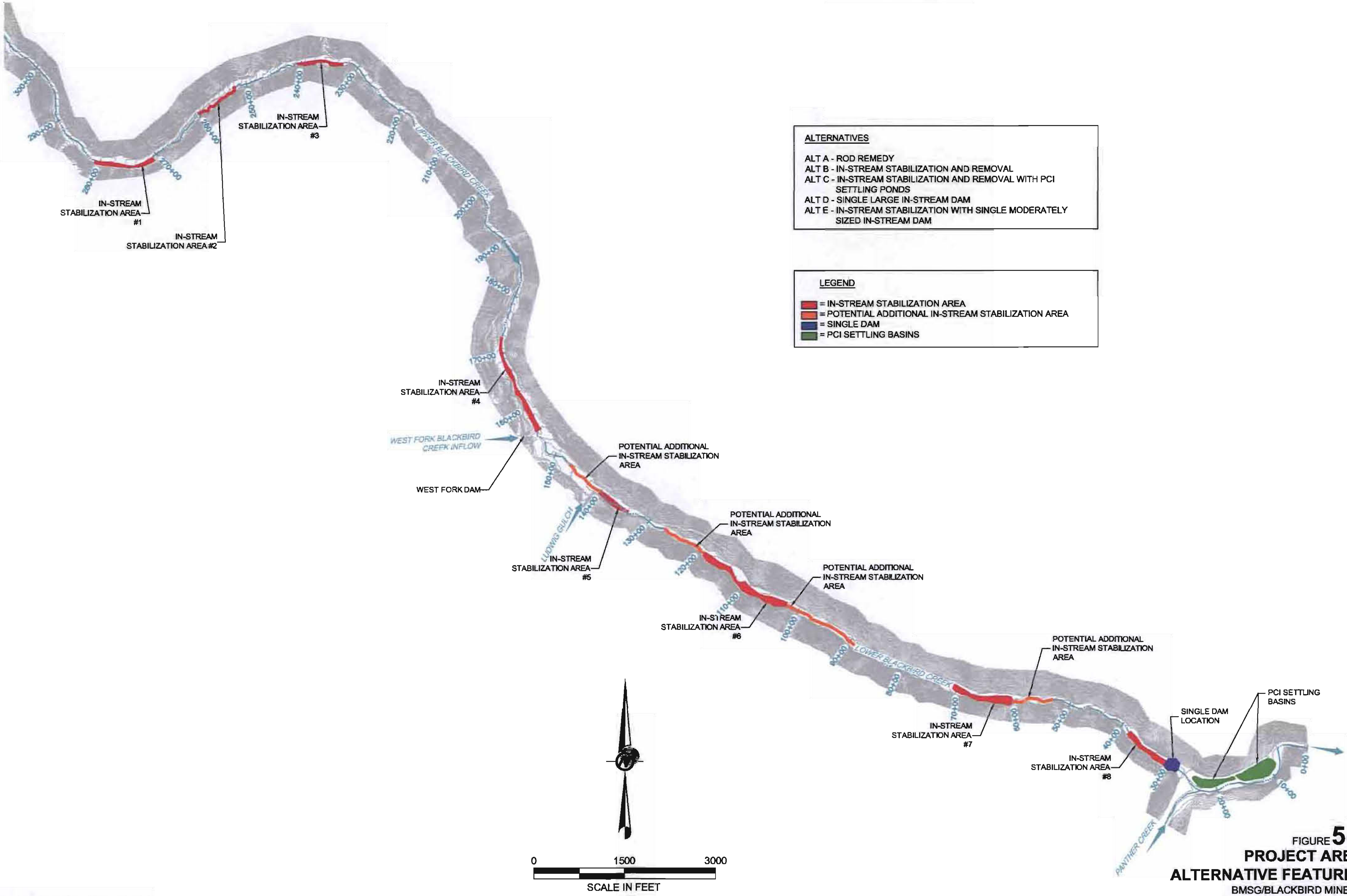
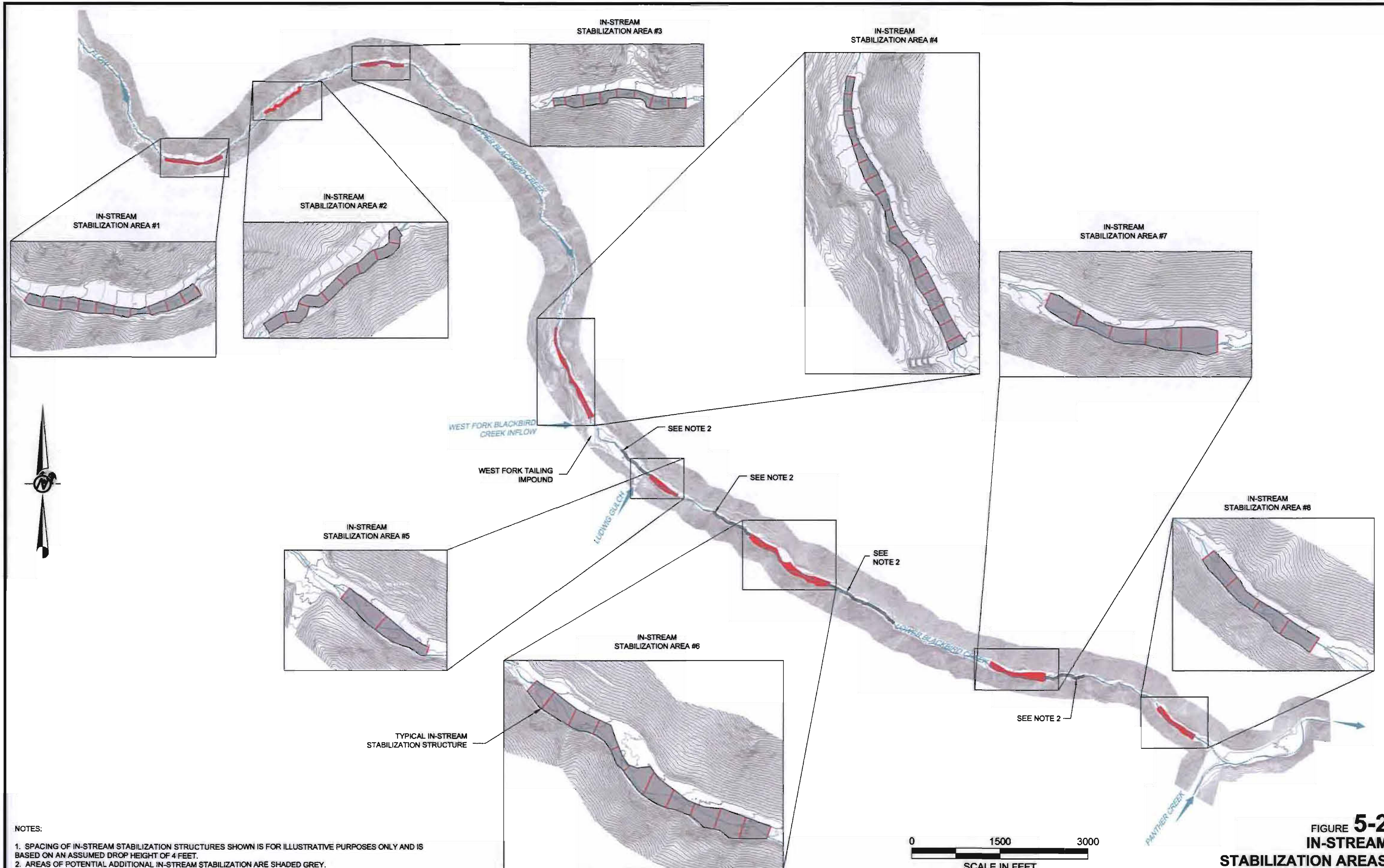


FIGURE **5-1**
PROJECT AREA ALTERNATIVE FEATURES
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\943-1595-004_1280_F5_1.dwg | Fig 5-1 | Mod: 02/22/2010, 13:14 | Plotted: 02/22/2010, 13:17 | SSimmons

Golder Associates



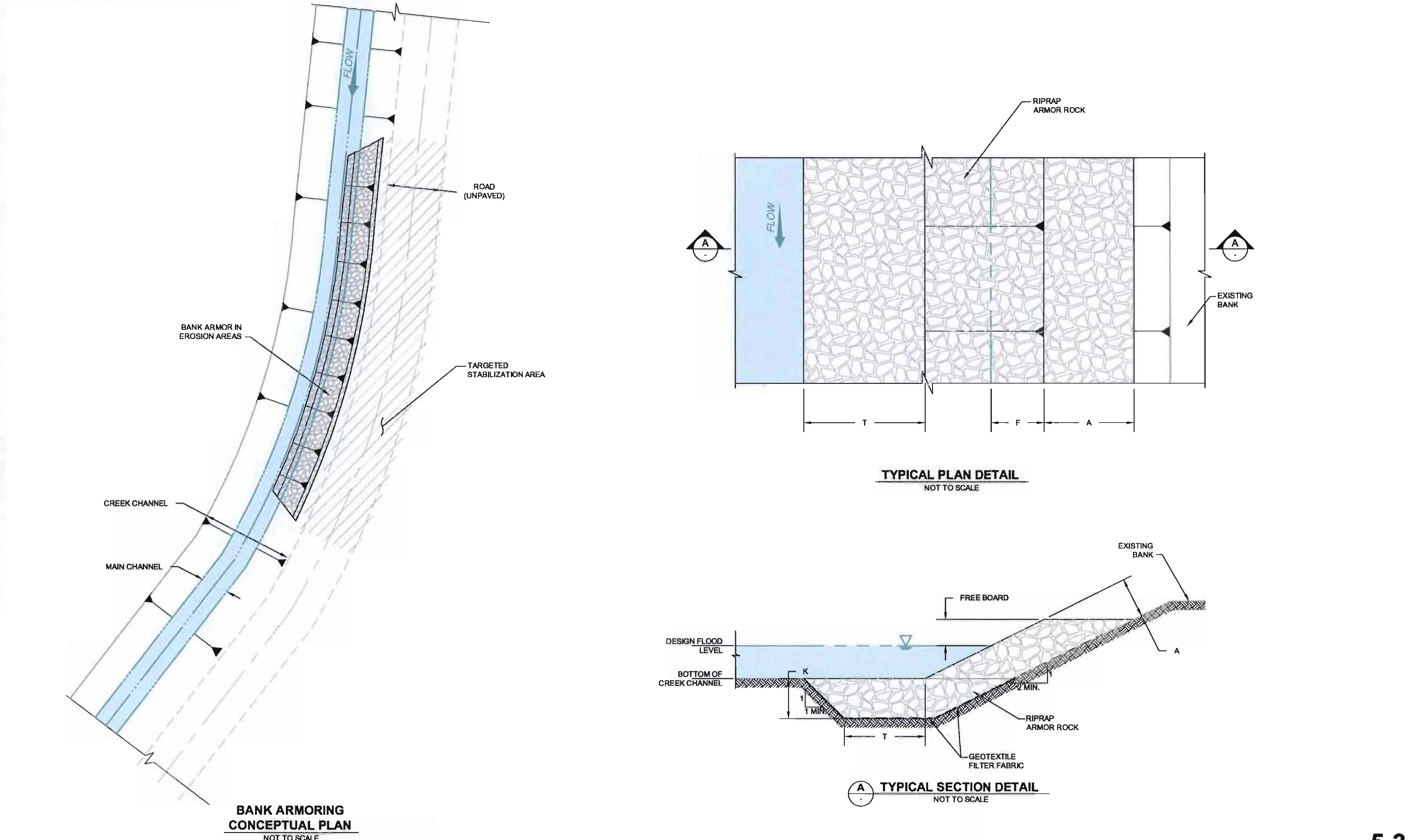
NOTES:

1. SPACING OF IN-STREAM STABILIZATION STRUCTURES SHOWN IS FOR ILLUSTRATIVE PURPOSES ONLY AND IS BASED ON AN ASSUMED DROP HEIGHT OF 4 FEET.
2. AREAS OF POTENTIAL ADDITIONAL IN-STREAM STABILIZATION ARE SHADED GREY.

FIGURE **5-2**
IN-STREAM STABILIZATION AREAS
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\943-1595-004_1280_F5_2.dwg | Fig 5-2 | Mod: 02/10/2010, 12:31 | Plotted: 05/07/2010, 09:03 | JMSchneider

Golder Associates

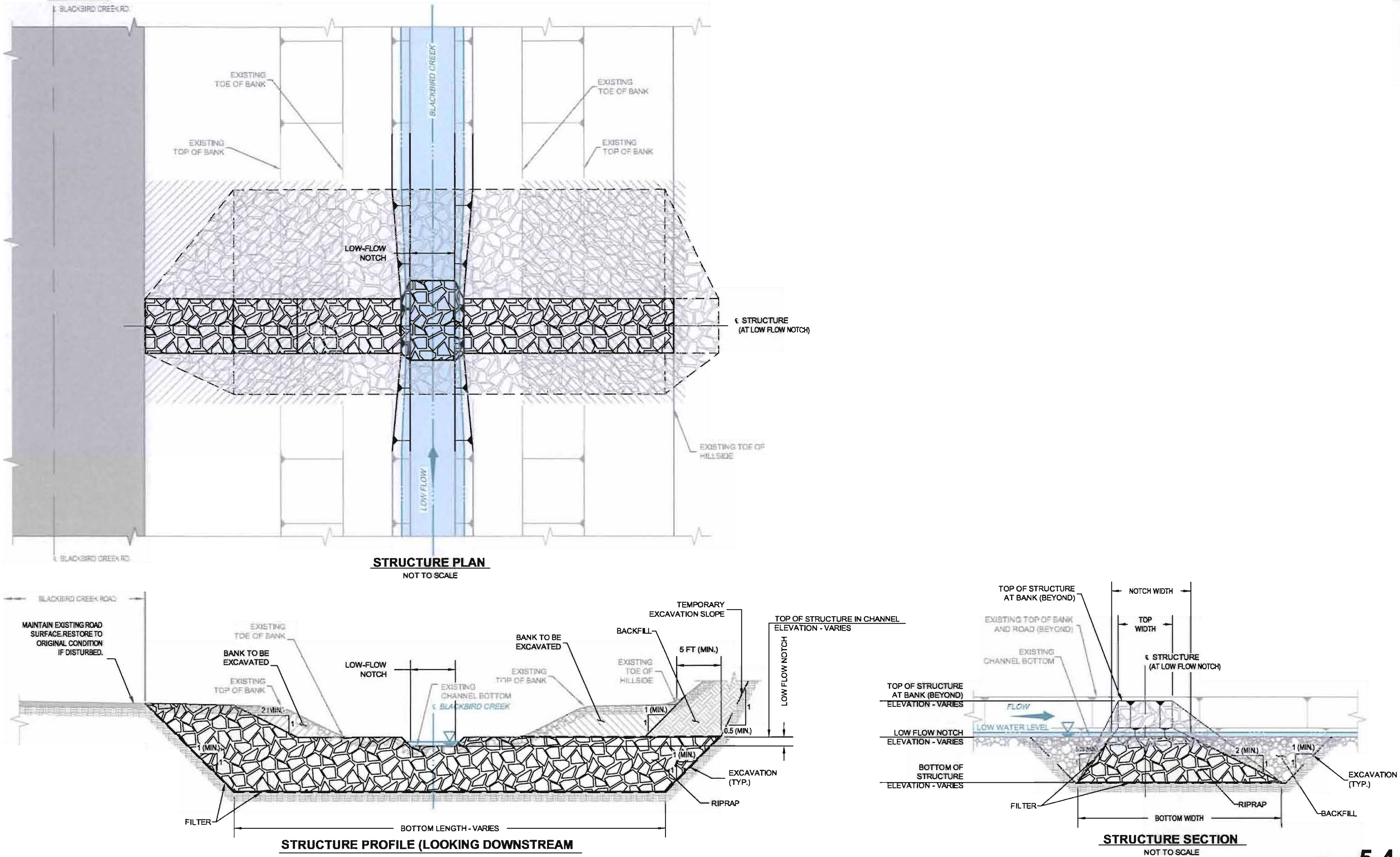


NOTES:
1. THESE ARE TYPICAL BANK ARMORING DETAILS. ROCK SIZE AND PLACEMENT WILL INCLUDED IN THE DESIGN.

FIGURE **5-3**
TYPICAL BANK ARMORING
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\943-1595\x004\1280\RI Report\943-1595-004_1280_F5_3thru5_5.dwg | F5-3 | Mod: 02/09/2010, 17:17 | Plotted: 02/10/2010, 11:33 | SSimmons

Golder Associates

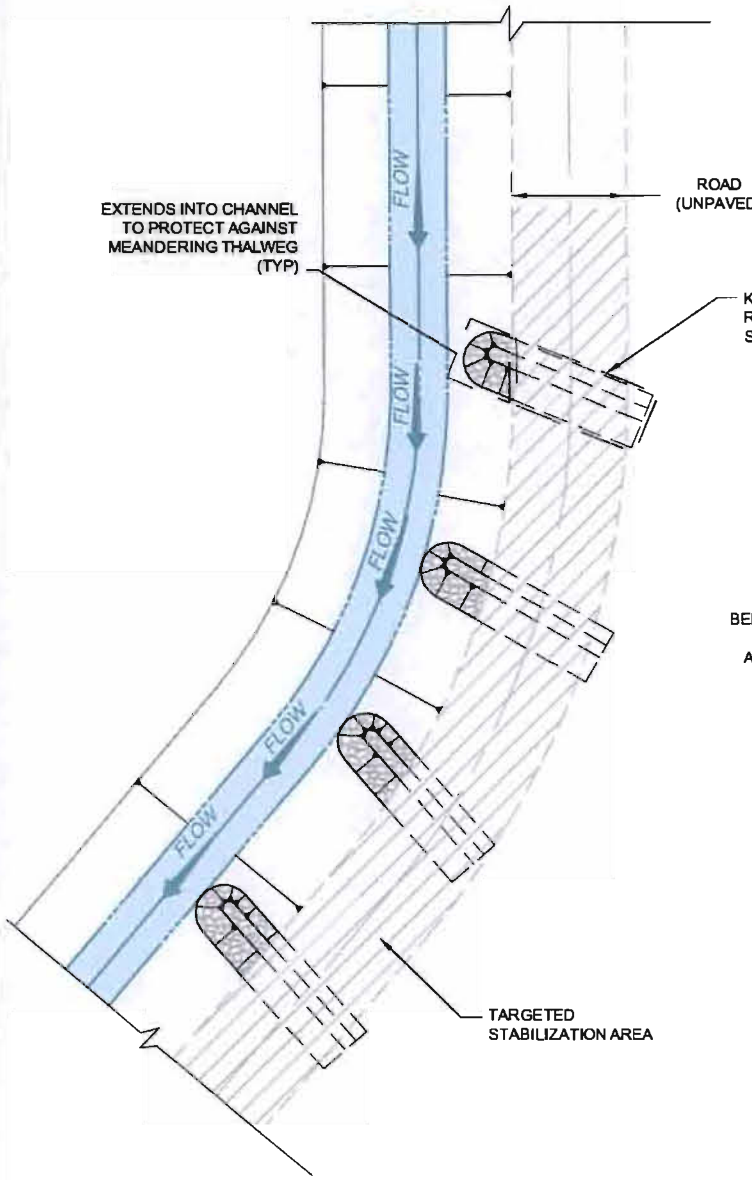


NOTES:
1. THESE ARE TYPICAL BLACKBIRD CREEK IN-STREAM STABILIZATION STRUCTURE IS SHOWN FOR ILLUSTRATIVE PURPOSES ONLY. STRUCTURE DESIGN DETAILS, INCLUDING DIMENSIONS AND MATERIAL TYPES, WILL BE INCLUDED IN THE DESIGN PACKAGE.

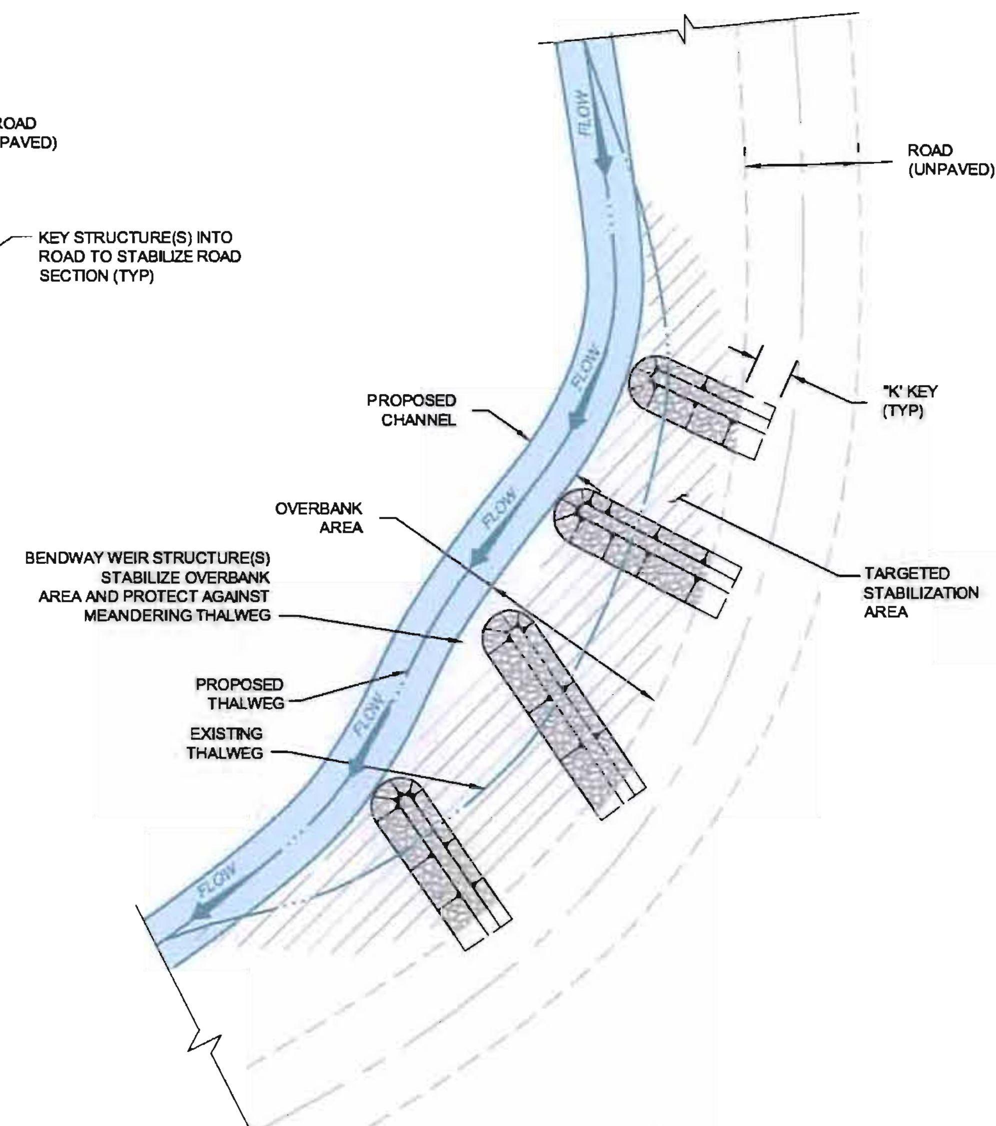
FIGURE 5-4
TYPICAL GRADE CONTROL STRUCTURES
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\943-1595\x004\1280\RI Report\943-1595-004_1280_F5_3thru5_5.dwg | F5-4 | Mod: 02/09/2010, 17:17 | Plotted: 02/10/2010, 11:36 | SSimmons

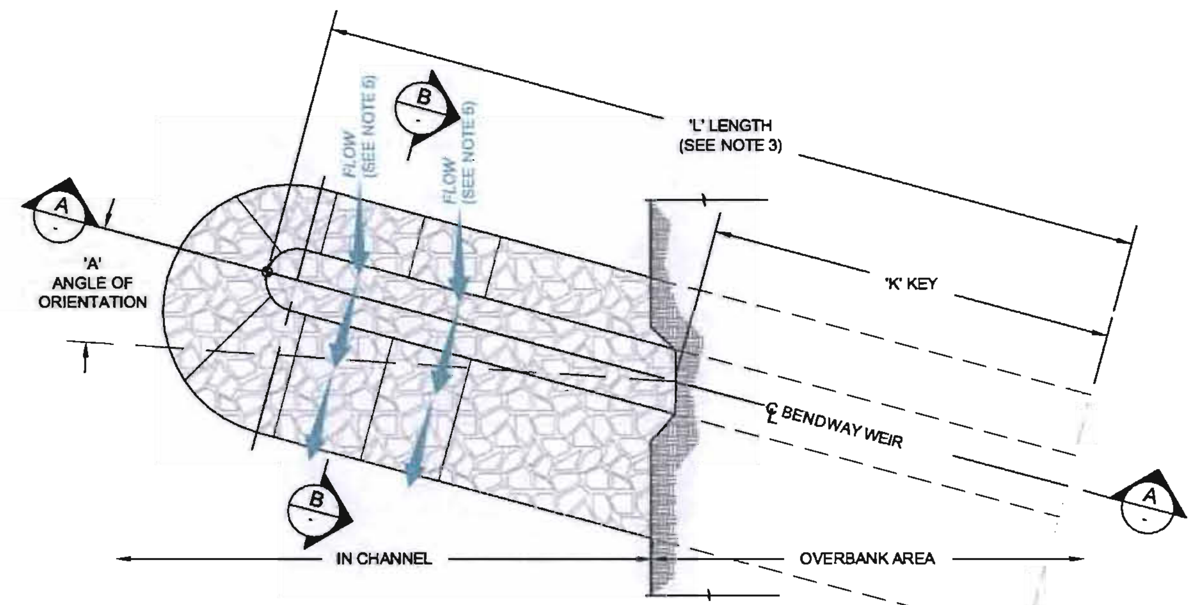
Golder Associates



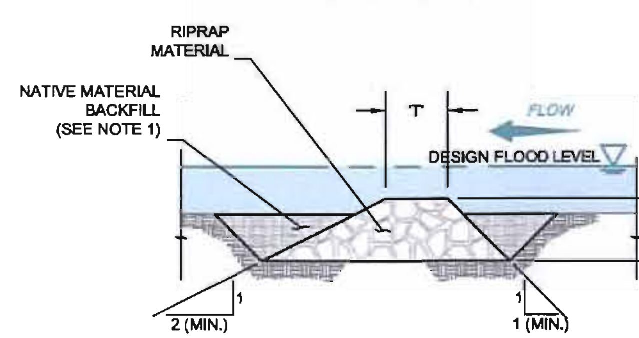
BENDWAY WEIR STRUCTURE
(IN ROAD)
CONCEPTUAL PLAN
NOT TO SCALE



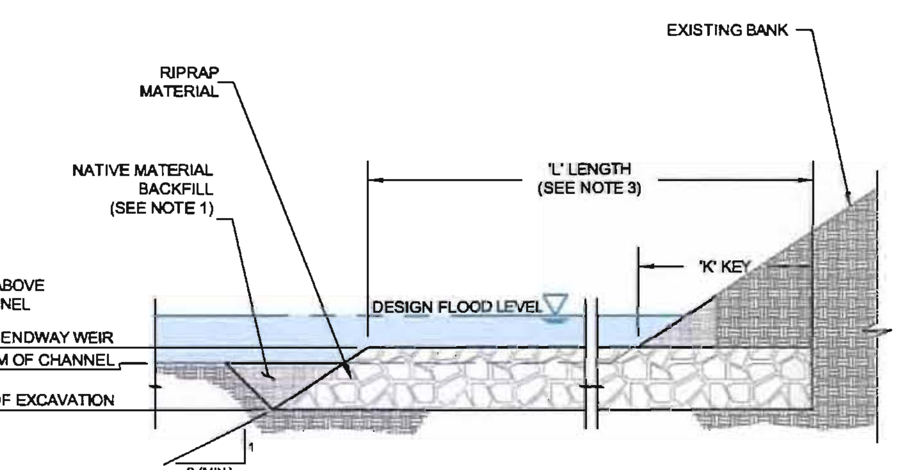
BENDWAY WEIR STRUCTURE
(IN OVERBANK AREA)
CONCEPTUAL PLAN
NOT TO SCALE



TYPICAL
DETAIL PLAN
NOT TO SCALE



TYPICAL
DETAIL SECTION (B)
NOT TO SCALE



TYPICAL
DETAIL PROFILE (A)
NOT TO SCALE

NOTES:
1. NATIVE MATERIAL MAY BE USED AS BACKFILL AROUND GRADE-CONTROL STRUCTURES.
2. PLACEMENT OF BENDWAY WEIR STRUCTURES TO BE DETERMINED AS DIRECTED BY THE ENGINEER.
3. LENGTH ('L') AND ANGLE OF ORIENTATION ('A') BASED ON SITE CONDITIONS.
4. DESIGN FLOOD LEVEL IS ABOVE TOP OF STRUCTURE (TYP.). FLOOD LEVELS MAY VARY DEPENDING ON SITE CONDITIONS. FLOOD LEVELS TO BE DETERMINED BASED ON SITE CONDITIONS.
5. FLOW APPROACH VECTORS ARE MODIFIED ON DOWNSTREAM SIDE OF BENDWAY WEIR STRUCTURE TO BE PERPENDICULAR TO WEIR ALIGNMENT. ANGLE OF ORIENTATION ('A') CAN BE ADJUSTED TO ACHIEVE DESIGN FLOW OBJECTIVES.
6. THESE TYPICAL DETAILS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY. THE BENDWAY WEIR DESIGN WILL BE COMPLETED AS PART OF THE BLACKBIRD CREEK STABILIZATION DESIGN.

FIGURE **5-5**
TYPICAL BENDWAY WEIR
BMSG/BLACKBIRD MINE/ID

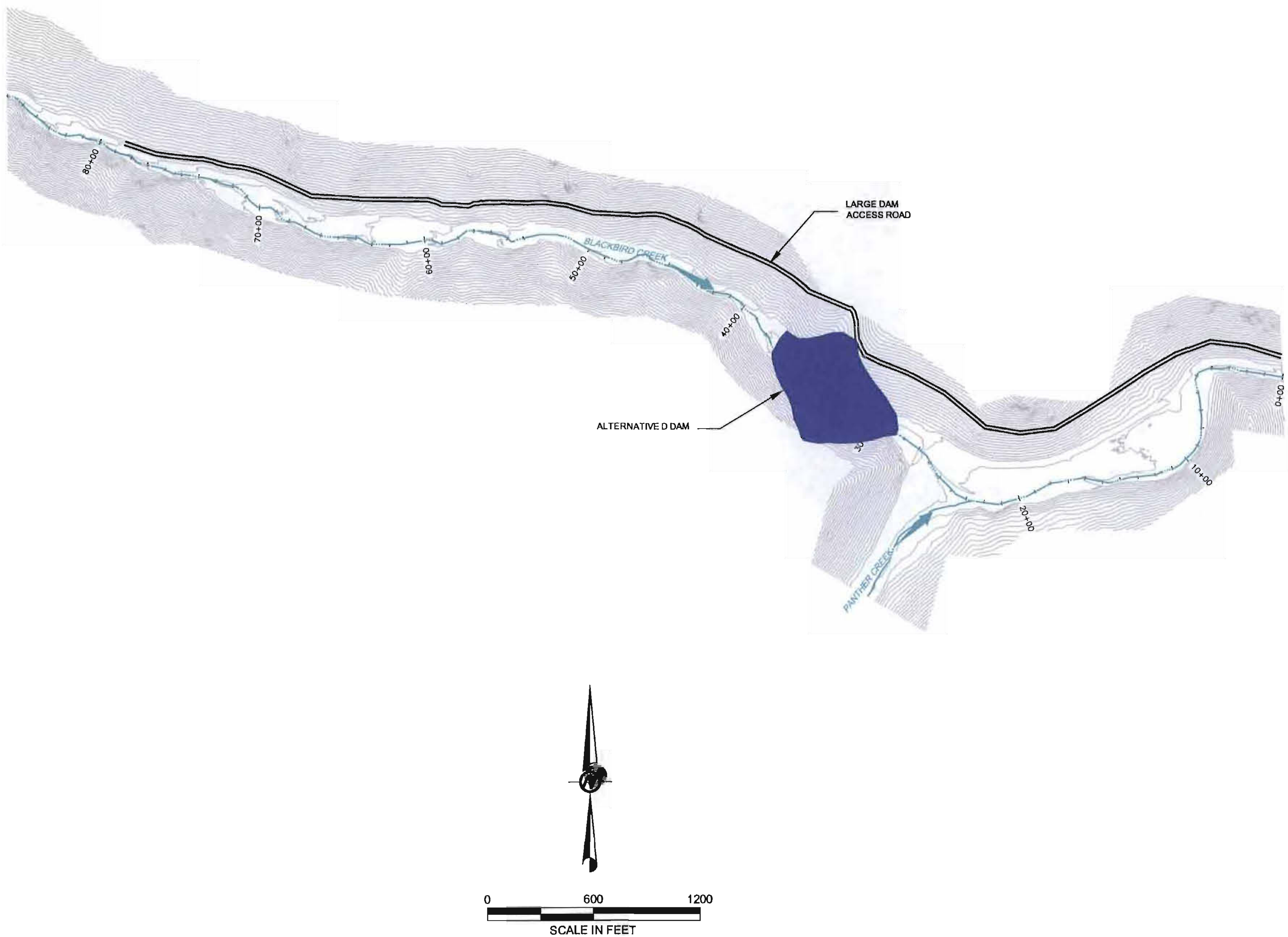


FIGURE **5-6**
ALTERNATIVE D
SINGLE LARGE DAM AND ACCESS ROAD
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\RI Report\943-1595-004_1280_F5_6.dwg | Fig 5-6 | Mod: 02/10/2010, 09:56 | Plotted: 02/10/2010, 11:54 | SSimmons

Golder Associates

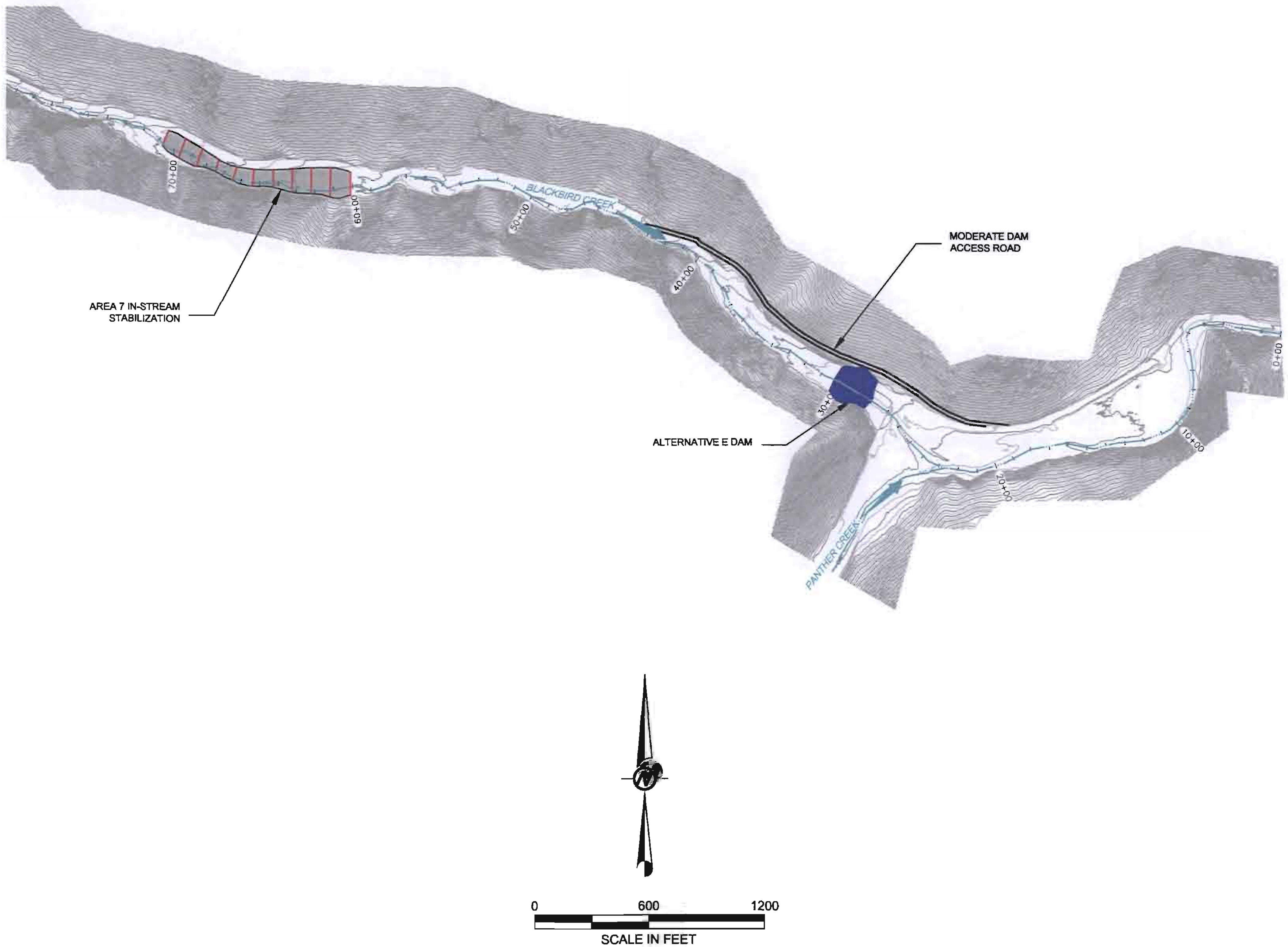


FIGURE **5-7**
ALTERNATIVE E
SINGLE MODERATE DAM AND ACCESS ROAD
BMSG/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\943-1595\x004\1280\RI Report\943-1595-004_1280_F5_7.dwg | Fig 5-7 | Mod: 02/10/2010, 10:13 | Plotted: 02/10/2010, 11:57 | SSimmons

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APPENDIX A

PHOTOGRAPHS TAKEN DURING THE MAY 2008 FLOOD EVENT ALONG BLACKBIRD CREEK

PHOTO NO. 1
LOWER SED POND(S), BLACKBIRD CREEK, VIEW LOOKING UPSTREAM

PHOTO NO. 2
LOWER SED POND(S), BLACKBIRD CREEK, VIEW LOOKING DOWNSTREAM

PHOTO NO. 3
LOCATION AT BBSW-O1A, BLACKBIRD CREEK, VIEW LOOKING UPSTREAM

PHOTO NO. 4
WESTFORK SED POND, BLACKBIRD CREEK, VIEW LOOKING UPSTREAM

PHOTO NO. 5
LOCATION NEAR HAYNES STELLITE, BLACKBIRD CREEK, VIEW LOOKING DOWNSTREAM

PHOTO NO. 6
LOCATION NEAR HAYNES STELLITE, BLACKBIRD CREEK, VIEW LOOKING UPSTREAM

PHOTO NO. 7
BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING DOWNSTREAM

PHOTO NO. 8
BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING UPSTREAM

PHOTO NO. 9
BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING DOWNSTREAM

PHOTO NO. 10 **BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING UPSTREAM**	
PHOTO NO. 11 **BLACKBIRD CREEK DOWNSTREAM OF PANTHER CREEK BRIDGE, VIEW LOOKING DOWNSTREAM FROM THE BRIDGE**	
PHOTO NO. 12 **LOWER SED POND(S), BLACKBIRD CREEK, VIEW LOOKING UPSTREAM FROM PANTHER CREEK BRIDGE**	

PHOTO NO. 13 **PANTHER CREEK BELOW THE CONFLUENCE WITH BLACKBIRD CREEK, VIEW LOOKING UPSTREAM**	
PHOTO NO. 14 **WESTFORK CHANNEL, VIEW LOOKING UPSTREAM, NOTE THAT HALF ROUNDS ARE NOT VISIBLE DUE TO FLOODING**	
PHOTO NO. 15 **WEST FORK SED POND, BLACKBIRD CREEK, VIEW LOOKING DOWNSTREAM FROM THE SPILLWAY**	

PHOTO NO. 16
CONFLUENCE OF BLACKBIRD CREEK AND WESTFORK FLOWS, VIEW LOOKING DOWN FROM THE SPILLWAY

PHOTO NO. 17
BLACKBIRD CREEK, VIEW LOOKING UPSTREAM FROM CONFLUENCE WITH WESTFORK

PHOTO NO. 18
BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING UPSTREAM

PHOTO NO. 19 BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING DOWNSTREAM	
PHOTO NO. 20 BLACKBIRD CREEK ROAD WASHOUT, VIEW LOOKING UPSTREAM	
PHOTO NO. 21 PANTHER CREEK ROAD VIEW LOOKING UPSTREAM BETWEEN PCI AND COBALT TOWNSITE	

PHOTO NO. 22
BLACKBIRD CREEK
UPSTREAM OF THE WEST
FORK SED POND LOOKING
DOWNSTREAM

PHOTO NO. 23
BLACKBIRD CREEK
LOOKING UPSTREAM OF THE
WESTFORK CONFLUENCE

PHOTO NO. 24
BLACKBIRD CREEK
LOOKING UPSTREAM OF THE
WESTFORK CONFLUENCE,
NOTE ATV FOR SCALE

PHOTO NO. 25 BLACKBIRD CREEK UPSTREAM OF THE CONFLUENCE WITH WESTFORK VIEWED FROM THE OLD ACCESS ROAD ON THE WEST SIDE OF VALLEY	
PHOTO NO. 26 BLACKBIRD CREEK ROAD UPSTREAM OF WESTFORK, LOOKING UPSTREAM ALONG THE ROAD	
PHOTO NO. 27 BLACKBIRD CREEK ROAD UPSTREAM OF WESTFORK, LOOKING DOWNSTREAM ALONG THE CREEK	

PHOTO NO. 28 **PANTHER CREEK BETWEEN THE CONFLUENCE WITH BLACKBIRD CREEK AND COBALT TOWNSITE**	
PHOTO NO. 29 **LOCATION NEAR HAYNES STELLITE, BLACKBIRD CREEK FLOWS OVER THE ROAD, VIEW LOOKING DOWNSTREAM**	

APPENDIX B

HYDROLOGY AND DAM SIZING & EFFECTIVENESS

Appendix B1 - HEC-HMS Hydrology Technical Memo

Appendix B2 – Dam and Spillway Sizing Memo

Appendix B3 – Dam Effectiveness Memo

APPENDIX B1

HEC-HMS HYDROLOGY TECHNICAL MEMO

Attachment B1-1 – Calculations

Attachment B1-2 – Supporting Documentation (NOAA Atlas 2 & USGS Peak Flows)

Golder Associates

TECHNICAL MEMORANDUM

Date: February 2010 **Project No.:** 943-1595-004.1280

To: Blackbird Mine Site Group

From: Sara L. Hillegas EIT, Jessica Cote PE

cc: Mike Brown PE, Andreas Kammereck PE, Cathy Smith PE

RE: HEC – HMS HYDROLOGY TECHNICAL MEMO

1.0 INTRODUCTION

This technical memorandum presents the hydrologic design criteria, methods and results of revised hydrologic calculations of peak flows in the Blackbird Creek watershed in central Idaho for use with the Blackbird Creek Evaluation Report (BCER) and subsequent design efforts. The original hydrologic analysis is described in Appendix B of the *Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments, Second Draft for EPA Review* (Golder, 2009). The current analysis includes modifications to hydrologic factors including time of concentration and runoff curve number for the pre-fire condition throughout the Blackbird Creek watershed. Peak discharge estimates from design thunderstorm events are provided in Section 3.

1.1 Design Criteria

The site modifications done in upper Blackbird Creek under the Blackbird Mine Early Action (1995-1998) had design criteria established by a letter from the EPA dated December 27, 1994. That letter required certain facilities to be designed for various criteria including the 500-year thunderstorm event and the 100-year snowmelt event. None of the criteria were clearly and directly applicable to the BCER and design effort we are now addressing. For this reason the criteria were revisited and a selection was made without the use of historical precedent, except that the general level of acceptable risk was maintained.

Golder has reviewed technical literature regarding hydrologic changes that can be expected following forest fires of various severities. In addition, the extent and severity of burn resulting from the 2000 Clear Creek Fire was evaluated based on GIS data generated from the USDA Remote Sensing Applications Center using Burned Area Reflectance Classification (BARC) to interpret pre and post satellite imagery. The predicted increase in peak flows is very large; however, in the years since the fire there have been no severe thunderstorms in the basin. All the high flows producing erosion occurred as a result of snowmelt, with peak flows in the range of 200 cfs. The literature on forest fires suggests that restoration of cover in a burned watershed takes approximately 20 years with hotter and more severe burns requiring longer periods. The most rapid restoration occurs in the first few years. It has now been more than 9 years since the fire at Blackbird and it will be nearly 10 years when the next snowmelt occurs.

Based on this information, and acknowledging the potential consequences of a hydrologic event exceeding the design criteria, we selected the design criteria for design of the channel stabilization structures as the peak flow from a pre-fire 100-year thunderstorm.

Hydrologic analysis was performed using SCS methods (curve number and time of concentration calculations) and the US Army Corps of Engineer Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS, Version 3.2, 2008) to estimate peak discharge from thunderstorm events in the Blackbird Creek basin. Design rainfall events with recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years were evaluated.

1.2 Blackbird Creek Watershed Sub-Basins

The Blackbird Creek drainage basin was divided into four sub-basins to provide discharge estimates at multiple locations along Blackbird Creek. A sub-basin summary is provided in Table B1. The Blackbird Creek basin and sub-basins are delineated on the USGS quad in Figure B1.

TABLE B1
Blackbird Creek Sub-Basins

Basin ID	Description	Incremental Drainage Area (sq mi)	Total Drainage Area (sq mi)
1	Blackbird Creek near Mine	4.02	4.02
2	Blackbird Creek above West Fork	4.41	8.43
3	Blackbird Creek below West Fork	8.44	16.87
4	Blackbird Creek at Mouth	3.99	20.86

1.3 Precipitation Depth-Duration for Thunderstorm Events

NOAA Atlas 2 (1973) precipitation duration frequency data were used as the rainfall depths throughout Blackbird Creek. Table B2 presents the areal-adjusted 2 through 500 year precipitation values. These values remain the most current complete statistical compilation and are the accepted values for extreme value precipitation in the region.

TABLE B2

Design Storm Precipitation

Recurrence Interval (yrs)	Duration (hrs)	Precipitation (inches)
2	24	1.58
5	24	1.97
10	24	2.17
25	24	2.46
50	24	2.76
100	24	2.96
500	24	3.55

A user-specified rainfall hyetograph was used for temporal distribution of rainfall as described in Golder, 2009. NOAA Atlas 2 isopluvial maps were used to determine 6-hour and 24-hour duration rainfall depths for the 2, 5, 10, 25, 50 and 100-year storm events. Rainfall depths for storm durations of 5, 10, 15, 30 minutes, and 1, 2, 3, and 12-hours as well as the rainfall depths for all 500-year storm durations were estimated using the methodology described in NOAA Atlas 2 (1973). An areal reduction factor was applied to scale the design rainfall events to a contributing basin area of 20.8 square miles (Figure 14, NOAA Atlas 2, 1973). Total rainfall depths for each 24-hour storm event were then distributed symmetrically based on rainfall intensity for shorter duration design events with the peak rainfall intensity occurring after 12 hours.

2.0 PRE-FIRE HYDROLOGY

2.1 Runoff Curve Number

The Hydrology Report for the West Fork of Blackbird Creek (Knight Piésold, 1994) recommends a runoff curve number (CN) of 77 for coniferous forest in the West Fork basin, which is based on hydrologic soil group B and antecedent moisture condition (AMC) III. Results of StreamStats analysis for the entire Blackbird Creek watershed indicate that more than 90% of the basin was forested (pre-fire). Design work for the Blackbird Creek in-stream stabilization project will be based on AMC II (average soil moisture conditions). Conditions simulated by AMC II are average conditions, whereas AMC III represents unusually wet conditions. To combine 100-year precipitation with a rare condition for basin cover would produce a flood with a recurrence interval much longer than 100 years. Since our criterion is the 100-year thunderstorm event it is appropriate to select AMC II.

Based on table 10-1 of the National Engineering Handbook (NEH), Part 630, Chapter 10 (USDA, 2004) a CN of 77 (AMC III) is equivalent to a CN of 59 (AMC II). This table is included in Attachment B1. Note: As seen in the NEH, the term "Antecedent Moisture Condition" (AMC) has been replaced with "Antecedent Runoff Condition" (ARC) to describe CN variability from a broader range of factors including rainfall intensity and duration, total rainfall, soil moisture conditions, cover density, stage of growth, and temperature. The current pre-fire analysis uses a curve number of 59 (coniferous forest, HSG B, AMC/ARC II).

2.2 Time of Concentration

Time of concentration (T_c) was calculated for each sub-basin and is summarized in Table B3. Detailed calculations are included in Attachment B1-1.

TABLE B3

Pre-Fire Time of Concentrations for Blackbird Creek Sub-Basins

Basin ID	Description	T_c (minutes)
1	Blackbird Creek near Mine	97.9
2	Blackbird Creek above West Fork	85.8
3	Blackbird Creek below West Fork	139.4
4	Blackbird Creek at Mouth	152.2

Note: Time of concentration values are calculated for the incremental drainage area added, not the entire contributing area to Blackbird Creek at each basin outlet.

3.0 RESULTS

3.1 Hydrologic Model Peak Discharges

Pre-fire peak discharges as calculated using HEC-HMS are summarized in Table B4. Figure B2 presents the peak discharge results from pre-fire condition modeling.

TABLE B4

Pre-Fire Peak Discharges

Basin ID	Drainage Area (sq mi)	Peak Discharge (cfs)						
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1	4.02	4	15	24	41	88	133	352
2	8.43	7	30	50	86	176	267	730
3	16.87	13	59	99	165	324	486	1,264
4	20.86	16	73	122	203	393	588	1,511

This hydrologic evaluation shows that the original Knight Piésold (KP) hydrology for the West Fork spillway design, upon which we based our previous BCER work, is very conservative, too conservative for our current design. KP used Antecedent Moisture Condition III (AMC III [aka ARC III], which assumes an extremely wet soil/cover condition) whereas the standard of practice is to use AMC II (average conditions). Therefore using the same pre-fire thunderstorm basin assumptions, the runoff curve number (CN) dropped from 70 to 59. This means that the estimate peak flow from the pre-fire 100-year thunderstorm dropped from about 2,000 cfs to 588 cfs at the mouth of Blackbird Creek.

3.2 Peak Discharges at Stabilization Areas

The peak flows calculated for the Blackbird basin and sub-basins were used to develop peak flows at the eight (8) areas targeted for stabilization along Blackbird Creek. The methodology used to calculate peak flows at locations between the modeled sub-basins uses a ratio of drainage area to an exponent specific to the storm recurrence interval. The exponents used in the calculations were taken from a USGS report, specifically developed for calculating peak flows for streams in Idaho (USGS, 2002). The peak discharge values between stabilization areas can be calculated as:

$$Q = (A/A_m)^r Q_m$$

Where:

Q is peak flow for the stabilization area

A is the drainage area for the stabilization area

A_m is the modeled drainage area

r is the exponent based on the hydrologic region and recurrence interval specified in Table B5.

Q_m is the peak flow from the model for the drainage area A_m.

TABLE B5

Flow to Area Ratio, r

Recurrence Interval	Ratio
2-year	0.893
5-year	0.846
10-year	0.824
25-year	0.801
50-year	0.787
100-year	0.775
500-year	0.750

Peak discharge values for the eight (8) stabilization areas were estimated using the HEC-HMS peak flow at the downstream sub-basin from the stabilization area to provide a conservative estimate of peak discharge for each recurrence interval. The drainage basins for each stabilization area are delineated in Figure B3. The peak discharge values used for design at each stabilization area are summarized in Table B6. Additional detailed calculations are provided in Attachment B1-1.

TABLE B6

Pre-Fire Peak Discharge for Stabilization Areas

Basin Name	Station (feet)	Basin Area (sq. mile)	Recurrence Interval						
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Area 1	270+50	5.34	4.3	20.3	34.1	59.4	122.8	187.6	518.0
Area 2	251+00	5.62	4.5	21.2	35.6	61.9	127.8	195.1	538.2
Area 3	231+50	6.30	5.0	23.4	39.1	67.8	139.9	213.2	586.4
Area 4	157+00	8.38	6.5	29.7	49.5	85.2	175.1	266.0	726.3
Area 5	131+00	18.74	14.6	64.9	107.6	179.7	352.4	526.8	1367.5
Area 6	90+00	19.63	15.2	67.5	111.8	186.5	365.5	546.1	1415.9
Area 7	50+00	20.37	15.7	69.7	115.3	192.1	376.3	562.0	1455.7
Area 8	29+00	20.82	16.0	71.0	117.4	195.5	382.8	571.6	1479.8

List of Tables

List of Figures

List of Attachments

4.0 REFERENCES

Golder Associates, 2009. Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments, Second Draft for EPA Review, Appendix B.

Knight Piésold, 1994. Hydrology Report for the WestFork of Blackbird Creek. In Lemhi County, Idaho.

NOAA Atlas 2, Volume V, 1973. Precipitation-Frequency Atlas of the Western United States. Isopluvials for 24-hour Precipitation in Idaho.

US Army Corps of Engineering, 2008. Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), Version 3.2

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USGS, 2002. Estimating the Peak Flows at Selected Recurrence Intervals for Streams in Idaho, Water Resources Investigation Report 02-4170.

FIGURES

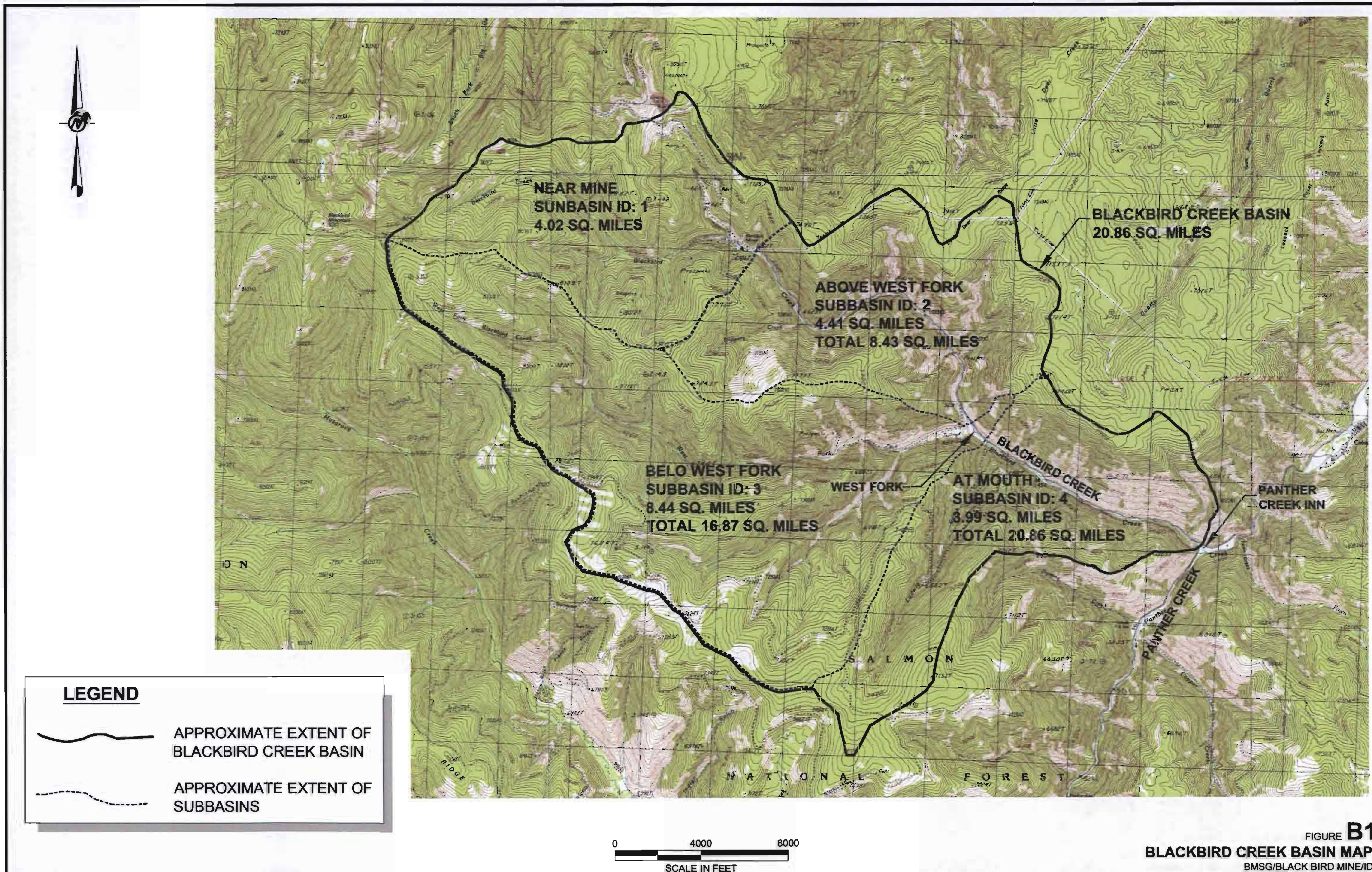

FIGURE **B1**

BLACKBIRD CREEK BASIN MAP

BMSG/BLACK BIRD MINE/ID

K:\CAD\Projects\1994\943159\x004\1280\Master CADD Base (Civil3D)\ENG\Figures\94315950041280 Basins_r3.dwg | Layout1 | Mod: 05/06/2010, 13:54 | Plotted: 05/06/2010, 14:46 | JMSchneider

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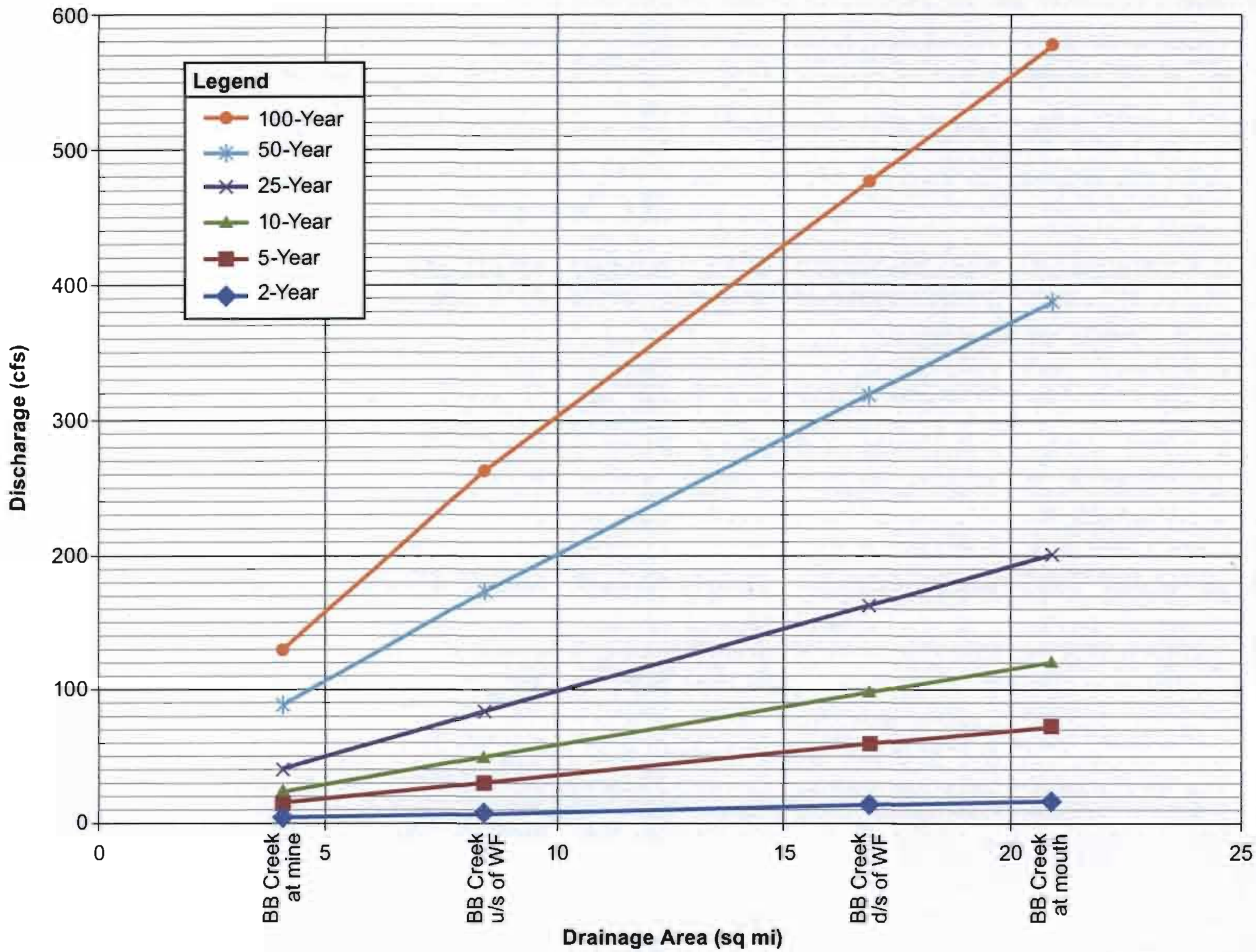

FIGURE **B2**

BLACKBIRD CREEK HYDROLOGIC MODEL
PRE-FIRE PEAK DISCHARGE ESTIMATES
BMSG/BLACK BIRD MINE/ID

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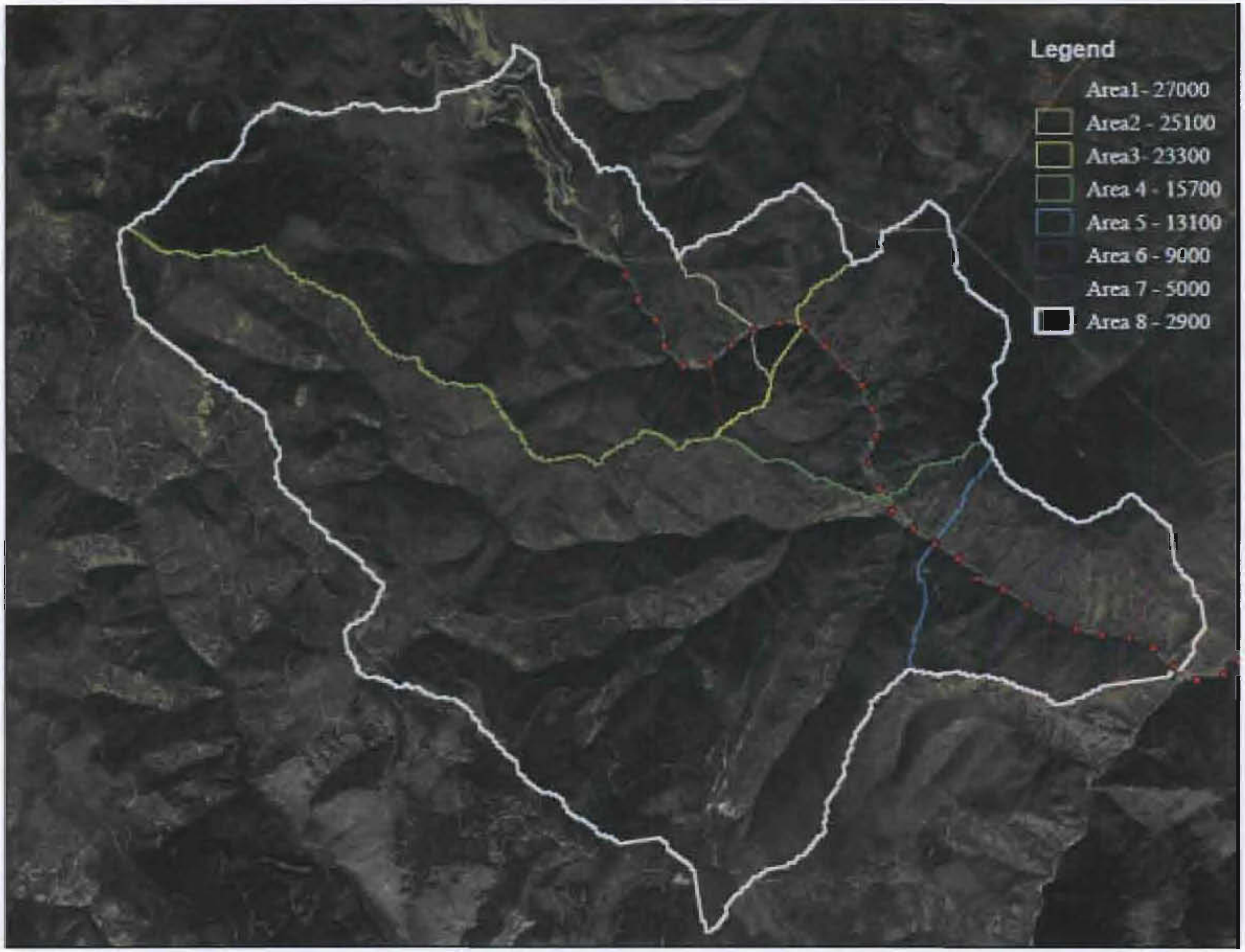
Golder Associates



Note: Values shown in legend for Areas 1-8 indicate stationing of the downstream location of the sub-basin area along the stream channel referenced to the design drawings. For instance, "27000" indicates STA 270+00, "25100" indicates STA 251+00, etc.

FIGURE **B3**

BLACKBIRD CREEK BASIN DELINEATION FOR STABILIZATION SUB-BASIN AREAS

BMSG/BLACK BIRD MINE/ID

ATTACHMENT B1-1
CALCULATIONS

Golder Associates, Inc.

Time of Concentration Calculation

Basin: Blackbird Creek
Sub-Basin: 1 BB CK NEAR MINE

Sheet Flow

T_{sheet} (minutes) =[$0.42(n_s L)^{0.8}$]/[$(P_2)^{0.5} * S^{0.4}$] *Source: Overton & Meadows (1976), Storm Water Modeling*

Where:

n_s = Sheet flow Manning's n (TR-55, Table 3-1)
L = flow length (ft) up to 300 feet
P_2 = 2-year, 24-hour rainfall (in.)
S = Slope of hydraulic grade line (land slope), ft/ft

Site Data:

n_s =	0.4	Woods (light underbrush)
L =	300	feet
P_2 =	1.6	inches
S =	0.13	sheet flow slope, ft/ft
T_{sheet} =	**34.5**	**minutes**

Shallow Concentrated Flow:

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow.

$T_{shallow}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$ *Source: SCS (1973), SCS-TP-149*

Where:

V = Velocity (ft/s)
k = time of concentration velocity factor (ft/s)
s = slope of flow path (ft/ft)

k =	5	Brushy ground with some trees (n = 0.60)
s_o =	0.32	ft/ft
V =	2.8	ft/s
L =	2326	ft
$T_{shallow}$ =	**13.7**	**minutes**

Open Channel Flow - Segment 1

$T_{channel}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$ *Source: SCS (1973), SCS-TP-149*

Where: k = 0.508/n

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.08	ft/ft
V =	5.7	ft/s
L =	16916	ft
$T_{channel}$ =	**49.7**	**minutes**

Time of Concentration for Basin:

T_{sheet}	34.5	minutes
$T_{shallow}$	13.7	minutes
$T_{channel-1}$	49.7	minutes
TOTAL Tc	**97.9**	**minutes**

Golder Associates, Inc.

Time of Concentration Calculation

Basin: Blackbird Creek

Sub-Basin: 2 BB CK ABOVE WEST FORK

Sheet Flow

T_{sheet} (minutes) =[$0.42(n_sL)^{0.8}]/[(P_2)^{0.5}*S^{0.4}]$

Where:

n_s = Sheet flow Manning's n (TR-55, Table 3-1)

L = flow length (ft) up to 300 feet

P_2 = 2-year, 24-hour rainfall (in.)

S = Slope of hydraulic grade line (land slope), ft/ft

Site Data:

n_s =	0.4	Woods (light underbrush)
L =	300	feet
P_2 =	1.6	inches
S =	0.20	sheet flow slope, ft/ft
T_{sheet} =	**29.3**	**minutes**

Shallow Concentrated Flow:

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow.

$T_{shallow}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$

Where:

V = Velocity (ft/s)

k = time of concentration velocity factor (ft/s)

s = slope of flow path (ft/ft)

k =	5	Brushy ground with some trees (n = 0.60)
s_o =	0.30	ft/ft
V =	2.7	ft/s
L =	1210	ft
$T_{shallow}$ =	**7.4**	**minutes**

Open Channel Flow - Segment 1

$T_{channel}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$

Where: k = 0.508/n

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.18	ft/ft
V =	8.6	ft/s
L =	5313	ft
$T_{channel}$ =	**10.3**	**minutes**

Open Channel Flow - Segment 2

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.07	ft/ft
V =	5.5	ft/s
L =	12727	ft
$T_{channel}$ =	**38.8**	**minutes**

Time of Concentration for Basin:

T_{sheet}	29.3	minutes
$T_{shallow}$	7.4	minutes
$T_{channel-1}$	10.3	minutes
$T_{channel-2}$	38.8	minutes
TOTAL Tc	**85.8**	**minutes**

Golder Associates, Inc.

Time of Concentration Calculation

Basin: Blackbird Creek

Sub-Basin: 3 BB CK BELOW WEST FORK

Sheet Flow

T_{sheet} (minutes) =[$0.42(n_s L)^{0.8}]/[(P_2)^{0.5} * S^{0.4}]$

Where:

n_s = *Sheet flow Manning's n (TR-55, Table 3-1)*

L = *flow length (ft) up to 300 feet*

P_2 = *2-year, 24-hour rainfall (in.)*

S = *Slope of hydraulic grode line (land slope), ft/ft*

Site Data:

n_s =	0.4	Woods (light underbrush)
L =	300	feet
P_2 =	1.6	inches
S =	0.13	sheet flow slope, ft/ft
T_{sheet} =	**34.5**	**minutes**

Shallow Concentrated Flow:

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow.

$T_{shallow}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$

Where:

V = *Velocity (ft/s)*

k = *time of concentration velocity factor (ft/s)*

s = *slope of flow path (ft/ft)*

k =	5	Brushy ground with some trees (n = 0.60)
s_o =	0.21	ft/ft
V =	2.3	ft/s
L =	2546	ft
$T_{shallow}$ =	**18.4**	**minutes**

Open Channel Flow - Segment 1

$T_{channel}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$

Where: k = 0.508/n

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.09	ft/ft
V =	6.2	ft/s
L =	27642	ft
$T_{channel}$ =	**74.5**	**minutes**

Open Channel Flow - Segment 2

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.05	ft/ft
V =	4.7	ft/s
L =	3371	ft
$T_{channel}$ =	**12.0**	**minutes**

Time of Concentration for Basin:

T_{sheet}	34.5	minutes
$T_{shallow}$	18.4	minutes
$T_{channel-1}$	74.5	minutes
$T_{channel-2}$	12.0	minutes
TOTAL Tc	**139.4**	**minutes**

Golder Associates, Inc.

Time of Concentration Calculation

Basin: Blackbird Creek

Sub-Basin: 4 BB CK @ MOUTH

Sheet Flow

T_{sheet} (minutes) $=[0.42(n_sL)^{0.8}]/[(P_2)^{0.5}*S^{0.4}]$

Where:

- n_s = *Sheet flow Manning's n (TR-55, Table 3-1)*
- L = *flow length (ft) up to 300 feet*
- P_2 = *2-year, 24-hour rainfall (in.)*
- S = *Slope of hydraulic grade line (land slope), ft/ft*

Site Data:

n_s =	0.4	Woods (light underbrush)
L =	300	feet
P_2 =	1.6	inches
S =	0.10	sheet flow slope, ft/ft
T_{sheet} =	**38.7**	**minutes**

Shallow Concentrated Flow:

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow.

$T_{shallow}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$

Where:

- V = *Velocity (ft/s)*
- k = *time of concentration velocity factor (ft/s)*
- s = *slope of flow path (ft/ft)*

k =	5	Brushy ground with some trees (n = 0.60)
s_o =	0.17	ft/ft
V =	2.1	ft/s
L =	4339	ft
$T_{shallow}$ =	**35.0**	**minutes**

Open Channel Flow - Segment 1

$T_{channel}$ = Length of sheet flow/V

$V = k(s_o)^{0.5}$

Where: k = 0.508/n

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.13	ft/ft
V =	7.4	ft/s
L =	11522	ft
$T_{channel}$ =	**26.0**	**minutes**

Open Channel Flow - Segment 2

n =	0.025	Earth-lined waterway
k =	20.3	
s_o =	0.03	ft/ft
V =	3.5	ft/s
L =	11169	ft
$T_{channel}$ =	**52.5**	**minutes**

Time of Concentration for Basin:

T_{sheet}	38.7	minutes
$T_{shallow}$	35.0	minutes
$T_{channel-1}$	26.0	minutes
$T_{channel-2}$	52.5	minutes
TOTAL Tc	**152.2**	**minutes**

Golder Associates
THUNDERSTORM DISTRIBUTION FOR 20.8 SQ MI BASIN
BMSG
Calculated by: JV Reviewed by: CC

REQUIRED Determine the rainfall distribution for the thunderstorm event for the Blackbird drainage basin above the PCI.

SOLUTION Since watershed of concern is 20.8 square miles, an areal reduction will by used. Use NOAA Atlas to determine peak rainfall for several durations less than 24-hrs, and then distribute rainfall intesities symmetrically about 12 hours to find the new rainfall distribution.

STEP 1 Find 6-hr and 24-hr precipitation depths from NOAA Atlas Isopluvial maps for 2, 5, 10, 25, 50 and 100 year events.
STEP 2 Extrapolate using Figure 6 to find the 500yr rainfall depth for both 6 and 24 hours.
STEP 3 Estimate the 1-hr rainfall for all events using Figure 6.
STEP 4 Estimate the 2 and 3-hr rainfall for all events using Equations 5 and 6.
STEP 5 Estimate the 12-hr event using Figure 16 where it is the average of the 6 and 24 hr rainfalls.
STEP 6 Estimate the 5, 10, 15, and 30-min depths using Table 13.

duration	2yr	5yr	10yr	25yr	50yr	100yr	500yr
5-min	0.12	0.19	0.23	0.29	0.35	0.37	0.49
10-min	0.19	0.29	0.36	0.45	0.54	0.58	0.77
15-min	0.24	0.37	0.46	0.57	0.68	0.73	0.97
30-min	0.34	0.51	0.63	0.79	0.95	1.01	1.34
1-hr	0.43	0.65	0.80	1.00	1.20	1.28	1.70
2-hr	0.55	0.79	0.95	1.15	1.35	1.46	1.90
3-hr	0.65	0.91	1.08	1.28	1.48	1.62	2.07
6-hr	0.90	1.20	1.40	1.60	1.80	2.00	2.50
12-hr	1.25	1.60	1.80	2.05	2.30	2.50	3.05
24-hr	1.60	2.00	2.20	2.50	2.80	3.00	3.60

STEP 7 Reduce the rainfall amounts by the area reduction factor using Figure 14. Aeral reduction factors are extrapolated where unavailable.

reduction	duration	2yr	5yr	10yr	25yr	50yr	100yr	500yr
0.78	*5-min*	0.097	0.15	0.18	0.23	0.27	0.29	0.38
0.83	*10-min*	0.16	0.24	0.30	0.37	0.45	0.48	0.63
0.85	*15-min*	0.21	0.31	0.39	0.48	0.58	0.62	0.82
0.89	*30-min*	0.30	0.45	0.56	0.70	0.84	0.90	1.19
0.93	*1-hr*	0.40	0.60	0.74	0.93	1.12	1.19	1.58
0.95	*2-hr*	0.52	0.75	0.90	1.09	1.28	1.39	1.81
0.97	*3-hr*	0.63	0.88	1.05	1.24	1.44	1.57	2.01
0.98	*6-hr*	0.88	1.18	1.37	1.57	1.76	1.96	2.45
0.98	*12-hr*	1.23	1.57	1.77	2.01	2.26	2.46	3.00
0.99	*24-hr*	1.58	1.97	2.17	2.46	2.76	2.96	3.55

Golder Associates
THUNDERSTORM DISTRIBUTION FOR 20.8 SQ MI BASIN
BMSG
Calculated by: JV Reviewed by: CC

STEP 8 Distributed various rainfall depths symmetrically centered about 12 hours where this distribution is a combination of the 5, 10, 15, 30min, 1, 2, 3, 6, 12, 24 depths.

time (hour)	*2yr*	*5yr*	*10yr*	*25yr*	*50yr*	*100yr*	*500yr*
0.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
0.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
1.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
2.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
3.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
4.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005

5.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
5.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
6.00	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.10	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.20	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.30	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.40	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.50	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.60	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.70	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.80	0.006	0.007	0.007	0.007	0.008	0.008	0.009
6.90	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.00	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.10	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.20	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.30	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.40	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.50	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.60	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.70	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.80	0.006	0.007	0.007	0.007	0.008	0.008	0.009
7.90	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.00	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.10	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.20	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.30	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.40	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.50	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.60	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.70	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.80	0.006	0.007	0.007	0.007	0.008	0.008	0.009
8.90	0.006	0.007	0.007	0.007	0.008	0.008	0.009
9.00	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.10	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.20	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.30	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.40	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.50	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.60	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.70	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.80	0.008	0.010	0.011	0.011	0.011	0.013	0.015
9.90	0.008	0.010	0.011	0.011	0.011	0.013	0.015
10.00	0.008	0.010	0.011	0.011	0.011	0.013	0.015
10.10	0.008	0.010	0.011	0.011	0.011	0.013	0.015
10.20	0.008	0.010	0.011	0.011	0.011	0.013	0.015
10.30	0.008	0.010	0.011	0.011	0.011	0.013	0.015
10.40	0.008	0.010	0.011	0.011	0.011	0.013	0.015
10.50	0.011	0.013	0.015	0.015	0.015	0.018	0.021
10.60	0.011	0.013	0.015	0.015	0.015	0.018	0.021
10.70	0.011	0.013	0.015	0.015	0.015	0.018	0.021
10.80	0.011	0.013	0.015	0.015	0.015	0.018	0.021

10.90	0.011	0.013	0.015	0.015	0.015	0.018	0.021
11.00	0.012	0.014	0.016	0.016	0.017	0.020	0.022
11.10	0.012	0.014	0.016	0.016	0.017	0.020	0.022
11.20	0.012	0.014	0.016	0.016	0.017	0.020	0.022
11.30	0.012	0.014	0.016	0.016	0.017	0.020	0.022
11.40	0.012	0.014	0.016	0.016	0.017	0.020	0.022
11.50	0.012	0.014	0.016	0.016	0.017	0.020	0.022
11.60	0.020	0.030	0.037	0.046	0.055	0.059	0.078
11.70	0.020	0.030	0.037	0.046	0.055	0.059	0.078
11.80	0.046	0.070	0.086	0.107	0.129	0.138	0.182
11.90	0.055	0.084	0.103	0.129	0.155	0.165	0.220
12.00	0.097	0.147	0.181	0.226	0.271	0.290	0.385
12.10	0.055	0.084	0.103	0.129	0.155	0.165	0.220
12.20	0.046	0.070	0.086	0.107	0.129	0.138	0.182
12.30	0.020	0.030	0.037	0.046	0.055	0.059	0.078
12.40	0.020	0.030	0.037	0.046	0.055	0.059	0.078
12.50	0.020	0.030	0.037	0.046	0.055	0.059	0.078
12.60	0.012	0.014	0.016	0.016	0.017	0.020	0.022
12.70	0.012	0.014	0.016	0.016	0.017	0.020	0.022
12.80	0.012	0.014	0.016	0.016	0.017	0.020	0.022
12.90	0.012	0.014	0.016	0.016	0.017	0.020	0.022
13.00	0.011	0.013	0.015	0.015	0.015	0.018	0.021
13.10	0.011	0.013	0.015	0.015	0.015	0.018	0.021
13.20	0.011	0.013	0.015	0.015	0.015	0.018	0.021
13.30	0.011	0.013	0.015	0.015	0.015	0.018	0.021
13.40	0.011	0.013	0.015	0.015	0.015	0.018	0.021
13.50	0.008	0.010	0.011	0.011	0.011	0.013	0.015
13.60	0.008	0.010	0.011	0.011	0.011	0.013	0.015
13.70	0.008	0.010	0.011	0.011	0.011	0.013	0.015
13.80	0.008	0.010	0.011	0.011	0.011	0.013	0.015
13.90	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.00	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.10	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.20	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.30	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.40	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.50	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.60	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.70	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.80	0.008	0.010	0.011	0.011	0.011	0.013	0.015
14.90	0.008	0.010	0.011	0.011	0.011	0.013	0.015
15.00	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.10	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.20	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.30	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.40	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.50	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.60	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.70	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.80	0.006	0.007	0.007	0.007	0.008	0.008	0.009
15.90	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.00	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.10	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.20	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.30	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.40	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.50	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.60	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.70	0.006	0.007	0.007	0.007	0.008	0.008	0.009

16.80	0.006	0.007	0.007	0.007	0.008	0.008	0.009
16.90	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.00	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.10	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.20	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.30	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.40	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.50	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.60	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.70	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.80	0.006	0.007	0.007	0.007	0.008	0.008	0.009
17.90	0.006	0.007	0.007	0.007	0.008	0.008	0.009
18.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
18.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
19.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
20.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
21.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005

22.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
22.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.10	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.20	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.30	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.40	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.50	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.60	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.70	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.80	0.003	0.003	0.003	0.004	0.004	0.004	0.005
23.90	0.003	0.003	0.003	0.004	0.004	0.004	0.005
24.00	0.003	0.003	0.003	0.004	0.004	0.004	0.005
total	1.576	1.970	2.167	2.462	2.758	2.955	3.546

Golder Associates, Inc.

943-1595-004.1280

Basin Hydrology - Blackbird Creek

Pre-Fire Conditions

Input to Hydrology Model

Model Used: HEC-HMS

See Time of Concentration sheets for additional calculations

Basin Model Parameters:

SCS Curve Number Method used

Basin	Sub-Basin	Inc. Area (acres)	Inc. Area (sq. mi.)	CN	Initial Loss (inches)	T_C (min.)	T_L (min)
Blackbird Creek							
	1	175065.0	4.02	59	1.39	97.9	58.7
	2	192081.3	4.41	59	1.39	85.8	51.5
	3	367851.7	8.44	59	1.39	139.4	83.6
	4	173780.1	3.99	59	1.39	152.2	91.3

NOTE: Drainage areas delineated based on USGS topographic maps.

Curve Number (CN) Determination:

A CN was selected for the basins based on land cover, hydrologic condition and hydrologic soil group

Coniferous forest, HSG B, AMC/ARC III	77	(Knight Piesold, 1994)
Coniferous forest, HSG B, AMC/ARC II	**59**	**(Knight Piesold, 1994; NEH, 2004)**
Woods, fair condition, HSG B	60	(SCS TR-55, 1986)
Woods, good condition, HSG B	55	(SCS TR-55, 1986)
Pinyon-juniper w/ grass, fair condition, HSG B	58	(SCS TR-55, 1986)

Initial Loss (in.) for each basin is then calculated:

Initial Loss = 0.2(1000/CN -10)

Calculate SCS Lag as a function of Time of Concentration (see attached sheets for Tc calculations):

SCS Lag Time (T_L) = ($0.6*T_C$)

Meteorological Model Parameters:

Model Used: Specified Hyetograph

Precip Distribution: Symmetrical

Precipitation Source: NOAA Atlas 2 (WRCC)

Storm Event	*Precipitation (in)*
2-year, 24-hour	1.58
5-year, 24-hour	1.97
10-year, 24-hour	2.17
25-year, 24-hour	2.46
50-year, 24-hour	2.76
100-year, 24-hour	2.96
500-year, 24-hour	3.55

Basin Hydrology - Blackbird Creek

Pre-Fire Conditions

Output from Hydrology Model

Model Used: HEC-HMS

See Time of Concentration sheets for additional calculations

See Input from Hydrology Model for additional data

Basin Model Parameters:

SCS Curve Number Method used

Storm Event		Basin Area	Peak Discharge	Time of Peak	Volume
RI (yrs)	Duration	(sq. mi.)	(cfs)		(ac-ft)
2	24 hr	20.86	16.0	02Jan2000, 01:06	5.9
5	24 hr	20.86	72.9	01Jan2000, 19:00	47.1
10	24 hr	20.86	121.5	01Jan2000, 18:42	86.1
25	24 hr	20.86	203.2	01Jan2000, 15:36	160.7
50	24 hr	20.86	393.2	01Jan2000, 14:06	238.5
100	24 hr	20.86	587.6	01Jan2000, 14:00	306.8
500	24 hr	20.86	1510.5	01Jan2000, 13:42	591.5

NOTE: Drainage areas delineated based on USGS topographic maps.

Golder Associates, Inc.

Subject:	Blackbird New Hydrology for Design Criteria
Job No.:	943-1595-004.1280
Made by:	J. Cote
Reviewed:	

Flow Determination for Sub-Basins using Flow-to-Area ratios.

Using the USGS Document, apply the area ratio to different drainage areas based on the calculated peak flow for Blackbird Basin.

Storm Intervals	Ratio	
2-year	0.893	*From USGS, Water Resources Investigation*
5-year	0.846	*Report 02-4170*
10-year	0.824	
25-year	0.801	
50-year	0.787	
100-year	0.775	
500-year	0.750	

Determine the flows based on the following relationship:

$(Q/Qbb) = (A/Abb)^r$, where

Qbb = Calculated peak flow for the Blackbird Creek Basin

Abb = Area of the Basin used for scaling

r = USGS ratio for the given storm interval

Determine adjusted flows for areas upstream of West Fork based on ***upstream HMS value:***

				Peak Flow, cfs						
Basin	**Basin Name**	**Station**	**Basin Area**	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**500-yr**
BB Creek @ mine	**HMS result**		**4.02**	**3.5**	**15.2**	**24.3**	**41.4**	**88.4**	**132.5**	**351.9**
	Area 1	27050	5.34	4.5	19.3	30.7	52.0	110.5	165.1	435.4
	Area 2	25100	5.62	4.7	20.2	32.0	54.1	115.1	171.8	452.4
	Area 3	23150	6.30	5.2	22.2	35.2	59.3	125.9	187.7	492.9
just above West Fork	Area 4	15700	8.38	6.7	28.3	44.5	74.6	157.6	234.1	610.5

Determine adjusted flows for areas upstream of West Fork based on ***downstream HMS value:***

Basin	Basin Name	Station	Basin Area	Peak Flow, cfs						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
BB Creek u/s of West Fork	**HMS results**		**8.43**	**6.5**	**29.9**	**49.7**	**85.6**	**175.9**	**267.2**	**729.5**
	Area 1	27050	5.34	4.3	20.3	34.1	59.4	122.8	187.6	518.0
	Area 2	25100	5.62	4.5	21.2	35.6	61.9	127.8	195.1	538.2
	Area 3	23150	6.30	5.0	23.4	39.1	67.8	139.9	213.2	586.4
just above West Fork	Area 4	15700	8.38	6.5	29.7	49.5	85.2	175.1	266.0	726.3

Determine adjusted flows for areas downstream of West Fork based on ***upstream HMS value:***

Basin	Basin Name	Station	Basin Area	Peak Flow, cfs						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
BB Creek d/s of West Fork	**HMS results**		**16.87**	**13.3**	**59.4**	**98.7**	**165.2**	**324.4**	**485.6**	**1263.8**
just downstream of West Fork	Area 5	13100	18.74	14.6	64.9	107.6	179.7	352.4	526.8	1367.5
	Area 6	9000	19.63	15.2	67.5	111.8	186.5	365.5	546.1	1415.9
	Area 7	5000	20.37	15.7	69.7	115.3	192.1	376.3	562.0	1455.7
BB Creek at mouth	Area 8	2900	20.82	16.0	71.0	117.4	195.5	382.8	571.6	1479.8

Determine adjusted flows for areas downstream of West Fork based on ***downstream HMS value:***

Basin	Basin Name	Station	Basin Area	Peak Flow, cfs						
				2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
BB Creek at mouth	**HMS results**		**20.86**	**16**	**72.9**	**121.5**	**203.2**	**393.2**	**587.6**	**1510.5**
just downstream of West Fork	Area 5	13100	18.74	14.5	66.6	111.2	186.5	361.4	540.8	1393.8
	Area 6	9000	19.63	15.2	69.2	115.6	193.5	374.8	560.6	1443.2
	Area 7	5000	20.37	15.7	71.4	119.1	199.4	385.9	576.9	1483.8
BB Creek at mouth	Area 8	2900	20.82	16.0	72.8	121.3	202.9	392.6	586.7	1508.3

ATTACHMENT B1-2

NOAA ATLAS 2 & USGS PEAK FLOWS

NOAA ATLAS 2

Precipitation-Frequency Atlas of the Western United States

J. F. Miller, R. H. Frederick, and R. J. Tracey

Volume V–Idaho

U.S. DEPARTMENT OF COMMERCE
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Prepared for U.S. Department of Agriculture, Soil Conservation Service, Engineering Division

Idaho

Discussion of Maps

Figures 19 through 30 present precipitation-frequency maps for Idaho for the 6- and 24-hr durations for return periods of 2, 5, 10, 25, 50, and 100 yrs. The isopluvial maps represent the 360- and 1,440-min durations for the partial-duration series. Data were tabulated for clock and observation-day intervals for the annual series and were adjusted by the empirical factors given in the ANALYSIS section.

Isoline interval. The isoline interval selected was designed to provide a reasonably complete description of the isopluvial pattern in various regions of the state. The intervals on the maps for the 24-hr duration are 0.2 in. where precipitation-frequency values are below 3.0 in. and 0.4 in. between 3.0 and 5.0 in. For the 6-hr duration, the isopluvial interval is 0.1 in. for precipitation-frequency values below 1.6 in. and 0.2 in. for values from 1.6 to 3.0 in. Dashed intermediate lines have been placed between widely separated isolines and in regions where a linear interpolation between the normal isopluvial interval would lead to erroneous interpolation. "Lows" that close within the boundaries of a particular map have been hatched on the low-valued side of the isoline.

Importance of snow in precipitation-frequency values. The maps in this Atlas represent frequency values of precipitation regardless of type. For many hydrologic purposes, precipitation falling as rain must be treated in a different manner from that falling as snow. The contribution of snow amounts to precipitation-frequency values in Idaho and the Pacific Northwest (roughly Idaho, Washington, Oregon, and small adjacent portions of California and Nevada) was investigated. Meteorological and statistical considerations suggest that any such contribution would be greatest at the 24-hr duration and at the short (2- to 5-yr) return periods. In the area under investigation, there were 179 stations having 10 to 15 yrs of observations of snowfall as part of the precipitation observing program. Fifty of these stations are in Idaho. Table 11 shows the distribution of these stations by regions considered to be more meteorologically realistic than are state boundaries. For each of the 179 stations (56 of which were equipped with recording precipitation gages), two data series were formed as discussed under Interpretation of Results, Importance of Snow in Estimating Frequency Values.

A ratio was formed of the 2-yr 24-hr value for the series containing maximum annual amounts and the 2-yr 24-hr value for the series with snow occurrences eliminated. At over 75 percent of the stations in the Pacific Northwest this ratio showed the difference between the two series to be 10 percent or less. The variation of this ratio with elevation and latitude was examined both analytically and graphically. There was, of course, some correlation with elevation. Most Idaho stations (including all stations at higher elevations) are included in Region 12 of table 11. In this region the correlation with elevation accounted for less than 25 percent of the variance. Even at elevations above 4,000 ft, this region had stations with no difference between the two series and there were more stations with a ratio of 1.10 or less than there were stations with a ratio greater than 1.10.

In addition to a graph of ratio versus latitude, the ratios were plotted on maps. For Idaho, neither view of geographical distribution showed a useful pattern.

The individual data series were inspected to determine where the values which contained some snow fell in a ranked series. This examination showed that, although the largest storms at each station could include some snow, there was a greater likelihood that the values containing snow would be in the middle or lower third of the station's ranked sample. For instance, in Region 12 the rank 7 storms (about the mid-point of the distribution) were three times as likely to be at least partially snow as were the rank 1 storms. In the Snake River Plains region the percentage of values having snow was somewhat less than in Region 12 and ranked changes were more evenly distributed.

The data analysis of the two series showed that the curves converge with increasing return period. At the 25-yr return period about 5 percent of the 179 stations showed differences greater than 10 percent.

At the 6-hr duration the data are restricted to the 14 stations with recording gages. An analysis similar to that for the 24-hr duration showed that the ratio of the maximum annual series and the series without snow was lower at the 6-hr duration than at the 24-hr duration. This is meteorologically realistic since the portion of a 24-hr storm that contains snow is most likely to be of less intensity than is the maximum 6-hr period of that storm.

In the selection of data for the series made up of amounts containing rain only, all observations containing snow were eliminated. Thus an eliminated amount could have contained only a small portion of the precipitation as snow or it could have been all snow. In some cases the amount of rain in a storm with only a little snow could have been greater than the value actually selected for that year since only a few stations report water content of snow (which would have enabled the tabulator to segregate such cases). Thus, the data could yield rain-only values actually less than the true amount but were unable to give results greater than the true amount. Therefore, the ratios compared tended to be maximum values.

The conclusion was made that the elimination of amounts containing snow does not materially change the precipitation-frequency values as presented on the maps for Idaho, especially at the longer return periods. At the higher elevations (above 5,000 or 6,000 ft) where data are sparse and at the eastern end of the Snake River Basin where the mountains form the western side of the Continental Divide, frequency values computed from a data series containing only rain occurrences would be 10 to 20 percent less (possibly even lower in some areas) than the map values for the 2-yr 24-hr events. This difference would likely decrease, in most cases, to 10 percent or less at the 25-yr return period. No differences are considered likely at the 100-yr return period. For the 6-hr duration such differences would be about one-half the 24-hr differences.

Table 11. *Percent of snowfall stations in Pacific Northwest by regions*

Number of region in figure 9	Region	Percent of stations
12	Mountainous region of eastern Washington and Oregon and of Idaho west of Bitterroot Range crest and Continental Divide and north of southern boundary of Snake River Basin—excluding Snake River Valley below a smoothed 5,000-ft contour	30
13	Orographic region east of crest of Cascade Range and west of Snake River Basin	20
14	Western slopes of Coast Ranges, Olympic Mountains, and Cascade Range	14
30	Snake River Valley below 5,000 ft	13
31	Coastal Plain, Puget Sound region, and Willamette Valley below 1,000 ft	12
32	Nonorographic region east of crest of Cascade Range	11

Procedures for Estimating Values for Durations Other Than 6 and 24 Hrs

The isopluvial maps in this Atlas are for the 6- and 24-hr duration. For many hydrologic purposes, values for other durations are necessary. Such values can be estimated using the 6- and 24-hr maps and the empirical methods outlined in the following sections. The procedures detailed below for obtaining 1-, 2-, and 3-hr estimates were developed specifically for this Atlas. The procedures for obtaining estimates for less than 1-hr duration and for the 12-hr duration were adopted from *Weather Bureau Technical Paper* No. 40 (U.S. Weather Bureau 1961) only after investigation demonstrated their applicability to data from the area covered by this Atlas.

Procedures for estimating 1-hr (60-min) precipitation-frequency values. Multiple-regression screening techniques were used to develop equations for estimating 1-hr values. Factors considered in the screening process were restricted to those that could be determined easily from the maps of this Atlas or from generally available topographic maps.

The 11 western states were separated into several geographic regions. The regions were chosen on the basis of meteorological and climatological homogeneity and are generally combinations of river basins separated by prominent divides. Three of these geographic regions are partially within Idaho. For convenience and use as an overlay on the precipitation-frequency maps, these regions are outlined on figure 18. The Snake River Plains in Idaho (Region 1, fig. 18) is one of three essentially nonorographic regions between the crest of the Cascade Mountains and the Continental Divide. The second region is the mountainous portion of the area between the Continental Divide and the crest of the Cascade Range. The portion that lies within Idaho is the mountainous area west of the Bitterroot Range crest and the Continental Divide and north of the southern boundary of the Snake River Basin (Region 2, fig. 18). The third region was primarily in

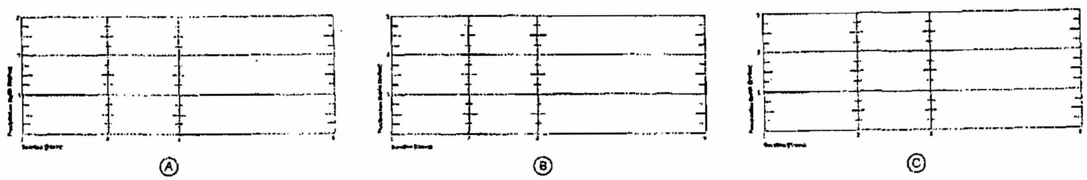

Figure 15. *Precipitation depth-duration diagram (1- to 6-hr).*
a. Snake River Valley below 5,000 ft (Region 1, fig. 18).
b. Mountainous regions of eastern Washington and Oregon east of crest of Cascade Range and of Idaho and Montana west of Continental Divide and north of southern boundary of Snake River Valley below a smoothed 5,000-ft contour (Region 2, fig. 18).
c. Western Utah and Nevada except Snake and Virgin River Basins and spillover zone east of Sierra Nevada crest (Region 3, fig. 18).

Nevada, western Utah, and the southeastern desert areas of California. The portion within Idaho is in the southeastern corner of the State and is south of the southern boundary of the Snake River Basin (Region 3, fig. 18). Equations to provide estimates for the 1-hr duration for 2- and 100-yr return periods are shown in table 12. Also listed are the statistical parameters associated with each equation. In these equations, the variable $[(X_1)(X_1/X_2)]$ or $[(X_3)(X_3/X_4)]$ can be regarded as the 6-hr value times the slope of the line connecting the 6- and 24-hr values for the appropriate return year.

As with any separation into regions, the boundary can only be regarded as the sharpest portion of a zone of transition between regions. These equations have been tested for boundary discontinuities by computing values using equations from both sides of the boundary. Differences were found to be mostly under 15 percent. However, it is suggested that when computing estimates along or within a few miles of a regional boundary computations be made using equations applicable to each region and that the average of such computations be adopted.

Estimates of 1-hr precipitation-frequency values for return periods between 2 and 100 yrs. The 1-hr values for the 2- and 100-yr return periods can be plotted on the nomogram of figure 6 to obtain values for return periods greater than 2 yrs or less than 100 yrs. Draw a straight line connecting the 2- and 100-yr values and read the desired return-period value from the nomogram.

Estimates for 2- and 3-hr (120- and 180-min) precipitation-frequency values. To obtain estimates of precipitation-frequency values for 2 or 3 hrs, plot the 1- and the 6-hr values from the Atlas on the appropriate nomogram of figure 15. Draw a straight line connecting the 1- and 6-hr values, and read the 2- and 3-hr values from the nomogram. This nomogram is independent of return period. It was developed using data from the same regions used to develop the 1-hr equations.

The mathematical solution from the data used to develop figure 15 gives the following equations for estimating the 2- and 3-hr values:

For Region 1,	2-hr = 0.278 (6-hr) + 0.722 (1-hr)	(3)
figure 18	3-hr = 0.503 (6-hr) + 0.497 (1-hr)	(4)
For Region 2,	2-hr = 0.250 (6-hr) + 0.750 (1-hr)	(5)
figure 18	3-hr = 0.467 (6-hr) + 0.533 (1-hr)	(6)
For Region 3,	2-hr = 0.299 (6-hr) + 0.701 (1-hr)	(7)
figure 18	3-hr = 0.526 (6-hr) + 0.474 (1-hr)	(8)

Estimates for 12-hr (720-min) precipitation-frequency values. To obtain estimates for the 12-hr duration, plot values from the 6- and 24-hr maps on figure 16. Read the 12-hr estimate at the intersection of the line connecting these points with the 12-hr duration line of the nomogram.

Estimates for less than 1 hr. To obtain estimates for durations of less than 1 hr, apply the values in table 13 to the 1-hr value for the return period of interest.

Table 12. *Equations for estimating 1-hr values in Idaho with statistical parameters for each equation*

Region of applicability*	Equation	Corr. coeff.	No. of stations	Mean of computed stn. values (inches)	Standard error of estimate (inches)
Snake River Valley below 5,000 ft (1)	$Y_2 = 0.077 + 0.715[(X_1)(X_1/X_2)] - 0.0004(X_5)(X_6)$	0.86	30	0.35	0.034
	$Y_{100} = 0.187 + 0.833[(X_3)(X_3/X_4)]$	.87	30	1.08	.161
Mountainous regions of Washington and Oregon east of crest of Cascade Range and of Idaho and Montana west of Continental Divide and north of southern boundary of Snake River Basin—excluding Snake River Valley below a smoothed 5,000-ft contour (2)	$Y_2 = 0.019 + 0.711[(X_1)(X_1/X_2)] + 0.001Z$	.82	98	0.40	.031
	$Y_{100} = 0.338 + 0.670[(X_3)(X_3/X_4)] + 0.001Z$	.80	79	1.04	.141
Western Utah and Nevada except Snake and Virgin River Basins and spillover zone east of Sierra Nevada crest (3)	$Y_2 = 0.005 + 0.852[(X_1)(X_1/X_2)]$	.89	65	0.41	.047
	$Y_{100} = 0.322 + 0.789[(X_3)(X_3/X_4)]$	.87	65	1.25	.196

* Numbers in parentheses refer to geographic regions shown in figure 18. See text for more complete description.

List of variables
Y_2 = 2-yr 1-hr estimated value
Y_{100} = 100-yr 1-hr estimated value
X_1 = 2-yr 6-hr value from precipitation-frequency maps
X_2 = 2-yr 24-hr value from precipitation-frequency maps
X_3 = 100-yr 6-hr value from precipitation-frequency maps
X_4 = 100-yr 24-hr value from precipitation-frequency maps
X_5 = latitude (in decimals) minus 40°
X_6 = longitude (in decimals) minus 100°
Z = point elevation in hundreds of feet

Illustration of Use of Precipitation-Frequency Maps, Diagrams, and Equations

To illustrate the use of these maps, values were read from figures 19 to 30 for the point at 44°00′ N. and 115°00′ W. These values are shown in boldface type in table 14. The values read from the maps should be plotted on the return-period diagram of figure 6 because (1) not all points are as easy to locate on a series of maps as are latitude-longitude intersections, (2) there may be some slight registration differences in printing, and (3) precise interpolation between isolines is difficult. This has been done for the 24-hr values in table 14 (fig. 17a) and a line of best fit has been drawn subjectively. On this nomogram, the 50-yr value appears somewhat below the line, so the value read from the maps is corrected (as shown by the strikeout in table 14); such corrected values are adopted in preference to the original readings.

The 2- and 100-yr 1-hr values for the point were computed from the equations applicable to Region 2, figure 18 (table 12) since the point is in the orographic region. The 2-yr 1-hr is estimated at 0.56 in. (using elevation of 9,100 ft and 2-yr 6- and 24-hr values from table 14); the estimated 100-yr 1-hr value is 1.37 in. (100-yr and 24-hr values from table 14). By plotting these 1-hr values on figure 6 and connecting them with a straight line, one can obtain estimates for return periods of 5, 10, 25, and 50 yrs.

The 2- and 3-hr values can be estimated by using the nomogram of figure 15 or equations (5) and (6). The 1- and 6-hr values for the desired return period are obtained as above. Plot these points on the nomogram of figure 15 and connect them with a straight line. Read the estimates for 2 or 3 hrs at the intersections of the connecting line and the 2- and 3-hr vertical lines. An example is shown in figure 17b for the 100-yr return period. The values of the 100-yr 2-hr (1.68 in.) and 100-yr 3-hr (1.95 in.) are in italics on table 14.

Duration (min)	5	10	15	30
Ratio to 1-hr	0.29	0.45	0.57	0.79

(Adapted from *U.S. Weather Bureau Technical Paper* No. 40, 1961.)

Table 13. *Adjustment factors to obtain n-min estimates from 1-hr values*

	1-hr	2-hr	3-hr	6-hr	24-hr
2-yr	0.56			1.24	2.44
5-yr				1.57	3.02
10-yr				1.83	3.42
25-yr				2.20	3.90
50-yr				2.42	4.42 ~~4.04~~
100-yr	*1.37*	*1.68*	*1.95*	2.61	4.85

Table 14. *Precipitation data for depth-frequency atlas computation point 44°00′ N., 115°00′ W.*

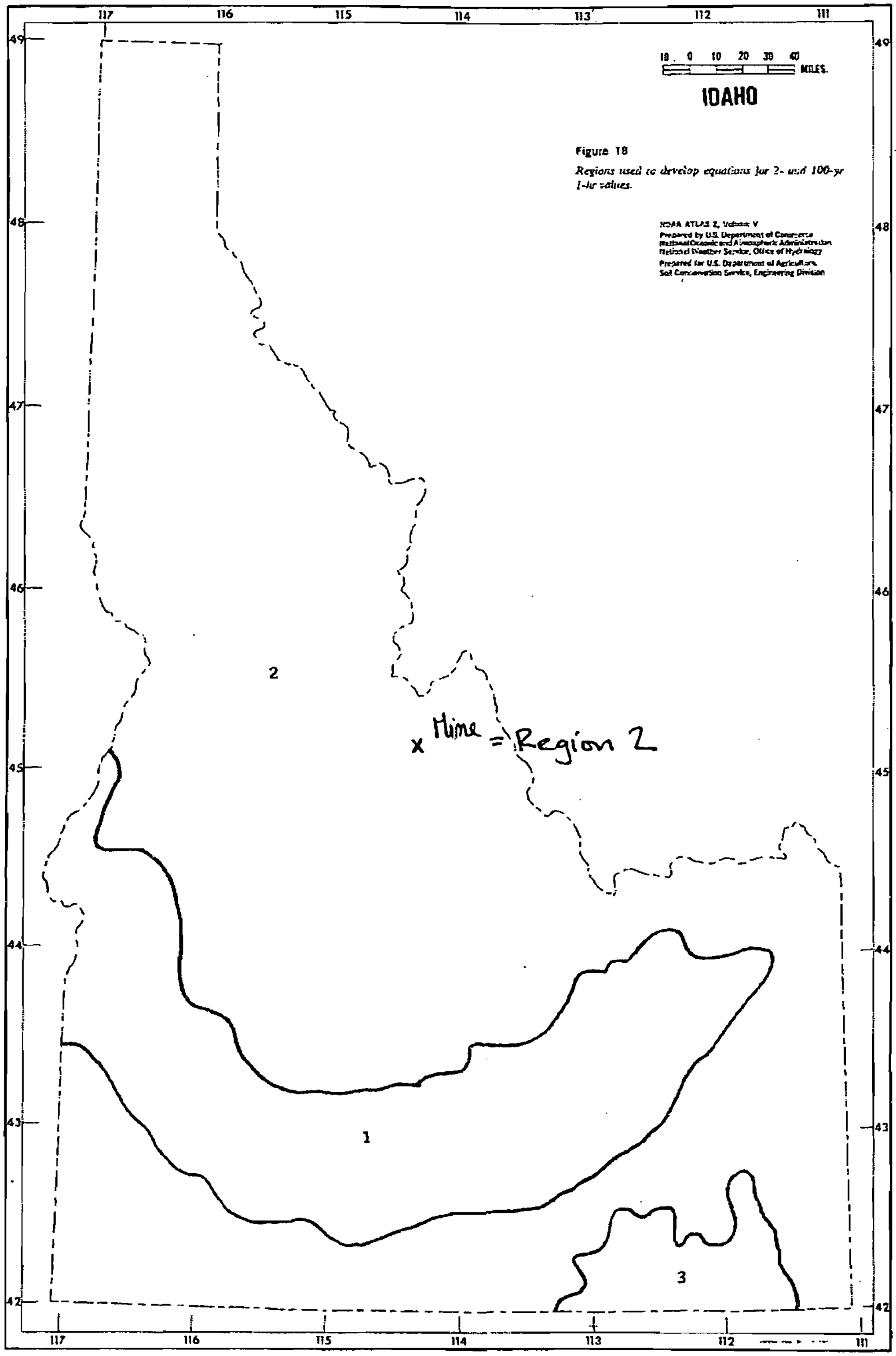

Figure 18

Regions used to develop equations for 2- and 100-yr 1-hr values.

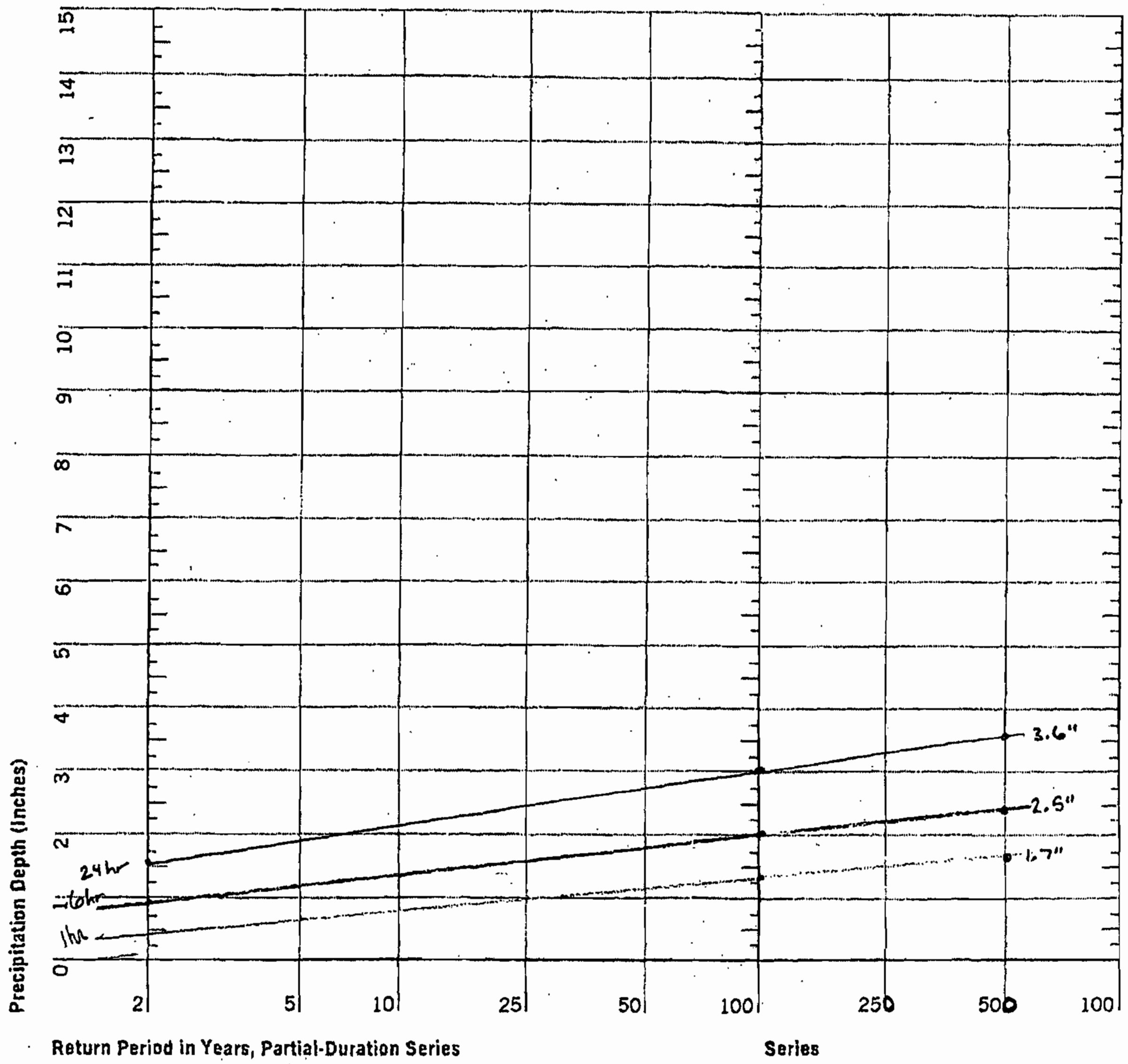

Figure 6. *Precipitation depth versus return period for partial-duration series.*

sus return period for

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Finally, various climato could be indexes of variatio were considered. The proce equations was a multiple-reg ess was done by computer computer program was cap pendent variables for as m The number of variables scr between 60 and 100. This pletely different factors cou factors might involve differe measures of slope might be ent orientations. In each in *computer to select the most* factor.

Although the compute ear during the regression an computations to use logarith binations of any or all of selected the single variable r tation-frequency value unde select the variable that, co lected, would explain the gr quency values. The third, f selected in a similar mann

Figure 16. *Precipitation depth-duration diagram (6- to 24-hr).*

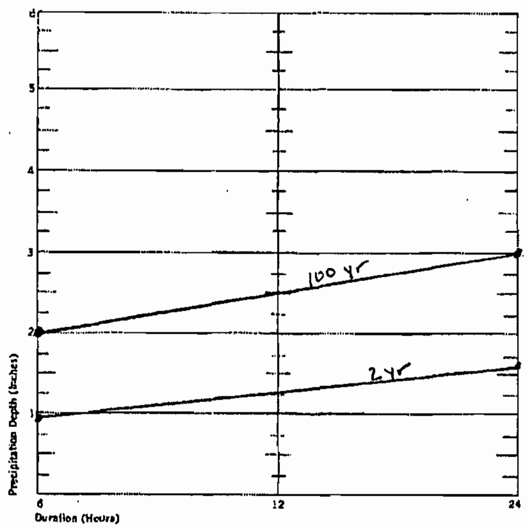
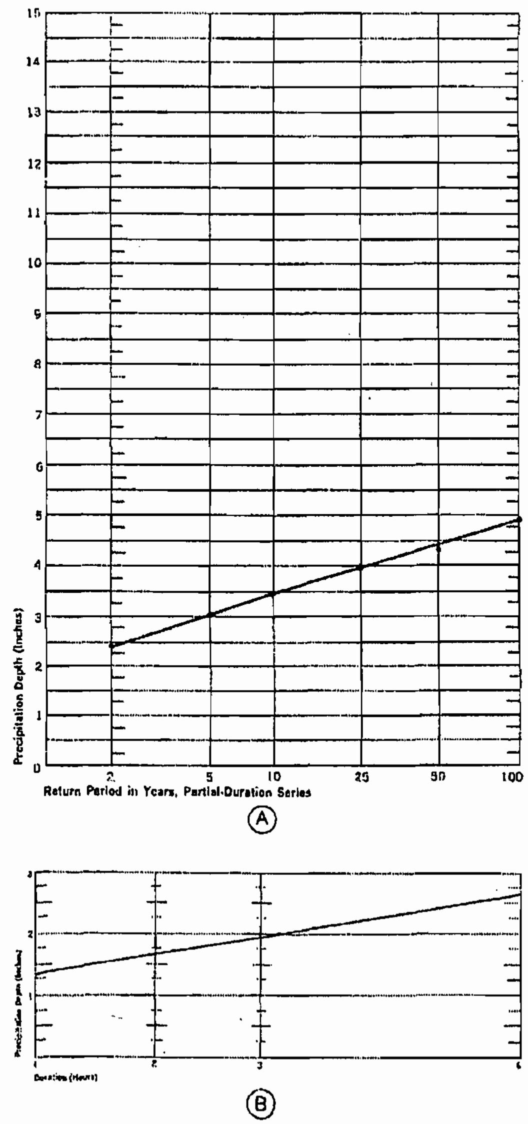


Figure 17. *Illustration of use of precipitation-frequency diagrams using values from precipitation-frequency maps and relations at 44°00′ N., 115°00′ W.*



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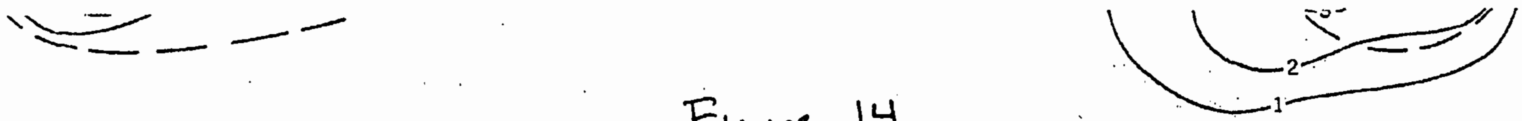
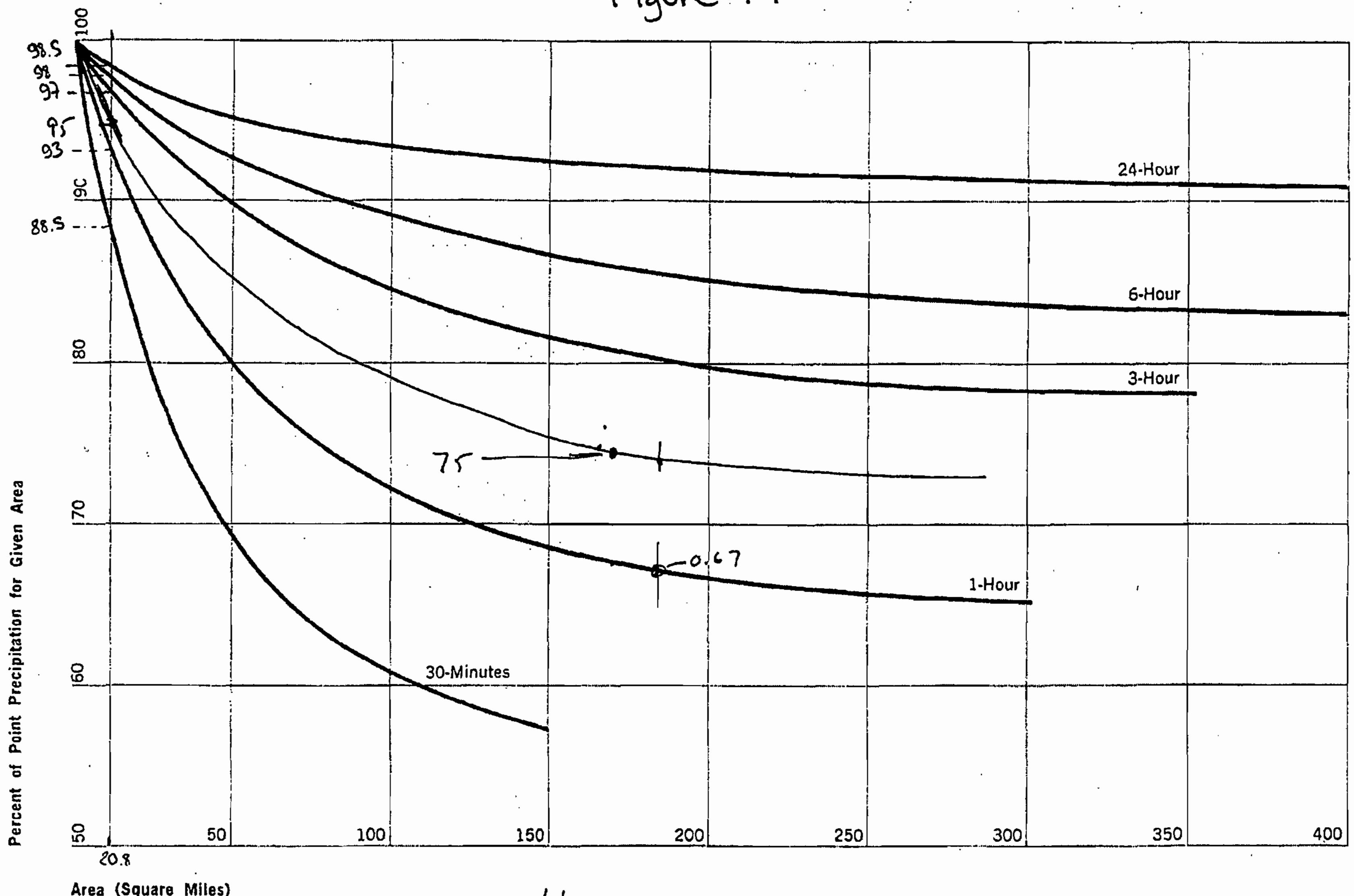


Figure 14



1 hr.

1.70 × 0.67 =

point

182 sq mi =

U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with
IDAHO TRANSPORTATION DEPARTMENT
IDAHO BUREAU OF DISASTER SERVICES
U.S. ARMY CORPS OF ENGINEERS

Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho

Water-Resources Investigations Report 02–4170

USGS
science for a changing world

Table 7. Predictive regression equations and their accuracy in estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho—Continued

Peak-flow regression equations for given recurrence interval (2 to 500 years)	Standard error of model (percent)	Standard error of prediction (percent)
Region 4 (Equations based on data from 60 gaging stations)		
$Q_2 = 16.3\ DA^{0.893}\ (E/1,000)^{-0.121}$	+80.5 to -44.6	+83.5 to -45.5
$Q_5 = 46.3\ DA^{0.874}\ (E/1,000)^{-0.459}$	+66.6 to -40.0	+69.1 to -40.9
$Q_{10} = 79.2\ DA^{0.863}\ (E/1,000)^{-0.628}$	+61.2 to -37.9	+63.6 to -38.9
$Q_{25} = 139\ DA^{0.852}\ (E/1,000)^{-0.801}$	+56.9 to -36.3	+59.5 to -37.3
$Q_{50} = 198\ DA^{0.844}\ (E/1,000)^{-0.910}$	+55.2 to -35.6	+57.7 to -36.6
$Q_{100} = 273\ DA^{0.837}\ (E/1,000)^{-1.01}$	+54.2 to -35.1	+56.9 to -36.3
$Q_{200} = 365\ DA^{0.831}\ (E/1,000)^{-1.10}$	+53.8 to -35.0	+56.6 to -36.1
$Q_{500} = 521\ DA^{0.822}\ (E/1,000)^{-1.20}$	+53.9 to -35.0	+56.9 to -36.3
Region 5 (Equations based on data from 46 gaging stations)		
$Q_2 = 0.0297\ DA^{0.995}\ P^{2.20}\ (NF30+1)^{-0.664}$	+43.6 to -30.4	+46.7 to -31.8
$Q_5 = 0.0992\ DA^{0.970}\ P^{1.92}\ (NF30+1)^{-0.602}$	+41.7 to -29.4	+44.8 to -30.9
$Q_{10} = 0.178\ DA^{0.957}\ P^{1.79}\ (NF30+1)^{-0.571}$	+41.7 to -29.4	+45.0 to -31.1
$Q_{25} = 0.319\ DA^{0.943}\ P^{1.66}\ (NF30+1)^{-0.538}$	+42.3 to -29.7	+46.0 to -31.5
$Q_{50} = 0.456\ DA^{0.934}\ P^{1.58}\ (NF30+1)^{-0.517}$	+43.1 to -30.1	+47.1 to -32.0
$Q_{100} = 0.620\ DA^{0.926}\ P^{1.52}\ (NF30+1)^{-0.499}$	+44.1 to -30.6	+48.4 to -32.6
$Q_{200} = 0.813\ DA^{0.919}\ P^{1.46}\ (NF30+1)^{-0.483}$	+45.3 to -31.2	+49.8 to -33.2
$Q_{500} = 1.12\ DA^{0.911}\ P^{1.39}\ (NF30+1)^{-0.464}$	+46.9 to -31.9	+51.9 to -34.2
Region 6 (Equations based on data from 31 gaging stations)		
$Q_2 = 0.000258\ DA^{0.893}\ P^{3.15}$	+71.2 to -41.6	+76.5 to -43.4
$Q_5 = 0.00223\ DA^{0.846}\ P^{2.68}$	+63.9 to -39.0	+68.8 to -40.8
$Q_{10} = 0.00632\ DA^{0.824}\ P^{2.45}$	+62.9 to -38.6	+67.9 to -40.4
$Q_{25} = 0.0181\ DA^{0.801}\ P^{2.22}$	+63.4 to -38.8	+68.8 to -40.8
$Q_{50} = 0.0346\ DA^{0.787}\ P^{2.08}$	+64.4 to -39.2	+70.2 to -41.2
$Q_{100} = 0.0607\ DA^{0.775}\ P^{1.96}$	+65.8 to -39.7	+71.8 to -41.8
$Q_{200} = 0.100\ DA^{0.763}\ P^{1.85}$	+67.3 to -40.2	+73.8 to -42.4
$Q_{500} = 0.180\ DA^{0.750}\ P^{1.73}$	+69.6 to -41.0	+76.5 to -43.3

APPENDIX B2

DAM AND SPILLWAY SIZING MEMO

Attachment B2 – Calculation – Dam and Spillway Sizing

Golder Associates

TECHNICAL MEMORANDUM

Date: February 18, 2010 **Project No.:** 943-1595-004.1280

To: Blackbird Mine Site Group

From: Sara Hillegas, Katy Cottingham

cc: Mike Brown, Cathy Smith

RE: DAM AND SPILLWAY SIZING

1.0 INTRODUCTION

This memorandum describes the methodology for sizing the dam and spillway for Alternative D and E. Alternative D involves the design of a single, large-sized in-stream impoundment at the proposed dam location along Blackbird Creek, as described in the main text of the Blackbird Creek Evaluation Report (Golder, 2010). Alternative E combines in-stream stabilization with a single, moderately-sized in-stream impoundment at the proposed dam location along Blackbird Creek.

2.0 DAM SIZING

2.1 Alternative D

A spillway crest height of 150 feet was selected to provide *highly effective* sediment capture during the 100-year, 24-hour flood event, while providing near 100% sediment trap efficiency during low flow events. A large dam providing near 100% sediment trap efficiency was assumed to be unreasonable. For example, at a dam crest height of 380 feet, the reservoir would extend up to the West Fork and the sediment trap efficiency would only be on the order of 85% during the 100-year, 24 hour flow. No specific criteria were used in determining the size of the reservoir; however site conditions were analyzed to determine elevation-volume relationships at the proposed dam location.

2.2 Alternative E

A spillway crest height of 26 feet was selected to provide *moderately effective* sediment capture during the 100-year, 24-hour flood event, while providing near 100% sediment trap efficiency during low flow events, in combination with in-stream stabilization measures. No specific criteria were used in determining the size of the reservoir; however site conditions were analyzed to determine elevation-volume relationships at the proposed dam location.

3.0 SPILLWAY SIZING

3.1 Alternative D

Spillway sizing for the Alternative D dam was calculated by routing the 500-year, 24-hour flood hydrograph, with a peak discharge of 1,511 cfs, through a reservoir element at the outlet of Blackbird

Creek using HEC-HMS (version 3.2). The spillway crest elevation was assumed to be at a height of 150 feet and the initial water elevation was assumed to be 150 feet (i.e. a full reservoir). During optimization of the spillway configuration, a spillway width of 10 feet was selected for the calculations.

The maximum water level at the dam during the 500-year, 24-hour flood event was modeled at 156.9 feet. Assuming 3 feet of freeboard, a dam crest height of 160 feet is reasonable and, based on the model results, would not be overtopped during the 500-year event. The design spillway height is 10 feet.

To calculate the spillway wall height down the face of the dam, FlowMaster (Bentley Systems Inc, version 08.00.11.03) was used to route the peak discharge (Q_{out}) for the 100-year, 24-hour and 500-year, 24-hour flows through a rectangular, concrete channel (n=0.013) with a bottom width of 10 feet and slope along the dam face of 0.4 ft/ft. Three feet of freeboard was added to the largest of the normal depths to determine the minimum spillway wall height. Normal flow depths of 0.56 feet and 0.94 feet were calculated for the 100-year and 500-year design events, respectfully; therefore the recommended minimum spillway wall height is 4.0 feet.

3.2 Alternative E

Spillway sizing for the Alternative E dam was calculated by assuming that the reservoir would be full and that flood attenuation effects for the smaller structure would be negligible, therefore, inflow to the reservoir would equal outflow from the spillway. The 500-year, 24-hour peak discharge of 1,511 cfs was routed through a broad-crested weir using FlowMaster (Bentley Systems Inc, version 08.00.11.03). Input variables included a crest elevation of 26.0 feet, tailwater elevation of 0.0 feet, crest breadth of 30.0 feet, and the assumption of a paved surface. A broad-crested weir length of 30 feet results in a headwater flow depth of 6.5 feet. Therefore, a spillway width of 30 feet is recommended for analysis of Alternative E, with a corresponding spillway height of 10 feet, which includes 3 feet of freeboard.

To calculate the spillway wall height down the face of the dam, FlowMaster was used to route the 500-year, 24-hour peak discharge of 1,511 cfs through a rectangular, concrete channel (n=0.013) with a 30-ft bottom width and a slope along the dam face of 0.4 ft/ft. Based on this configuration, the normal flow depth would be 0.82 feet. Three feet of freeboard is recommended above the normal flow depth to determine the minimum spillway wall height. The recommended minimum spillway wall height is 4.0 feet.

List of Attachments:

Attachment B2 Calculations Dam and Spillway Sizing

ATTACHMENT B2

CALCULATIONS
DAM AND SPILLWAY SIZING

Golder Associates, Inc.

943-1595-004.1280

Blackbird Creek Evaluation Report

Alternative D "Single Large In-Stream Dam"

Revised H&H

Calc'd by: S. Hillegas
Date: 12/23/2009
Chk'd by:
Date:

1) HEC-HMS Results - Dam spillway modeling (broad-crested weir)

Purpose: Determine optimal spillway configuration to pass the 100 and 500 year flood hydrographs at Blackbird Creek
Method: HEC-HMS (USACE, version 3.2, build 1282, date 21Apr2008)
File location: ...Extender 004\Task 1280 - Evaluation Report\H&H\Revised H&H (Dec 2009)\HECHMS\Revised - Dec 2009
Results: See table below

	100yr Design Event		500yr Design Event			
Spillway Width (ft)	Peak Elev (ft)	Qp (cfs)	Peak Elev (ft)	Qp (cfs)	Max Elev (ft)	Height w/ FB (ft)
10	154.0	254.3	156.9	582.2	156.9	160.0
8	*154.4*	*232.9*	*157.5*	*524.7*	*157.5*	*161.0*
6	*154.8*	*204.3*	*158.3*	*459.1*	*158.3*	*162.0*

Note: Spillway widths of 8 and 6 ft were used during model optimization and are not recommended for design

Given:

Spillway crest elev = 150.0 ft
Initial water elev = 150.0 ft
Spillway type: Broad-crested spillway
C = 3.2
Freeboard = 3.0 ft

Note: Zero reference elevation ~ 5245 ft AMSL

Golder Associates, Inc.

943-1595-004.1280

Blackbird Creek Evaluation Report

Alternative D "Single Large In-Stream Dam"

Revised H&H

Calc'd by: S. Hillegas
Date: 12/23/2009
Chk'd by:
Date:

2) FLOWMASTER - Downstream embankment channel capacity calculations

Purpose: Determine minimum recommended spillway wall height based on normal depth calculations
Method: FlowMaster (Bentley Systems Inc, version dated 8/26/2008, 08.11.00.03)
File location: ...Extender 004\Task 1280 - Evaluation Report\H&H\Revised H&H (Dec 2009)\Flowmaster
Results: See table below

	100yr Design Event			500yr Design Event		
Spillway Width (ft)	Qp (cfs)	D_{normal} (ft)	Velocity (ft/s)	Qp (cfs)	D_{normal} (ft)	Velocity (ft/s)
10	255.0	0.56	45.69	583.0	**0.94**	61.91
8	*233.0*	*0.61*	*47.48*	*525.0*	*1.03*	*63.42*
6	*205.0*	*0.69*	*49.3*	*460.0*	*1.18*	*64.81*

Note: Spillway widths of 8 and 6 ft were used during model optimization and are not recommended for design

Given:

Geometry: Rectangular
n = 0.013
S = 0.40 ft/ft

Design Depth:

Freeboard = 3.0 ft
Total Depth = 4.0 ft

Golder Associates, Inc.

943-1595-004.1280

Blackbird Creek Evaluation Report

Alternative E "Single Moderate In-Stream Dam" (with In-stream Stabilization)

Revised H&H

Calc'd by: S. Hillegas
Date: 2/9/2010
Chk'd by:
Date:

1) FLOWMASTER - Broad-crested weir calculations (Alt E spillway sizing)

Purpose: Determine the spillway configuration to pass the 500-yr, 24-hr peak discharge with broad-crested weir calculations

Assumption: Full reservoir, no flood routing attenuation, therefore reservoir inflow equals spillway outflow

Method: FlowMaster (Bentley Systems Inc, version dated 8/26/2008, 08.11.00.03)

File location: ...Extender 004\Task 1280 - Evaluation Report\H&H\Revised H&H (Dec 2009)\Flowmaster

Design Criteria:

Design Event: 500-yr, 24-hr peak discharge
Design Discharge = 1,511 cfs

Weir Configuration:

Weir type: Broad-crested weir
Crest Elevation = 26.0 ft
Tailwater Elevation = 0.0 ft
Surface = Paved
Crest Breadth = 30.0 ft
Crest Length = 30.0 ft

Results:

Headwater above Crest = 6.5 ft
Freeboard = 3.0 ft
Spillway Height = 10.0 ft

Golder Associates, Inc.

943-1595-004.1280

Blackbird Creek Evaluation Report

Alternative E "Single Moderate In-Stream Dam" (with In-stream Stabilization)

Revised H&H

Calc'd by: S. Hillegas
Date: 2/9/2010
Chk'd by:
Date:

2) FLOWMASTER - Downstream embankment channel calculations

Purpose: Determine minimum recommended spillway wall height based on normal depth calculations

Method: FlowMaster (Bentley Systems Inc, version dated 8/26/2008, 08.11.00.03)

File location: ...Extender 004\Task 1280 - Evaluation Report\H&H\Revised H&H (Dec 2009)\Flowmaster

Design Criteria:

Design Event:	500-yr, 24-hr peak discharge	
Design Discharge =	1,511	cfs

Channel Configuration:

Geometry:	Rectangular	
n =	0.013	
S =	0.40	ft/ft
Bottom Width =	30.0	ft/ft

Results:

Normal Depth =	0.82	ft
Freeboard =	3.0	ft
Min Depth (recommended) =	**4.0**	**ft**

APPENDIX B3
DAM EFFECTIVENESS MEMO

Attachment B3 – Sediment Trap Efficiency Calculations

Golder Associates

TECHNICAL MEMORANDUM

Date: January 22, 2010 **Project No.:** 943-1595-004.1280

To: George W. Annandale

From: Katy Cottingham, Mike Brown

RE: BLACKBIRD MINE RESERVOIR TRAP EFFICIENCY

1.0 INTRODUCTION

This memorandum describes the methodology used to estimate the trap efficiency of the two proposed sediment management dams at the Blackbird Mine. The estimated efficiency of each dam under varying flow conditions is also presented.

2.0 APPROACH

The Churchill (1948) approach was used to assess the sediment pass-through in the reservoirs. The Churchill method is based on empirical data and indirectly accounts for the effects of the sediment transport capacity of the water flowing through the reservoir. The approach has been found suitable for small reservoirs, settling basins, flood retarding structures, and semi-dry dams (Morris & Fan 1997).

The estimated trap efficiency for each dam was computed based on range in flood conditions. The peak discharge for each flood condition evaluated is summarized in Table 1. The reservoir geometry used in the analyses is presented in Table 2.

TABLE 1

Peak Flows

Peak Flow (cfs)						
2 year	**5 year**	**10 year**	**25 year**	**50 year**	**100 year**	**500 year**
16	73	122	203	393	588	1,511

TABLE 2

Reservoir Geometry

Dam	Reservoir Volume	Reservoir Length
Alt D	58,854,875 ft^3	4290 ft
Alt E	5,830,500 ft^3	950 ft

3.0 RESULTS

The estimated sediment trap efficiency for the large Alternative D dam and the moderate size Alternative E dam are shown in Table 3. Calculations and the methodology are provided in Attachment A.

TABLE 3

Sediment Trap Efficiency

Dam	Sediment Trap Efficiency						
	2 year	5 year	10 year	25 year	50 year	100 year	500 year
Alt D	99%	94%	92%	87%	73%	64%	43%
Alt E	94%	75%	64%	53%	35%	23%	0%

4.0 REFERENCES

Churchill, M.A. 1948. Analysis and use of reservoir sedimentation data, Journal of the Hydr. Div., ASCE, Vol. 90, HY2.

Morris, G.L. and Fan, J. 1997. Reservoir Sedimentation Handbook, McGraw-Hill, New York.

List of Tables

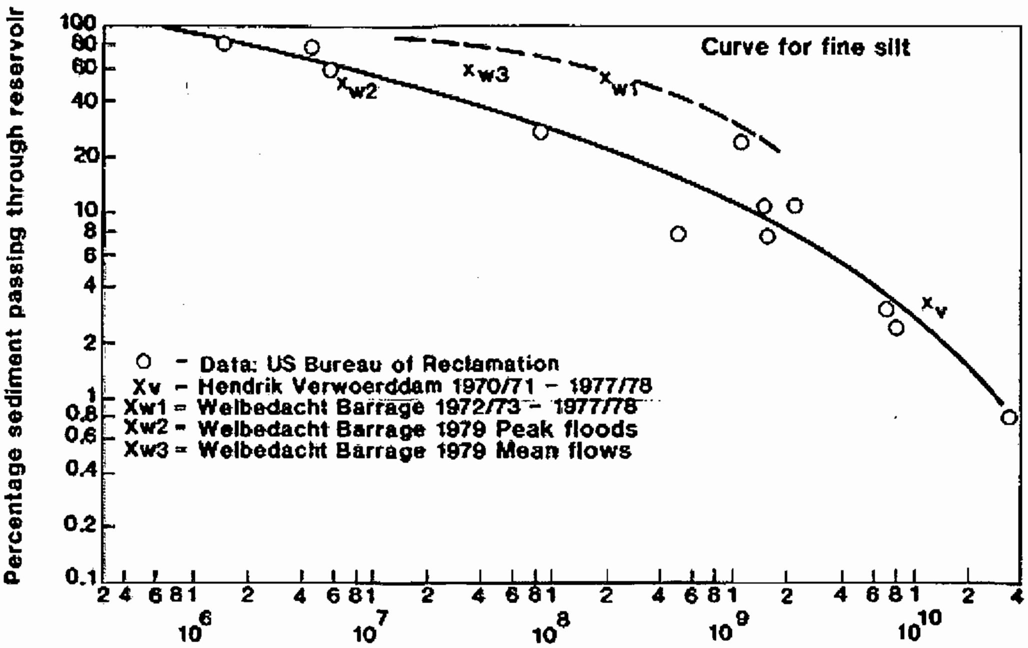
List of Attachments

ATTACHMENT B3

SEDIMENT TRAP EFFICIENCY CALCULATIONS

This summarizes the calculation of the sediment trap efficiency for the proposed reservoirs at Blackbird mine using the Churchill method.

The recommended use for the Churchill (1948) method is application to small reservoirs, settling basins, flood retarding structures and semi-dry reservoirs (Morris and Fan, 1997). The version of the Churchill curve used in this analysis is based on a modification by Roberts (1982), as presented in Annandale (1987). Roberts (1982) changed the sedimentation index to a dimensionless form, which facilitates general application.



$$\text{Sedimentation index} = \frac{g \times (\text{capacity})^2}{(\text{DISCHARGE})^2 \times \text{Reservoir length}}$$

The Churchill graph relates a sedimentation index to the percent of the incoming sediment passing through the reservoir. The relationship is based on field observations and is deemed to account for effects not allowed for in the method normally used for sizing settling basins in water and sewerage treatment facilities. The latter can be deemed more of a "controlled" design condition, as the structures are often rectangular and the water discharging into the facility is more steady and uniform in nature. The Churchill method has been tested in the field and has been found to be fairly reliable.

The Sedimentation Index (SI) is calculated as follows:

$$SI = \frac{g * Capacity^2}{Q^2 * Length}$$

The Churchill curve is approximated by the following series of equations, where *P* is the percentage of sediment passing through the reservoir:

$$SI < 9 \cdot 10^5 \qquad P = 100$$

$$9 \cdot 10^5 \le SI \le 10^7 \qquad P = -14.265 \cdot \ln(SI) + 291.089$$

$$10^7 < SI \le 10^9 \qquad P = -10.857 \cdot \ln(SI) + 233$$

$$10^9 < SI \le 3 \cdot 10^9 \qquad P = -2.554 \cdot \ln(SI) + 62.588$$

$$3 \cdot 10^9 < SI \qquad P = 0.8$$

The computed sediment passing through each reservoir for the flow conditions evaluated is summarized in the attached calculation sheet (Page A-3).

REFERENCES

Annandale, G.W. 1987. Reservoir Sedimentation, Elsevier Science Publishers, Amsterdam.

Churchill, M.A. 1948. Analysis and Use of Reservoir Sedimentation Data, Jnl of the Hydr. Div., ASCE, Vol. 90, HY2.

Morris, G.L. and Fan, J. 1997. Reservoir Sedimentation Handbook, McGraw-Hill, New York.

Roberts, C.P.R. 1982. Flow Profile Calculations, HYDRO 82, University of Pretoria, Pretoria.

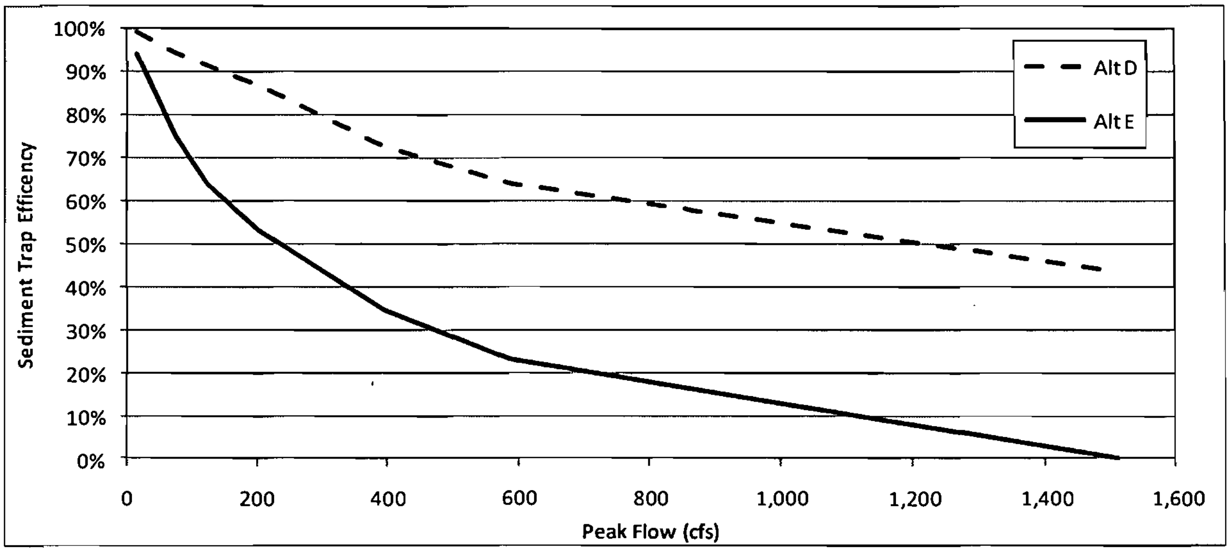
Sediment Trap Efficiency Calculation

			Peak Flow						
	Drainage Area		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	500 yr
Dam	(sq mi)	(acres)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
D or E	20.86	13,350	16	73	122	203	393	588	1,511

g =	32.2 ft/s^2

Dam	L	V	Sedimentation Index = $g*V^2/Q^2L$						
			2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	500 yr
(-)	(ft)	(ft^3)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Alt D	4290	58854875	1.0E+11	4.9E+09	1.7E+09	6.3E+08	1.7E+08	7.5E+07	1.1E+07
Alt E	950	5830500	4.5E+09	2.2E+08	7.7E+07	2.8E+07	7.5E+06	3.3E+06	5.0E+05

Dam	Sediment Trap Efficiency						
	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	500 yr
Alt D	99%	94%	92%	87%	73%	64%	43%
Alt E	94%	75%	64%	53%	35%	23%	0%



APPENDIX C

HEC-RAS HYDRAULIC MODEL RESULTS

Appendix C1 – HEC-RAS Hydraulic Model Results

Appendix C2 – HEC-RAS Sediment Transport Capacity Potential Analysis Results

APPENDIX C1
HEC-RAS HYDRAULIC MODEL RESULTS

Golder Associates

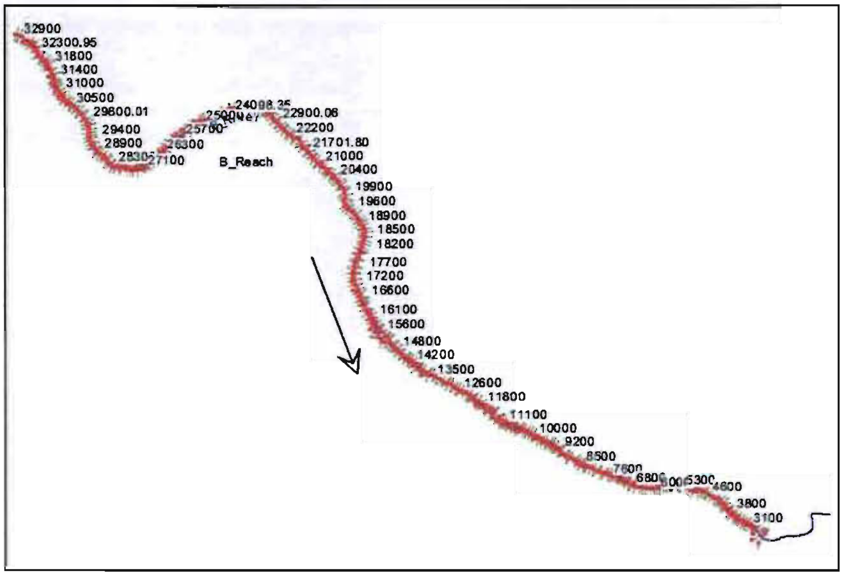
BMSG/Blackbird Mine Site
943-1595-004.1280
Blackbird Creek HEC-RAS Modeling
Revised: May 5, 2010/AQK

Objective: Develop a HEC-RAS hydraulic model of Blackbird Creek, extending from the Water Treatment Plant (WTP) downstream to the confluence with Panther Creek, to develop hydraulic parameters for design flow scenarios, assess inundation along Blackbird Creek road, and to evaluate sediment transport potential in Blackbird Creek.

Discussion:

HEC-RAS is a one-dimensional model that is designed to perform steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modeling. For the Blackbird Creek model, the steady flow and sediment transport/mobile bed components of the model were used.

Recent LIDAR data was used to generate topography along Blackbird Creek from the WTP downstream to the confluence with Panther Creek. Over 300 cross-sections, approximately one every 100 feet were derived from the topography using the GeoRas utility. Upstream reaches of Blackbird Creek start a STA 329+00 and continue to the end of the downstream reach at STA 24+00 (see figure below). The West Fork tributary confluence is located approximately at station 150+00.



The following inputs were used in the model:

- **Channel and overbank roughness** = 0.045 (Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages, bottom: gravels, cobbles, and few boulders)
- **Contraction Coefficient** = 0.1
- **Expansion Coefficient** = 0.3
- **Boundary Conditions** = Normal Depth
- **Ineffective Flow Areas** = None
- **Structures** = None Added

Peak flows for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr and 500-yr events (Appendix B), were used as steady state flow inputs to the model. Corresponding input and flow summaries are reported in Appendix C1. The model was calibrated using anecdotal information from the recent May 2008 and June 2009 flood events. The results of the model corresponded well with observed road overtopping areas during these events. A simplified quasi-unsteady flow time series representative of the 100-year flood event was used as input to a sediment transport assessment. Sediment grain size distributions derived from the sediment sampling program (Appendix D) were used as inputs to the sediment transport analysis. Corresponding input and flow summaries for the sediment analysis are reported in Appendix C2.

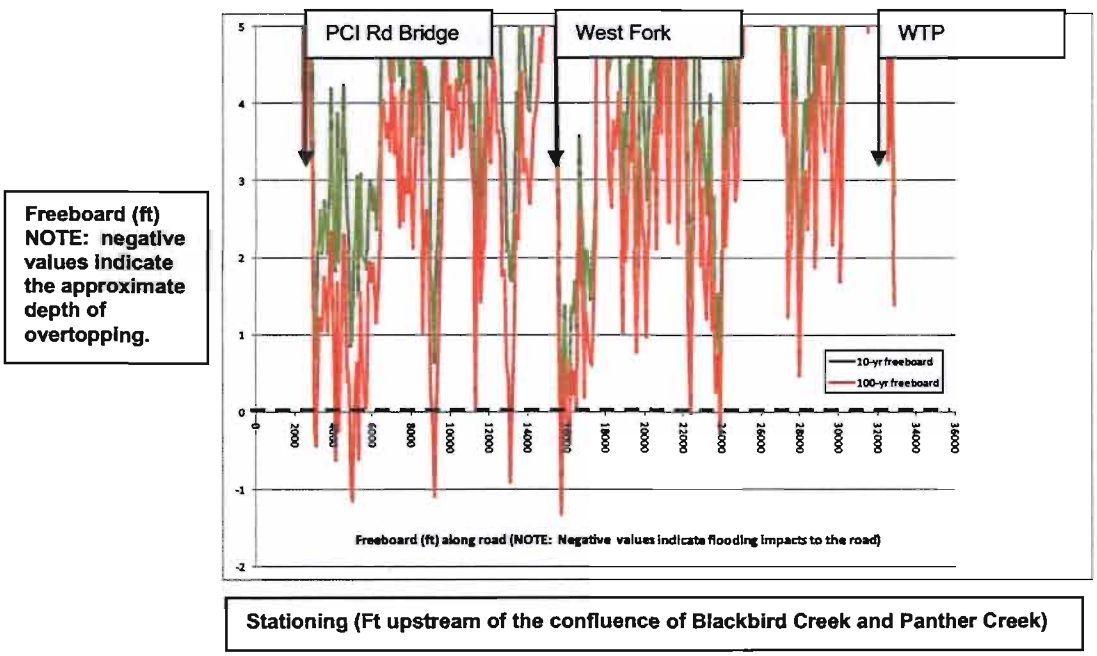
Results:

Summary tables for calculated HEC-RAS model results are provided below (see attached) by STA and for the full range of recurrence interval flows.

The model results show that the Blackbird Creek road will be overtopped in several locations, mostly in the downstream reaches, starting at approximately the 10 year recurrence interval flood event. The 100-year flood overtops the road at several locations by approximately 1-2 feet. The 500-year event overtops the road in limited locations by 2-3 feet. Refer to the figure below. During larger recurrence interval events, not only is the roadway overtopped, but in some cases because the valley is so confined, floods fill the entire width of the valley.

The HEC-RAS modeling indicates that some areas along the channel experience localized supercritical flow conditions (i.e. Froude numbers >1). This can produce decreased transport efficiency where flow friction is increased. Modeling results show the majority of the channel has sub-critical flows (i.e. Froude number <1).

Blackbird Creek Road HEC-RAS Freeboard Results



HEC-RAS Version 4.0.0 March 2008
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X      XXX   XXXX     XXXXXX    XXXX
X     X  X        X            X X      X    X        X
X     X  X        X    X       X  X     X    X        X
X     X  XXXXXX    XXXX        X   X    X    X   XXXXX
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PROJECT DATA
Project Title: Blackbird_100ft
Project File : Blackbird_100ft.prj
Run Date and Time: 5/8/2010 5:20:06 PM

Project in English units

PLAN DATA

Plan Title: Plan 23
Plan File : C:\GOLDER\PROJECTS\Blackbird Work\temp modeling\HECRAS_050710\Blackbird_100ft.p23

Geometry Title: 020509_100ft_aqk
Geometry File : C:\GOLDER\PROJECTS\Blackbird Work\temp modeling\HECRAS_050710\Blackbird_100ft.g03

Flow Title : Design_peaks_REVISED HYDRO_091709
Flow File : C:\GOLDER\PROJECTS\Blackbird Work\temp modeling\HECRAS_050710\Blackbird_100ft.f10

Plan Summary Information:

```
Number of:  Cross Sections =  306    Multiple Openings  =   0
            Culverts       =    0    Inline Structures  =   0
            Bridges        =    0    Lateral Structures =   0
```

Computational Information

```
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001
```

Computation Options

```
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Mixed Flow
```

FLOW DATA

Flow Title: Design_peaks_REVISED HYDRO_091709
Flow File : C:\GOLDER\PROJECTS\Blackbird Work\temp modeling\HECRAS_050710\Blackbird_100ft.f10

Flow Data (cfs)

River	Reach	RS	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
B_River	B_Reach	32900	4.3	20.3	34.1	59.4	122.8	187.6	518
B_River	B_Reach	27000	4.5	21.2	35.6	61.9	127.8	195.1	538.2
B_River	B_Reach	25100	5	23.4	39.1	67.8	139.9	213.2	586.4
B_River	B_Reach	23100	6.5	29.7	49.5	85.2	175.1	266	726.3
B_River	B_Reach	15700	14.5	66.6	111.2	186.5	361.4	540.8	1393.8
B_River	B_Reach	13100	15.2	69.2	115.6	193.5	374.8	560.6	1443.2
B_River	B_Reach	9000	15.7	71.4	119.1	199.4			

385.9	576.9	1483.8				
B_River	B_Reach	5000	16	72.8	121.3	202.9
392.6	586.7	1508.3				

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
B_River	B_Reach	2-yr	Normal S = 0.03	Normal S = 0.03
B_River	B_Reach	5-yr	Normal S = 0.03	Normal S = 0.03
B_River	B_Reach	10-yr	Normal S = 0.03	Normal S = 0.03
B_River	B_Reach	25-yr	Normal S = 0.03	Normal S = 0.03
B_River	B_Reach	50-yr	Normal S = 0.03	Normal S = 0.03
B_River	B_Reach	100-yr	Normal S = 0.03	Normal S = 0.03
B_River	B_Reach	500-yr	Normal S = 0.03	Normal S = 0.03

GEOMETRY DATA

Geometry Title: 020509_100ft_aqk
Geometry File : C:\GOLDER\PROJECTS\Blackbird Work\temp modeling\HECRAS_050710\Blackbird_100ft.g03

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
B_Reach	32900	2-yr	4.3	6806.67	6807.03	6806.99	6807.1	0.027664	2.13	2.02	8.3	0.76
B_Reach	32900	5-yr	20.3	6806.67	6807.37	6807.35	6807.61	0.034339	3.93	5.16	9.77	0.95
B_Reach	32900	10-yr	34.1	6806.67	6807.57	6807.57	6807.92	0.035575	4.74	7.19	10.45	1.01
B_Reach	32900	25-yr	59.4	6806.67	6807.9	6807.9	6808.37	0.03269	5.52	10.75	11.55	1.01
B_Reach	32900	50-yr	122.8	6806.67	6808.5	6808.52	6809.19	0.029995	6.7	18.33	13.6	1.02
B_Reach	32900	100-yr	187.6	6806.67	6808.94	6808.99	6809.84	0.030015	7.58	24.75	15.11	1.04
B_Reach	32900	500-yr	518	6806.67	6810.49	6811.09	6812.02	0.030054	9.94	52.69	35.33	1.11
B_Reach	32800	2-yr	4.3	6803.03	6803.34	6803.34	6803.45	0.050402	2.62	1.64	7.79	1
B_Reach	32800	5-yr	20.3	6803.03	6803.71	6803.71	6803.98	0.038474	4.15	4.89	9.21	1
B_Reach	32800	10-yr	34.1	6803.03	6803.93	6803.94	6804.31	0.036713	4.93	6.92	9.55	1.02
B_Reach	32800	25-yr	59.4	6803.03	6804.22	6804.28	6804.8	0.039086	6.09	9.75	10	1.09
B_Reach	32800	50-yr	122.8	6803.03	6804.8	6804.93	6805.74	0.039753	7.78	15.78	10.91	1.14
B_Reach	32800	100-yr	187.6	6803.03	6805.31	6805.47	6806.48	0.037273	8.69	21.6	11.72	1.13
B_Reach	32800	500-yr	518	6803.03	6807.38	6807.43	6809.09	0.028293	10.51	49.31	15.15	1.03
B_Reach	32700	2-yr	4.3	6796.99	6797.53	6797.56	6797.75	0.064759	3.83	1.12	3.3	1.15
B_Reach	32700	5-yr	20.3	6796.99	6797.92	6798.04	6798.34	0.089819	5.2	3.91	9.66	1.44
B_Reach	32700	10-yr	34.1	6796.99	6798.07	6798.25	6798.68	0.095963	6.25	5.45	10.7	1.54
B_Reach	32700	25-yr	59.4	6796.99	6798.31	6798.55	6799.13	0.08833	7.26	8.18	11.98	1.55
B_Reach	32700	50-yr	122.8	6796.99	6798.71	6799.1	6800.04	0.086721	9.25	13.27	13.1	1.62
B_Reach	32700	100-yr	187.6	6796.99	6799.01	6799.56	6800.85	0.091447	10.9	17.21	13.61	1.71
B_Reach	32700	500-yr	518	6796.99	6800.07	6801.27	6803.99	0.103449	15.88	32.62	15.33	1.92
B_Reach	32600	2-yr	4.3	6791.45	6791.68	6791.65	6791.71	0.034005	1.48	2.9	24.16	0.75
B_Reach	32600	5-yr	20.3	6791.45	6791.85	6791.83	6791.93	0.035351	2.35	8.64	37.08	0.86
B_Reach	32600	10-yr	34.1	6791.45	6791.93	6791.92	6792.06	0.036341	2.87	11.89	38.66	0.91
B_Reach	32600	25-yr	59.4	6791.45	6792.01	6792.04	6792.26	0.052704	3.95	15.04	39.98	1.13
B_Reach	32600	50-yr	122.8	6791.45	6792.21	6792.3	6792.65	0.059622	5.35	22.96	42.44	1.28
B_Reach	32600	100-yr	187.6	6791.45	6792.36	6792.52	6792.98	0.062662	6.33	29.65	44.16	1.36
B_Reach	32600	500-yr	518	6791.45	6792.87	6793.3	6794.33	0.077657	9.72	53.27	48.79	1.64
B_Reach	32500	2-yr	4.3	6787.21	6787.55	6787.55	6787.67	0.048611	2.68	1.6	7.11	1
B_Reach	32500	5-yr	20.3	6787.21	6787.94	6787.94	6788.18	0.039557	3.99	5.08	10.58	1.02
B_Reach	32500	10-yr	34.1	6787.21	6788.15	6788.15	6788.47	0.035045	4.52	7.55	11.88	1
B_Reach	32500	25-yr	59.4	6787.21	6788.45	6788.45	6788.88	0.03276	5.26	11.29	13.34	1.01
B_Reach	32500	50-yr	122.8	6787.21	6789.01	6789.01	6789.63	0.029326	6.32	19.43	15.87	1.01
B_Reach	32500	100-yr	187.6	6787.21	6789.45	6789.45	6790.2	0.027718	6.99	26.83	17.97	1.01
B_Reach	32500	500-yr	518	6787.21	6790.95	6790.95	6792.14	0.024202	8.75	59.22	25.31	1.01
B_Reach	32400	2-yr	4.3	6763.74	6763.81	6763.99	6766.83	10.04488	13.95	0.31	6.33	11.14
B_Reach	32400	5-yr	20.3	6763.74	6763.92	6764.19	6768.14	4.358773	16.47	1.23	10.54	8.49
B_Reach	32400	10-yr	34.1	6763.74	6763.9	6764.3	6780.43	19.10726	32.62	1.05	9.72	17.53
B_Reach	32400	25-yr	59.4	6763.74	6764.01	6764.47	6771.25	6.274546	21.58	2.75	20.63	10.41
B_Reach	32400	50-yr	122.8	6763.74	6764.06	6764.79	6779.75	9.60066	31.78	3.86	22.29	13.45
B_Reach	32400	100-yr	187.6	6763.74	6764.18	6765.05	6776.72	4.449763	28.42	6.6	25.29	9.8
B_Reach	32400	500-yr	518	6763.74	6764.49	6766.04	6782.44	2.559433	33.99	15.24	29.42	8.32
B_Reach	32300.95	2-yr	4.3	6754.73	6755.11	6755.11	6755.23	0.051999	2.79	1.54	6.78	1.03
B_Reach	32300.95	5-yr	20.3	6754.73	6755.54	6755.54	6755.72	0.042537	3.46	5.86	15.98	1.01
B_Reach	32300.95	10-yr	34.1	6754.73	6755.64	6755.69	6755.96	0.054952	4.54	7.51	16.5	1.19
B_Reach	32300.95	25-yr	59.4	6754.73	6755.9	6755.92	6756.28	0.037806	4.92	12.08	17.69	1.05
B_Reach	32300.95	50-yr	122.8	6754.73	6756.19	6756.37	6756.97	0.053339	7.08	17.36	18.97	1.3
B_Reach	32300.95	100-yr	187.6	6754.73	6756.52	6756.74	6757.48	0.048534	7.85	23.89	20.72	1.29
B_Reach	32300.95	500-yr	518	6754.73	6757.45	6758.14	6759.45	0.061263	11.34	45.67	27	1.54
B_Reach	32200	2-yr	4.3	6750.25	6750.8	6750.77	6750.89	0.034826	2.45	1.75	6.84	0.86
B_Reach	32200	5-yr	20.3	6750.25	6751.17	6751.18	6751.45	0.042144	4.25	4.78	9.41	1.05
B_Reach	32200	10-yr	34.1	6750.25	6751.41	6751.41	6751.75	0.035787	4.67	7.3	10.98	1.01
B_Reach	32200	25-yr	59.4	6750.25	6751.65	6751.73	6752.19	0.043334	5.91	10.05	12.22	1.15
B_Reach	32200	50-yr	122.8	6750.25	6752.3	6752.31	6752.97	0.030187	6.56	18.72	14.57	1.02
B_Reach	32200	100-yr	187.6	6750.25	6752.71	6752.77	6753.58	0.031086	7.49	25.04	16.2	1.06
B_Reach	32200	500-yr	518	6750.25	6754.46	6754.46	6755.5	0.025506	8.2	63.14	30.86	1.01
B_Reach	32100	2-yr	4.3	6746.17	6746.58	6746.58	6746.71	0.051071	2.9	1.48	6.06	1.03
B_Reach	32100	5-yr	20.3	6746.17	6747.02	6747.02	6747.26	0.041387	3.96	5.13	11.14	1.03

B_Reach	32100	10-yr	34.1	6746.17	6747.17	6747.23	6747.54	0.050162	4.9	6.96	12.67	1.17
B_Reach	32100	25-yr	59.4	6746.17	6747.47	6747.52	6747.9	0.041809	5.28	11.25	15.97	1.11
B_Reach	32100	50-yr	122.8	6746.17	6747.75	6748	6748.66	0.065659	7.65	16.05	18.29	1.44
B_Reach	32100	100-yr	187.6	6746.17	6748.03	6748.36	6749.22	0.064433	8.73	21.5	19.74	1.47
B_Reach	32100	500-yr	518	6746.17	6748.95	6749.69	6751.39	0.071133	12.54	41.31	23.38	1.66
B_Reach	32000	2-yr	4.3	6740.12	6740.67	6740.72	6740.89	0.066699	3.74	1.15	3.79	1.2
B_Reach	32000	5-yr	20.3	6740.12	6741.12	6741.27	6741.66	0.078989	5.91	3.44	6.44	1.43
B_Reach	32000	10-yr	34.1	6740.12	6741.4	6741.55	6742.01	0.060938	6.22	5.48	7.77	1.31
B_Reach	32000	25-yr	59.4	6740.12	6741.69	6741.95	6742.57	0.068818	7.57	7.85	9.05	1.43
B_Reach	32000	50-yr	122.8	6740.12	6742.45	6742.62	6743.26	0.044837	7.2	17.05	15.48	1.21
B_Reach	32000	100-yr	187.6	6740.12	6742.82	6743.05	6743.84	0.044819	8.09	23.19	17.66	1.24
B_Reach	32000	500-yr	518	6740.12	6744.06	6744.48	6745.87	0.041508	10.79	48.03	22.02	1.29
B_Reach	31900	2-yr	4.3	6733.12	6733.41	6733.45	6733.58	0.080451	3.25	1.33	6.45	1.26
B_Reach	31900	5-yr	20.3	6733.12	6733.76	6733.86	6734.17	0.070282	5.15	3.94	8.59	1.34
B_Reach	31900	10-yr	34.1	6733.12	6733.89	6734.09	6734.58	0.092198	6.66	5.12	9.25	1.58
B_Reach	31900	25-yr	59.4	6733.12	6734.16	6734.43	6735.05	0.082565	7.58	7.83	10.66	1.56
B_Reach	31900	50-yr	122.8	6733.12	6734.48	6735.03	6736.26	0.119763	10.7	11.47	12.23	1.95
B_Reach	31900	100-yr	187.6	6733.12	6734.81	6735.49	6737	0.111638	11.88	15.79	13.54	1.94
B_Reach	31900	500-yr	518	6733.12	6735.97	6737.1	6739.57	0.098963	15.21	34.05	18.05	1.95
B_Reach	31800	2-yr	4.3	6727.14	6727.6	6727.6	6727.72	0.047828	2.83	1.52	6.12	1
B_Reach	31800	5-yr	20.3	6727.14	6727.99	6728.04	6728.31	0.049228	4.53	4.48	9.04	1.13
B_Reach	31800	10-yr	34.1	6727.14	6728.25	6728.28	6728.61	0.040641	4.85	7.03	11.06	1.07
B_Reach	31800	25-yr	59.4	6727.14	6728.52	6728.6	6729.03	0.044502	5.74	10.34	13.51	1.16
B_Reach	31800	50-yr	122.8	6727.14	6729.07	6729.15	6729.72	0.037788	6.47	18.99	18.34	1.12
B_Reach	31800	100-yr	187.6	6727.14	6729.37	6729.53	6730.26	0.040991	7.56	24.81	20.08	1.2
B_Reach	31800	500-yr	518	6727.14	6730.36	6730.89	6732.26	0.049655	11.06	46.84	24.43	1.41
B_Reach	31700	2-yr	4.3	6723.19	6723.52	6723.52	6723.63	0.047039	2.7	1.59	6.8	0.99
B_Reach	31700	5-yr	20.3	6723.19	6723.92	6723.92	6724.18	0.038423	4.04	5.03	10.05	1.01
B_Reach	31700	10-yr	34.1	6723.19	6724.11	6724.15	6724.48	0.042064	4.85	7.03	11.38	1.09
B_Reach	31700	25-yr	59.4	6723.19	6724.41	6724.46	6724.88	0.038491	5.5	10.81	13.54	1.08
B_Reach	31700	50-yr	122.8	6723.19	6724.85	6725.01	6725.62	0.04437	7.02	17.49	16.84	1.21
B_Reach	31700	100-yr	187.6	6723.19	6725.24	6725.43	6726.14	0.041217	7.61	24.65	19.87	1.2
B_Reach	31700	500-yr	518	6723.19	6726.49	6726.73	6727.63	0.039307	8.6	60.25	39.24	1.22
B_Reach	31600	2-yr	4.3	6718.46	6718.84	6718.85	6718.95	0.046457	2.72	1.58	6.61	0.98
B_Reach	31600	5-yr	20.3	6718.46	6719.19	6719.25	6719.48	0.058625	4.35	4.66	11.5	1.2
B_Reach	31600	10-yr	34.1	6718.46	6719.38	6719.44	6719.72	0.053943	4.72	7.23	14.84	1.19
B_Reach	31600	25-yr	59.4	6718.46	6719.57	6719.7	6720.09	0.061169	5.79	10.27	17.03	1.31
B_Reach	31600	50-yr	122.8	6718.46	6719.96	6720.15	6720.71	0.054563	6.92	17.74	20.59	1.31
B_Reach	31600	100-yr	187.6	6718.46	6720.22	6720.5	6721.23	0.059232	8.07	23.24	22.75	1.41
B_Reach	31600	500-yr	518	6718.46	6721.24	6721.75	6722.75	0.061129	9.86	52.55	39.07	1.5
B_Reach	31500	2-yr	4.3	6713.52	6713.94	6713.95	6714.07	0.051289	2.89	1.49	6.12	1.03
B_Reach	31500	5-yr	20.3	6713.52	6714.37	6714.38	6714.63	0.040771	4.14	4.9	9.84	1.03
B_Reach	31500	10-yr	34.1	6713.52	6714.56	6714.6	6714.93	0.042938	4.84	7.04	11.63	1.1
B_Reach	31500	25-yr	59.4	6713.52	6714.88	6714.92	6715.32	0.037888	5.38	11.05	14.16	1.07
B_Reach	31500	50-yr	122.8	6713.52	6715.34	6715.45	6716.02	0.040414	6.66	18.45	17.99	1.16
B_Reach	31500	100-yr	187.6	6713.52	6715.73	6715.85	6716.53	0.037399	7.18	26.14	21.46	1.15
B_Reach	31500	500-yr	518	6713.52	6716.94	6717.16	6718.04	0.035622	8.42	61.49	38.46	1.17
B_Reach	31400	2-yr	4.3	6708.2	6708.59	6708.61	6708.72	0.055737	2.89	1.49	6.47	1.06
B_Reach	31400	5-yr	20.3	6708.2	6708.92	6709.03	6709.36	0.070404	5.33	3.81	7.73	1.34
B_Reach	31400	10-yr	34.1	6708.2	6709.13	6709.28	6709.72	0.063962	6.13	5.56	8.4	1.33
B_Reach	31400	25-yr	59.4	6708.2	6709.4	6709.64	6710.28	0.069077	7.51	7.9	9.22	1.43
B_Reach	31400	50-yr	122.8	6708.2	6710	6710.32	6711.21	0.05705	8.79	13.96	10.87	1.37
B_Reach	31400	100-yr	187.6	6708.2	6710.45	6710.87	6711.95	0.055297	9.83	19.09	12.13	1.38
B_Reach	31400	500-yr	518	6708.2	6712.23	6712.83	6714.18	0.04019	11.21	46.23	18.78	1.26
B_Reach	31300	2-yr	4.3	6701.56	6701.92	6701.96	6702.1	0.079552	3.49	1.23	5.28	1.28
B_Reach	31300	5-yr	20.3	6701.56	6702.33	6702.43	6702.78	0.061561	5.38	3.77	6.76	1.27
B_Reach	31300	10-yr	34.1	6701.56	6702.53	6702.71	6703.2	0.066346	6.53	5.22	7.3	1.36
B_Reach	31300	25-yr	59.4	6701.56	6702.88	6703.11	6703.76	0.061553	7.55	7.87	8.2	1.36
B_Reach	31300	50-yr	122.8	6701.56	6703.41	6703.84	6704.88	0.069874	9.74	12.6	9.61	1.5
B_Reach	31300	100-yr	187.6	6701.56	6703.85	6704.44	6705.71	0.070109	10.95	17.13	10.84	1.54

B_Reach	31300	500-yr	518	6701.56	6705.22	6706.36	6708.52	0.080644	14.57	35.56	16.23	1.73
B_Reach	31200	2-yr	4.3	6696.75	6697.3	6697.3	6697.43	0.046849	2.94	1.46	5.39	1
B_Reach	31200	5-yr	20.3	6696.75	6697.75	6697.79	6698.09	0.042739	4.63	4.39	7.52	1.07
B_Reach	31200	10-yr	34.1	6696.75	6697.98	6698.05	6698.44	0.047015	5.49	6.22	8.85	1.15
B_Reach	31200	25-yr	59.4	6696.75	6698.37	6698.42	6698.9	0.037836	5.84	10.17	11.17	1.08
B_Reach	31200	50-yr	122.8	6696.75	6698.94	6699.04	6699.71	0.037025	7.03	17.46	14.23	1.12
B_Reach	31200	100-yr	187.6	6696.75	6699.35	6699.55	6700.32	0.039111	7.9	23.73	16.93	1.18
B_Reach	31200	500-yr	518	6696.75	6700.6	6701.05	6702.09	0.044856	9.79	52.89	30.66	1.31
B_Reach	31100	2-yr	4.3	6692.35	6692.79	6692.78	6692.93	0.04341	2.91	1.48	5.21	0.96
B_Reach	31100	5-yr	20.3	6692.35	6693.23	6693.28	6693.58	0.047613	4.74	4.28	7.68	1.12
B_Reach	31100	10-yr	34.1	6692.35	6693.48	6693.54	6693.93	0.043304	5.38	6.33	8.67	1.11
B_Reach	31100	25-yr	59.4	6692.35	6693.74	6693.91	6694.46	0.052422	6.79	8.75	9.7	1.26
B_Reach	31100	50-yr	122.8	6692.35	6694.31	6694.57	6695.35	0.051329	8.16	15.05	12.36	1.3
B_Reach	31100	100-yr	187.6	6692.35	6694.77	6695.06	6696	0.047248	8.91	21.06	14.11	1.28
B_Reach	31100	500-yr	518	6692.35	6696.44	6696.8	6698.06	0.036211	10.19	50.83	22.54	1.2
B_Reach	31000	2-yr	4.3	6687.43	6688.17	6688.17	6688.3	0.049343	2.88	1.49	5.76	1
B_Reach	31000	5-yr	20.3	6687.43	6688.6	6688.63	6688.92	0.045524	4.55	4.46	8.11	1.08
B_Reach	31000	10-yr	34.1	6687.43	6688.81	6688.9	6689.27	0.050319	5.44	6.26	9.4	1.18
B_Reach	31000	25-yr	59.4	6687.43	6689.18	6689.25	6689.69	0.042548	5.77	10.3	12.57	1.12
B_Reach	31000	50-yr	122.8	6687.43	6689.66	6689.81	6690.43	0.045722	7.07	17.38	16.6	1.22
B_Reach	31000	100-yr	187.6	6687.43	6689.96	6690.24	6691.02	0.051539	8.26	22.72	18.8	1.32
B_Reach	31000	500-yr	518	6687.43	6690.89	6691.63	6693.11	0.069412	11.98	43.25	25.68	1.63
B_Reach	30900	2-yr	4.3	6683.03	6683.41	6683.4	6683.52	0.040145	2.59	1.66	6.71	0.92
B_Reach	30900	5-yr	20.3	6683.03	6683.76	6683.8	6684.08	0.051639	4.53	4.48	9.36	1.15
B_Reach	30900	10-yr	34.1	6683.03	6683.97	6684.04	6684.39	0.047232	5.16	6.6	10.55	1.15
B_Reach	30900	25-yr	59.4	6683.03	6684.21	6684.37	6684.83	0.055579	6.31	9.41	12.57	1.29
B_Reach	30900	50-yr	122.8	6683.03	6684.7	6684.91	6685.56	0.051841	7.48	16.42	16.09	1.3
B_Reach	30900	100-yr	187.6	6683.03	6685.08	6685.32	6686.1	0.046827	8.1	23.17	18.62	1.28
B_Reach	30900	500-yr	518	6683.03	6686.39	6686.89	6687.89	0.03772	9.83	52.71	26.79	1.23
B_Reach	30800	2-yr	4.3	6678.63	6678.92	6678.92	6679.02	0.050442	2.55	1.69	8.36	1
B_Reach	30800	5-yr	20.3	6678.63	6679.24	6679.26	6679.49	0.048715	3.97	5.11	12.63	1.1
B_Reach	30800	10-yr	34.1	6678.63	6679.43	6679.46	6679.73	0.045228	4.41	7.72	15.36	1.1
B_Reach	30800	25-yr	59.4	6678.63	6679.67	6679.71	6680.08	0.040178	5.12	11.61	16.85	1.09
B_Reach	30800	50-yr	122.8	6678.63	6680.04	6680.17	6680.73	0.044248	6.67	18.42	19.17	1.2
B_Reach	30800	100-yr	187.6	6678.63	6680.3	6680.53	6681.29	0.049273	8	23.46	20.01	1.3
B_Reach	30800	500-yr	518	6678.63	6681.29	6681.9	6683.32	0.055162	11.45	45.25	24.18	1.47
B_Reach	30700	2-yr	4.3	6673.18	6673.66	6673.62	6673.76	0.032548	2.64	1.63	5.38	0.85
B_Reach	30700	5-yr	20.3	6673.18	6674.05	6674.11	6674.44	0.051865	5.07	4	6.88	1.17
B_Reach	30700	10-yr	34.1	6673.18	6674.28	6674.4	6674.83	0.052899	5.91	5.77	7.96	1.22
B_Reach	30700	25-yr	59.4	6673.18	6674.6	6674.79	6675.36	0.055274	7.01	8.48	9.31	1.29
B_Reach	30700	50-yr	122.8	6673.18	6675.26	6675.47	6676.21	0.045681	7.85	15.65	12.5	1.24
B_Reach	30700	100-yr	187.6	6673.18	6675.76	6675.98	6676.84	0.040427	8.34	22.49	14.92	1.2
B_Reach	30700	500-yr	518	6673.18	6677.3	6677.63	6678.86	0.034778	10.03	51.63	23.22	1.19
B_Reach	30600	2-yr	4.3	6669.55	6669.92	6669.92	6670.02	0.043456	2.42	1.77	8.45	0.93
B_Reach	30600	5-yr	20.3	6669.55	6670.27	6670.27	6670.47	0.039908	3.61	5.62	13.75	1
B_Reach	30600	10-yr	34.1	6669.55	6670.45	6670.45	6670.71	0.037755	4.11	8.31	16.08	1.01
B_Reach	30600	25-yr	59.4	6669.55	6670.69	6670.69	6671.04	0.035497	4.73	12.55	18.71	1.02
B_Reach	30600	50-yr	122.8	6669.55	6671.02	6671.13	6671.66	0.043625	6.39	19.21	21.22	1.18
B_Reach	30600	100-yr	187.6	6669.55	6671.24	6671.47	6672.19	0.052976	7.84	23.92	22.41	1.34
B_Reach	30600	500-yr	518	6669.55	6672.08	6672.76	6674.16	0.065272	11.57	44.77	27.08	1.59
B_Reach	30500	2-yr	4.3	6664.54	6664.96	6664.91	6665.04	0.026145	2.29	1.88	6.63	0.76
B_Reach	30500	5-yr	20.3	6664.54	6665.26	6665.34	6665.62	0.059769	4.84	4.19	8.86	1.24
B_Reach	30500	10-yr	34.1	6664.54	6665.45	6665.57	6665.95	0.061087	5.67	6.01	10.16	1.3
B_Reach	30500	25-yr	59.4	6664.54	6665.71	6665.9	6666.4	0.061912	6.66	8.92	11.93	1.36
B_Reach	30500	50-yr	122.8	6664.54	6666.29	6666.48	6667.1	0.04737	7.19	17.07	16.62	1.25
B_Reach	30500	100-yr	187.6	6664.54	6666.74	6666.89	6667.58	0.039946	7.38	25.41	20.92	1.18
B_Reach	30500	500-yr	518	6664.54	6667.99	6668.16	6668.98	0.037516	8	64.78	45.5	1.18
B_Reach	30400	2-yr	4.3	6661.06	6661.41	6661.4	6661.52	0.050223	2.66	1.62	7.47	1.01
B_Reach	30400	5-yr	20.3	6661.06	6661.79	6661.79	6662.01	0.039235	3.7	5.49	12.79	1

B_Reach	30400	10-yr	34.1	6661.06	6661.98	6661.98	6662.26	0.038366	4.25	8.02	14.91	1.02
B_Reach	30400	25-yr	59.4	6661.06	6662.25	6662.25	6662.6	0.033837	4.78	12.42	17.57	1
B_Reach	30400	50-yr	122.8	6661.06	6662.72	6662.74	6663.2	0.033524	5.55	22.11	24.8	1.04
B_Reach	30400	100-yr	187.6	6661.06	6662.98	6663.08	6663.62	0.037969	6.47	29.02	28.45	1.13
B_Reach	30400	500-yr	518	6661.06	6663.85	6664.13	6664.99	0.04239	8.58	60.37	42	1.26
B_Reach	30300	2-yr	4.3	6656.72	6657.26	6657.23	6657.39	0.034636	2.84	1.51	4.63	0.88
B_Reach	30300	5-yr	20.3	6656.72	6657.77	6657.78	6658.09	0.03898	4.5	4.51	7.42	1.02
B_Reach	30300	10-yr	34.1	6656.72	6658.04	6658.05	6658.44	0.037769	5.09	6.7	8.94	1.04
B_Reach	30300	25-yr	59.4	6656.72	6658.36	6658.42	6658.93	0.039568	6.06	9.8	10.33	1.1
B_Reach	30300	50-yr	122.8	6656.72	6659.01	6659.07	6659.8	0.033803	7.12	17.25	12.46	1.07
B_Reach	30300	100-yr	187.6	6656.72	6659.57	6659.58	6660.47	0.028608	7.6	24.69	14.09	1.01
B_Reach	30300	500-yr	518	6656.72	6661.39	6661.39	6662.36	0.027059	7.92	65.38	34.75	1.02
B_Reach	30200	2-yr	4.3	6652.9	6653.25	6653.25	6653.39	0.046699	2.94	1.46	5.42	1
B_Reach	30200	5-yr	20.3	6652.9	6653.7	6653.72	6654.04	0.042089	4.68	4.33	7.15	1.06
B_Reach	30200	10-yr	34.1	6652.9	6653.94	6654	6654.42	0.04274	5.54	6.15	7.87	1.1
B_Reach	30200	25-yr	59.4	6652.9	6654.34	6654.41	6654.92	0.040508	6.1	9.73	10.26	1.1
B_Reach	30200	50-yr	122.8	6652.9	6654.87	6655.07	6655.79	0.048059	7.69	15.97	13.52	1.25
B_Reach	30200	100-yr	187.6	6652.9	6655.18	6655.56	6656.5	0.057842	9.2	20.39	15.16	1.4
B_Reach	30200	500-yr	518	6652.9	6656.46	6657.08	6658.47	0.056701	11.38	45.53	24.41	1.47
B_Reach	30100	2-yr	4.3	6646.45	6646.84	6646.9	6647.06	0.09013	3.73	1.15	4.91	1.36
B_Reach	30100	5-yr	20.3	6646.45	6647.19	6647.37	6647.8	0.10045	6.28	3.23	6.74	1.6
B_Reach	30100	10-yr	34.1	6646.45	6647.39	6647.64	6648.22	0.096349	7.3	4.67	7.42	1.62
B_Reach	30100	25-yr	59.4	6646.45	6647.66	6648.03	6648.86	0.097993	8.76	6.78	8.17	1.69
B_Reach	30100	50-yr	122.8	6646.45	6648.29	6648.74	6649.81	0.074797	9.9	12.41	9.9	1.56
B_Reach	30100	100-yr	187.6	6646.45	6648.81	6649.3	6650.51	0.061273	10.44	17.97	11.14	1.45
B_Reach	30100	500-yr	518	6646.45	6650.53	6651.66	6653.06	0.0506	12.77	40.55	15.44	1.39
B_Reach	30000	2-yr	4.3	6638.01	6638.34	6638.38	6638.52	0.08068	3.45	1.25	5.49	1.28
B_Reach	30000	5-yr	20.3	6638.01	6638.72	6638.84	6639.2	0.073851	5.59	3.63	7.14	1.38
B_Reach	30000	10-yr	34.1	6638.01	6638.91	6639.11	6639.6	0.076787	6.66	5.12	7.89	1.46
B_Reach	30000	25-yr	59.4	6638.01	6639.2	6639.49	6640.16	0.076488	7.86	7.56	8.94	1.51
B_Reach	30000	50-yr	122.8	6638.01	6639.63	6640.17	6641.34	0.096102	10.5	11.69	10.48	1.75
B_Reach	30000	100-yr	187.6	6638.01	6639.93	6640.7	6642.35	0.111317	12.49	15.02	11.47	1.92
B_Reach	30000	500-yr	518	6638.01	6641.1	6642.44	6645.44	0.120096	16.72	30.98	15.87	2.11
B_Reach	29900	2-yr	4.3	6630.92	6631.26	6631.26	6631.35	0.051972	2.48	1.73	9.04	1
B_Reach	29900	5-yr	20.3	6630.92	6631.51	6631.59	6631.83	0.072447	4.54	4.47	12.11	1.32
B_Reach	29900	10-yr	34.1	6630.92	6631.66	6631.78	6632.1	0.071852	5.3	6.43	13.67	1.36
B_Reach	29900	25-yr	59.4	6630.92	6631.86	6632.03	6632.49	0.075032	6.36	9.34	15.57	1.45
B_Reach	29900	50-yr	122.8	6630.92	6632.24	6632.5	6633.21	0.066119	7.89	15.56	16.88	1.45
B_Reach	29900	100-yr	187.6	6630.92	6632.55	6632.9	6633.81	0.062842	9.02	20.8	17.58	1.46
B_Reach	29900	500-yr	518	6630.92	6633.58	6634.37	6636.17	0.066435	12.93	40.07	19.92	1.61
B_Reach	29800.01	2-yr	4.3	6624.2	6624.51	6624.56	6624.71	0.087537	3.62	1.19	5.2	1.33
B_Reach	29800.01	5-yr	20.3	6624.2	6624.95	6625.03	6625.35	0.058244	5.04	4.02	7.74	1.23
B_Reach	29800.01	10-yr	34.1	6624.2	6625.17	6625.29	6625.7	0.057232	5.88	5.8	8.67	1.27
B_Reach	29800.01	25-yr	59.4	6624.2	6625.49	6625.65	6626.2	0.053529	6.77	8.78	10	1.27
B_Reach	29800.01	50-yr	122.8	6624.2	6626.04	6626.35	6627.06	0.057212	8.13	15.1	13.73	1.37
B_Reach	29800.01	100-yr	187.6	6624.2	6626.42	6626.77	6627.64	0.060526	8.86	21.18	17.77	1.43
B_Reach	29800.01	500-yr	518	6624.2	6627.52	6628.13	6629.58	0.062297	11.51	44.99	26.11	1.55
B_Reach	29700	2-yr	4.3	6615.88	6616.2	6616.25	6616.37	0.099204	3.33	1.29	7.06	1.37
B_Reach	29700	5-yr	20.3	6615.88	6616.45	6616.62	6617.02	0.127942	6.03	3.37	9.08	1.75
B_Reach	29700	10-yr	34.1	6615.88	6616.59	6616.84	6617.42	0.129242	7.3	4.67	9.46	1.83
B_Reach	29700	25-yr	59.4	6615.88	6616.79	6617.17	6618.05	0.1359	9.03	6.58	9.93	1.95
B_Reach	29700	50-yr	122.8	6615.88	6617.23	6617.81	6619.09	0.115682	10.93	11.24	10.99	1.9
B_Reach	29700	100-yr	187.6	6615.88	6617.63	6618.32	6619.83	0.101472	11.93	15.73	12.05	1.84
B_Reach	29700	500-yr	518	6615.88	6619	6620.08	6622.38	0.080724	14.75	35.11	15.94	1.75
B_Reach	29600	2-yr	4.3	6603.93	6604.29	6604.37	6604.54	0.143296	4.02	1.07	5.75	1.64
B_Reach	29600	5-yr	20.3	6603.93	6604.63	6604.82	6605.25	0.108385	6.3	3.22	7.01	1.64
B_Reach	29600	10-yr	34.1	6603.93	6604.82	6605.08	6605.66	0.107413	7.37	4.63	7.86	1.69
B_Reach	29600	25-yr	59.4	6603.93	6605.09	6605.46	6606.24	0.103049	8.61	6.9	8.93	1.72
B_Reach	29600	50-yr	122.8	6603.93	6605.52	6606.12	6607.45	0.116902	11.16	11.01	10.46	1.92
B_Reach	29600	100-yr	187.6	6603.93	6605.82	6606.67	6608.46	0.127468	13.02	14.41	11.48	2.05

B_Reach	29600	500-yr	518	6603.93	6606.93	6608.33	6611.7	0.143494	17.52	29.56	16.25	2.29
B_Reach	29500	2-yr	4.3	6594.09	6594.49	6594.52	6594.64	0.072126	3.11	1.38	6.55	1.19
B_Reach	29500	5-yr	20.3	6594.09	6594.8	6594.94	6595.26	0.091441	5.49	3.7	8.88	1.5
B_Reach	29500	10-yr	34.1	6594.09	6594.97	6595.17	6595.6	0.093185	6.39	5.34	10.3	1.56
B_Reach	29500	25-yr	59.4	6594.09	6595.2	6595.45	6596.06	0.098979	7.44	7.98	12.8	1.66
B_Reach	29500	50-yr	122.8	6594.09	6595.59	6595.99	6596.9	0.09234	9.19	13.36	14.73	1.7
B_Reach	29500	100-yr	187.6	6594.09	6595.89	6596.41	6597.57	0.089459	10.4	18.04	16.06	1.73
B_Reach	29500	500-yr	518	6594.09	6596.91	6597.89	6600.02	0.089565	14.17	36.57	20.12	1.85
B_Reach	29400	2-yr	4.3	6586.44	6586.69	6586.73	6586.81	0.085025	2.79	1.54	9.86	1.24
B_Reach	29400	5-yr	20.3	6586.44	6586.96	6587.03	6587.26	0.069835	4.38	4.64	12.93	1.29
B_Reach	29400	10-yr	34.1	6586.44	6587.1	6587.21	6587.52	0.069648	5.16	6.61	14.33	1.34
B_Reach	29400	25-yr	59.4	6586.44	6587.3	6587.46	6587.91	0.067172	6.22	9.55	15.11	1.38
B_Reach	29400	50-yr	122.8	6586.44	6587.65	6587.95	6588.69	0.072026	8.19	15	16.41	1.51
B_Reach	29400	100-yr	187.6	6586.44	6587.92	6588.34	6589.34	0.074516	9.56	19.62	17.33	1.58
B_Reach	29400	500-yr	518	6586.44	6588.93	6589.8	6591.7	0.075818	13.36	38.77	20.49	1.71
B_Reach	29300	2-yr	4.3	6578.36	6578.69	6578.7	6578.8	0.060921	2.71	1.58	8.17	1.09
B_Reach	29300	5-yr	20.3	6578.36	6578.94	6579.06	6579.36	0.089744	5.18	3.92	10.22	1.47
B_Reach	29300	10-yr	34.1	6578.36	6579.1	6579.27	6579.67	0.088665	6.08	5.61	11.33	1.52
B_Reach	29300	25-yr	59.4	6578.36	6579.32	6579.58	6580.12	0.090902	7.18	8.27	13.26	1.6
B_Reach	29300	50-yr	122.8	6578.36	6579.73	6580.05	6580.81	0.086559	8.32	14.75	18.26	1.63
B_Reach	29300	100-yr	187.6	6578.36	6579.99	6580.41	6581.42	0.084506	9.6	19.55	19.05	1.67
B_Reach	29300	500-yr	518	6578.36	6580.92	6581.78	6583.71	0.084197	13.41	38.63	22.3	1.8
B_Reach	29200	2-yr	4.3	6570.77	6571.02	6571.06	6571.17	0.098104	3.11	1.38	8.38	1.35
B_Reach	29200	5-yr	20.3	6570.77	6571.33	6571.4	6571.6	0.06692	4.2	4.83	13.93	1.26
B_Reach	29200	10-yr	34.1	6570.77	6571.47	6571.57	6571.85	0.0686	4.92	6.93	16.07	1.32
B_Reach	29200	25-yr	59.4	6570.77	6571.66	6571.8	6572.18	0.068581	5.75	10.34	18.98	1.37
B_Reach	29200	50-yr	122.8	6570.77	6571.97	6572.2	6572.79	0.073189	7.24	16.95	23.05	1.49
B_Reach	29200	100-yr	187.6	6570.77	6572.19	6572.52	6573.3	0.076249	8.43	22.24	24.77	1.57
B_Reach	29200	500-yr	518	6570.77	6572.95	6573.66	6575.23	0.082332	12.12	42.74	29.05	1.76
B_Reach	29100	2-yr	4.3	6562.71	6563.15	6563.18	6563.37	0.063258	3.76	1.14	3.53	1.17
B_Reach	29100	5-yr	20.3	6562.71	6563.63	6563.84	6564.27	0.079713	6.41	3.17	5.06	1.43
B_Reach	29100	10-yr	34.1	6562.71	6563.93	6564.14	6564.63	0.075518	6.67	5.11	7.48	1.42
B_Reach	29100	25-yr	59.4	6562.71	6564.27	6564.61	6565.13	0.071772	7.44	7.99	9.6	1.44
B_Reach	29100	50-yr	122.8	6562.71	6564.85	6565.11	6565.77	0.067263	7.69	15.97	17.77	1.43
B_Reach	29100	100-yr	187.6	6562.71	6565.16	6565.47	6566.28	0.064869	8.47	22.14	20.75	1.45
B_Reach	29100	500-yr	518	6562.71	6566.18	6566.84	6568.26	0.058645	11.58	44.75	23.93	1.49
B_Reach	29000	2-yr	4.3	6555.37	6555.81	6555.85	6555.99	0.087155	3.36	1.28	6.22	1.3
B_Reach	29000	5-yr	20.3	6555.37	6556.19	6556.27	6556.5	0.073858	4.42	4.59	13.09	1.32
B_Reach	29000	10-yr	34.1	6555.37	6556.35	6556.46	6556.72	0.080663	4.85	7.02	18.61	1.39
B_Reach	29000	25-yr	59.4	6555.37	6556.51	6556.64	6557.02	0.089818	5.72	10.39	23.32	1.51
B_Reach	29000	50-yr	122.8	6555.37	6556.74	6557.01	6557.67	0.099248	7.77	15.81	24.02	1.69
B_Reach	29000	100-yr	187.6	6555.37	6556.93	6557.32	6558.23	0.101656	9.16	20.47	24.62	1.77
B_Reach	29000	500-yr	518	6555.37	6557.63	6558.47	6560.43	0.107803	13.41	38.62	27.07	1.98
B_Reach	28900	2-yr	4.3	6549.64	6549.94	6549.94	6550.04	0.050783	2.56	1.68	8.3	1
B_Reach	28900	5-yr	20.3	6549.64	6550.26	6550.29	6550.54	0.04907	4.22	4.8	10.8	1.12
B_Reach	28900	10-yr	34.1	6549.64	6550.45	6550.5	6550.82	0.045005	4.87	7.01	11.87	1.12
B_Reach	28900	25-yr	59.4	6549.64	6550.78	6550.83	6551.21	0.040301	5.23	11.35	15.81	1.09
B_Reach	28900	50-yr	122.8	6549.64	6551.27	6551.32	6551.81	0.037427	5.88	20.87	23	1.09
B_Reach	28900	100-yr	187.6	6549.64	6551.56	6551.65	6552.26	0.037391	6.71	27.94	25.18	1.12
B_Reach	28900	500-yr	518	6549.64	6552.54	6552.82	6553.83	0.039628	9.1	56.93	33.95	1.24
B_Reach	28800	2-yr	4.3	6544.2	6544.42	6544.44	6544.51	0.102689	2.43	1.77	16.05	1.29
B_Reach	28800	5-yr	20.3	6544.2	6544.63	6544.67	6544.84	0.066352	3.68	5.51	19.27	1.21
B_Reach	28800	10-yr	34.1	6544.2	6544.73	6544.81	6545.06	0.076122	4.61	7.39	20.44	1.35
B_Reach	28800	25-yr	59.4	6544.2	6544.85	6545.02	6545.39	0.090693	5.88	10.11	22.16	1.53
B_Reach	28800	50-yr	122.8	6544.2	6545.11	6545.38	6545.99	0.101123	7.52	16.33	26.81	1.7
B_Reach	28800	100-yr	187.6	6544.2	6545.32	6545.65	6546.42	0.10166	8.43	22.24	30.85	1.75
B_Reach	28800	500-yr	518	6544.2	6546.01	6546.63	6548.07	0.087945	11.54	44.89	34.66	1.79
B_Reach	28700	2-yr	4.3	6537.23	6537.51	6537.55	6537.67	0.104344	3.27	1.31	7.71	1.4
B_Reach	28700	5-yr	20.3	6537.23	6537.83	6537.89	6538.11	0.068183	4.25	4.78	13.65	1.27

B_Reach	28700	10-yr	34.1	6537.23	6537.99	6538.06	6538.36	0.059429	4.88	6.98	14.55	1.24
B_Reach	28700	25-yr	59.4	6537.23	6538.22	6538.31	6538.71	0.051103	5.63	10.54	15.77	1.21
B_Reach	28700	50-yr	122.8	6537.23	6538.65	6538.8	6539.39	0.04595	6.92	17.75	17.89	1.22
B_Reach	28700	100-yr	187.6	6537.23	6538.99	6539.21	6539.93	0.044435	7.81	24.01	19.51	1.24
B_Reach	28700	500-yr	518	6537.23	6540.08	6540.52	6541.74	0.04609	10.34	50.1	27.32	1.35
B_Reach	28600	2-yr	4.3	6530.09	6530.52	6530.57	6530.69	0.101184	3.35	1.28	7.03	1.38
B_Reach	28600	5-yr	20.3	6530.09	6530.84	6530.91	6531.14	0.071086	4.43	4.59	12.72	1.3
B_Reach	28600	10-yr	34.1	6530.09	6530.97	6531.08	6531.42	0.081779	5.43	6.28	14.23	1.44
B_Reach	28600	25-yr	59.4	6530.09	6531.12	6531.34	6531.87	0.095377	6.92	8.58	15.1	1.62
B_Reach	28600	50-yr	122.8	6530.09	6531.43	6531.82	6532.73	0.10284	9.17	13.4	16.23	1.78
B_Reach	28600	100-yr	187.6	6530.09	6531.69	6532.21	6533.42	0.100976	10.56	17.77	17.02	1.82
B_Reach	28600	500-yr	518	6530.09	6532.77	6533.65	6535.65	0.080583	13.6	38.08	20.46	1.76
B_Reach	28500	2-yr	4.3	6523.34	6523.7	6523.71	6523.82	0.049528	2.78	1.55	6.55	1.01
B_Reach	28500	5-yr	20.3	6523.34	6524.04	6524.13	6524.45	0.063053	5.14	3.95	7.82	1.28
B_Reach	28500	10-yr	34.1	6523.34	6524.27	6524.38	6524.8	0.054738	5.81	5.87	8.62	1.24
B_Reach	28500	25-yr	59.4	6523.34	6524.62	6524.75	6525.28	0.047903	6.52	9.11	10.08	1.21
B_Reach	28500	50-yr	122.8	6523.34	6525.21	6525.41	6526.15	0.044517	7.75	15.84	12.65	1.22
B_Reach	28500	100-yr	187.6	6523.34	6525.64	6525.91	6526.8	0.044727	8.66	21.67	14.64	1.25
B_Reach	28500	500-yr	518	6523.34	6526.88	6527.49	6529.04	0.051893	11.78	43.99	20.66	1.42
B_Reach	28400	2-yr	4.3	6518.33	6518.52	6518.55	6518.63	0.103693	2.72	1.58	12.12	1.33
B_Reach	28400	5-yr	20.3	6518.33	6518.81	6518.82	6519.01	0.046447	3.6	5.64	15.53	1.05
B_Reach	28400	10-yr	34.1	6518.33	6518.92	6518.98	6519.24	0.055122	4.55	7.49	16.49	1.19
B_Reach	28400	25-yr	59.4	6518.33	6519.08	6519.21	6519.61	0.067149	5.87	10.12	17.58	1.36
B_Reach	28400	50-yr	122.8	6518.33	6519.37	6519.66	6520.34	0.078657	7.93	15.49	19.22	1.56
B_Reach	28400	100-yr	187.6	6518.33	6519.62	6520.02	6520.92	0.080463	9.16	20.47	20.67	1.62
B_Reach	28400	500-yr	518	6518.33	6520.63	6521.22	6522.46	0.083229	10.86	47.71	38.23	1.71
B_Reach	28300	2-yr	4.3	6512.78	6513.06	6513.06	6513.15	0.051567	2.36	1.82	10.31	0.99
B_Reach	28300	5-yr	20.3	6512.78	6513.31	6513.35	6513.52	0.065845	3.74	5.42	18.39	1.22
B_Reach	28300	10-yr	34.1	6512.78	6513.44	6513.49	6513.72	0.055129	4.25	8.02	19.65	1.17
B_Reach	28300	25-yr	59.4	6512.78	6513.65	6513.7	6514.01	0.046619	4.88	12.17	21.34	1.14
B_Reach	28300	50-yr	122.8	6512.78	6514	6514.1	6514.57	0.042585	6.02	20.38	24.27	1.16
B_Reach	28300	100-yr	187.6	6512.78	6514.27	6514.42	6515.01	0.042969	6.92	27.13	26.36	1.2
B_Reach	28300	500-yr	518	6512.78	6515.32	6515.53	6516.31	0.043955	7.98	64.87	51.73	1.26
B_Reach	28200	2-yr	4.3	6506.43	6506.66	6506.68	6506.77	0.080751	2.62	1.64	11.07	1.2
B_Reach	28200	5-yr	20.3	6506.43	6506.93	6506.98	6507.19	0.060917	4.1	4.95	13.75	1.21
B_Reach	28200	10-yr	34.1	6506.43	6507.04	6507.15	6507.46	0.071448	5.16	6.61	14.68	1.35
B_Reach	28200	25-yr	59.4	6506.43	6507.21	6507.42	6507.86	0.083858	6.51	9.13	16.09	1.52
B_Reach	28200	50-yr	122.8	6506.43	6507.54	6507.82	6508.49	0.092055	7.86	15.62	22.22	1.65
B_Reach	28200	100-yr	187.6	6506.43	6507.77	6508.14	6509.02	0.08759	8.97	20.91	23.42	1.67
B_Reach	28200	500-yr	518	6506.43	6508.7	6509.33	6510.84	0.066612	11.76	44.05	26.28	1.6
B_Reach	28100	2-yr	4.3	6501.61	6501.94	6501.92	6502.03	0.0388	2.35	1.83	8.41	0.89
B_Reach	28100	5-yr	20.3	6501.61	6502.29	6502.29	6502.52	0.039836	3.77	5.39	12.32	1
B_Reach	28100	10-yr	34.1	6501.61	6502.49	6502.49	6502.77	0.036778	4.28	7.97	14.14	1.01
B_Reach	28100	25-yr	59.4	6501.61	6502.76	6502.76	6503.14	0.033959	4.94	12.01	16.14	1.01
B_Reach	28100	50-yr	122.8	6501.61	6503.25	6503.25	6503.78	0.030595	5.87	20.93	20.05	1.01
B_Reach	28100	100-yr	187.6	6501.61	6503.55	6503.62	6504.28	0.033402	6.84	27.42	22.23	1.09
B_Reach	28100	500-yr	518	6501.61	6504.68	6505.02	6505.96	0.03398	9.1	57.55	34.63	1.17
B_Reach	28000	2-yr	4.3	6497.29	6497.57	6497.57	6497.66	0.049635	2.44	1.77	9.24	0.98
B_Reach	28000	5-yr	20.3	6497.29	6497.87	6497.9	6498.11	0.048907	3.99	5.09	12.5	1.1
B_Reach	28000	10-yr	34.1	6497.29	6498.02	6498.09	6498.38	0.053245	4.84	7.04	13.78	1.19
B_Reach	28000	25-yr	59.4	6497.29	6498.22	6498.35	6498.76	0.058746	5.88	10.1	15.85	1.3
B_Reach	28000	50-yr	122.8	6497.29	6498.58	6498.83	6499.45	0.06607	7.5	16.37	19.46	1.44
B_Reach	28000	100-yr	187.6	6497.29	6498.9	6499.28	6499.92	0.058527	8.09	23.19	22.45	1.4
B_Reach	28000	500-yr	518	6497.29	6499.78	6500.3	6501.22	0.070091	9.63	54.57	60.2	1.57
B_Reach	27900	2-yr	4.3	6492.05	6492.3	6492.3	6492.38	0.056219	2.23	1.93	12.68	1.01
B_Reach	27900	5-yr	20.3	6492.05	6492.53	6492.56	6492.74	0.058947	3.63	5.59	18.26	1.16
B_Reach	27900	10-yr	34.1	6492.05	6492.66	6492.71	6492.95	0.055105	4.29	7.95	19.22	1.18
B_Reach	27900	25-yr	59.4	6492.05	6492.85	6492.92	6493.24	0.051182	5.05	11.77	21.06	1.19
B_Reach	27900	50-yr	122.8	6492.05	6493.19	6493.32	6493.82	0.047505	6.36	19.31	22.96	1.22
B_Reach	27900	100-yr	187.6	6492.05	6493.42	6493.64	6494.32	0.053035	7.61	24.66	24.22	1.33

B_Reach	27900	500-yr	518	6492.05	6494.47	6494.75	6495.67	0.044048	8.77	59.06	40.54	1.28
B_Reach	27799.92	2-yr	4.3	6485.77	6486.09	6486.11	6486.21	0.067492	2.86	1.5	7.76	1.15
B_Reach	27799.92	5-yr	20.3	6485.77	6486.42	6486.47	6486.69	0.061888	4.18	4.85	13.26	1.22
B_Reach	27799.92	10-yr	34.1	6485.77	6486.55	6486.65	6486.95	0.06498	5.07	6.73	14.24	1.3
B_Reach	27799.92	25-yr	59.4	6485.77	6486.75	6486.91	6487.34	0.068267	6.18	9.62	15.66	1.39
B_Reach	27799.92	50-yr	122.8	6485.77	6487.11	6487.4	6488.04	0.070708	7.73	15.89	18.92	1.49
B_Reach	27799.92	100-yr	187.6	6485.77	6487.44	6487.74	6488.5	0.063629	8.24	22.77	22.68	1.45
B_Reach	27799.92	500-yr	518	6485.77	6488.34	6488.94	6490.34	0.0635	11.37	45.56	27.71	1.56
B_Reach	27700	2-yr	4.3	6480.46	6480.89	6480.85	6480.97	0.031961	2.36	1.82	6.98	0.82
B_Reach	27700	5-yr	20.3	6480.46	6481.25	6481.27	6481.55	0.04333	4.44	4.57	8.42	1.06
B_Reach	27700	10-yr	34.1	6480.46	6481.48	6481.51	6481.89	0.040695	5.12	6.65	9.36	1.07
B_Reach	27700	25-yr	59.4	6480.46	6481.82	6481.87	6482.36	0.037804	5.92	10.04	10.65	1.07
B_Reach	27700	50-yr	122.8	6480.46	6482.44	6482.51	6483.2	0.034649	7	17.54	13.48	1.08
B_Reach	27700	100-yr	187.6	6480.46	6482.86	6483	6483.84	0.035291	7.94	23.64	15.18	1.12
B_Reach	27700	500-yr	518	6480.46	6484.46	6484.65	6485.93	0.030488	9.74	53.17	22.35	1.11
B_Reach	27600	2-yr	4.3	6476.17	6476.72	6476.72	6476.83	0.056055	2.58	1.66	8.57	1.03
B_Reach	27600	5-yr	20.3	6476.17	6477.04	6477.08	6477.34	0.051317	4.38	4.64	10.02	1.13
B_Reach	27600	10-yr	34.1	6476.17	6477.26	6477.29	6477.64	0.044278	4.95	6.9	11.06	1.1
B_Reach	27600	25-yr	59.4	6476.17	6477.5	6477.61	6478.08	0.048698	6.09	9.76	12.26	1.2
B_Reach	27600	50-yr	122.8	6476.17	6477.94	6478.18	6478.92	0.05326	7.96	15.43	13.67	1.32
B_Reach	27600	100-yr	187.6	6476.17	6478.32	6478.64	6479.58	0.051852	9.01	20.82	14.87	1.34
B_Reach	27600	500-yr	518	6476.17	6479.56	6480.15	6481.41	0.072423	10.9	47.52	33.44	1.61
B_Reach	27500	2-yr	4.3	6472.45	6472.84	6472.84	6472.95	0.049177	2.69	1.6	7.14	1
B_Reach	27500	5-yr	20.3	6472.45	6473.21	6473.21	6473.36	0.043406	3.17	6.39	20.28	1
B_Reach	27500	10-yr	34.1	6472.45	6473.34	6473.34	6473.55	0.040937	3.67	9.3	22.72	1.01
B_Reach	27500	25-yr	59.4	6472.45	6473.5	6473.54	6473.82	0.045431	4.55	13.05	24.92	1.11
B_Reach	27500	50-yr	122.8	6472.45	6473.86	6473.89	6474.31	0.037898	5.39	22.78	29.4	1.08
B_Reach	27500	100-yr	187.6	6472.45	6474.07	6474.18	6474.71	0.042529	6.4	29.31	31.85	1.18
B_Reach	27500	500-yr	518	6472.45	6474.97	6475.38	6475.99	0.038754	8.21	65.99	59.38	1.21
B_Reach	27400	2-yr	4.3	6467.04	6467.35	6467.36	6467.47	0.061492	2.83	1.52	7.36	1.1
B_Reach	27400	5-yr	20.3	6467.04	6467.67	6467.75	6468.03	0.066515	4.83	4.21	9.66	1.29
B_Reach	27400	10-yr	34.1	6467.04	6467.84	6467.97	6468.35	0.067325	5.74	5.94	10.57	1.35
B_Reach	27400	25-yr	59.4	6467.04	6468.13	6468.29	6468.77	0.055763	6.39	9.29	12.15	1.29
B_Reach	27400	50-yr	122.8	6467.04	6468.59	6468.98	6469.58	0.059085	7.98	15.39	15	1.39
B_Reach	27400	100-yr	187.6	6467.04	6469.1	6469.33	6469.93	0.053624	7.31	25.67	26.85	1.32
B_Reach	27400	500-yr	518	6467.04	6469.98	6470.54	6471.4	0.05443	9.54	54.28	38.59	1.42
B_Reach	27300	2-yr	4.3	6461.46	6461.81	6461.79	6461.88	0.038082	2	2.15	12.44	0.85
B_Reach	27300	5-yr	20.3	6461.46	6462.04	6462.06	6462.21	0.050328	3.3	6.15	20.51	1.06
B_Reach	27300	10-yr	34.1	6461.46	6462.17	6462.19	6462.38	0.0519	3.73	9.14	25.96	1.11
B_Reach	27300	25-yr	59.4	6461.46	6462.28	6462.37	6462.64	0.065848	4.81	12.34	28.61	1.29
B_Reach	27300	50-yr	122.8	6461.46	6462.6	6462.71	6463.02	0.069001	5.22	23.55	50.14	1.34
B_Reach	27300	100-yr	187.6	6461.46	6462.71	6462.89	6463.35	0.080996	6.38	29.39	52.06	1.5
B_Reach	27300	500-yr	518	6461.46	6463.18	6463.59	6464.53	0.088741	9.31	55.64	59.74	1.7
B_Reach	27200	2-yr	4.3	6456.91	6457.42	6457.42	6457.56	0.049276	2.92	1.47	5.76	1.02
B_Reach	27200	5-yr	20.3	6456.91	6457.85	6457.85	6458.1	0.039176	4.02	5.06	10.3	1.01
B_Reach	27200	10-yr	34.1	6456.91	6458.05	6458.05	6458.39	0.038748	4.65	7.34	11.88	1.04
B_Reach	27200	25-yr	59.4	6456.91	6458.43	6458.43	6458.71	0.037975	4.29	13.85	25.01	1.02
B_Reach	27200	50-yr	122.8	6456.91	6458.84	6458.85	6459.12	0.039894	4.26	28.8	54.67	1.04
B_Reach	27200	100-yr	187.6	6456.91	6459.04	6459.04	6459.37	0.035352	4.62	40.64	62.54	1.01
B_Reach	27200	500-yr	518	6456.91	6459.65	6459.65	6460.21	0.030651	6.05	85.68	79.01	1.02
B_Reach	27100	2-yr	4.3	6452.22	6452.72	6452.72	6452.8	0.05027	2.3	1.87	10.63	0.97
B_Reach	27100	5-yr	20.3	6452.22	6452.96	6453.01	6453.24	0.061964	4.22	4.81	12.79	1.21
B_Reach	27100	10-yr	34.1	6452.22	6453.1	6453.2	6453.51	0.063145	5.14	6.63	13.22	1.28
B_Reach	27100	25-yr	59.4	6452.22	6453.32	6453.46	6453.91	0.062666	6.15	9.66	14.55	1.33
B_Reach	27100	50-yr	122.8	6452.22	6453.77	6453.96	6454.61	0.051246	7.33	16.75	16.48	1.28
B_Reach	27100	100-yr	187.6	6452.22	6454.12	6454.39	6455.18	0.048518	8.27	22.68	17.73	1.29
B_Reach	27100	500-yr	518	6452.22	6455.72	6455.86	6456.45	0.04698	6.85	75.57	79.14	1.24
B_Reach	27000	2-yr	4.5	6446.04	6446.29	6446.32	6446.41	0.082771	2.78	1.62	10.24	1.23
B_Reach	27000	5-yr	21.2	6446.04	6446.57	6446.64	6446.88	0.065146	4.44	4.78	12.39	1.26

B_Reach	27000	10-yr	35.6	6446.04	6446.73	6446.83	6447.16	0.063895	5.27	6.75	13.28	1.3
B_Reach	27000	25-yr	61.9	6446.04	6446.94	6447.1	6447.57	0.063947	6.39	9.68	14.16	1.36
B_Reach	27000	50-yr	127.8	6446.04	6447.29	6447.63	6448.43	0.074399	8.58	14.9	15.56	1.54
B_Reach	27000	100-yr	195.1	6446.04	6447.59	6448.04	6449.11	0.076061	9.9	19.7	16.75	1.61
B_Reach	27000	500-yr	538.2	6446.04	6448.87	6449.53	6451.23	0.054367	12.34	43.62	19.75	1.46
B_Reach	26900	2-yr	4.5	6435.49	6435.65	6435.71	6435.88	0.325714	3.82	1.18	12.87	2.23
B_Reach	26900	5-yr	21.2	6435.49	6435.82	6435.99	6436.38	0.225623	6.01	3.53	14.81	2.17
B_Reach	26900	10-yr	35.6	6435.49	6435.93	6436.14	6436.67	0.20137	6.91	5.15	16.09	2.15
B_Reach	26900	25-yr	61.9	6435.49	6436.07	6436.36	6437.1	0.199515	8.15	7.6	18.4	2.24
B_Reach	26900	50-yr	127.8	6435.49	6436.35	6436.78	6437.84	0.16158	9.8	13.05	20.4	2.16
B_Reach	26900	100-yr	195.1	6435.49	6436.55	6437.12	6438.51	0.156423	11.23	17.37	21.51	2.2
B_Reach	26900	500-yr	538.2	6435.49	6437.17	6438.39	6441.76	0.19124	17.19	31.31	23.48	2.62
B_Reach	26800	2-yr	4.5	6424.04	6424.67	6424.69	6424.83	0.054887	3.16	1.42	5.2	1.07
B_Reach	26800	5-yr	21.2	6424.04	6425.07	6425.15	6425.38	0.064304	4.5	4.71	11.61	1.25
B_Reach	26800	10-yr	35.6	6424.04	6425.22	6425.34	6425.68	0.068304	5.42	6.57	12.83	1.33
B_Reach	26800	25-yr	61.9	6424.04	6425.44	6425.62	6426.08	0.068561	6.4	9.67	14.73	1.39
B_Reach	26800	50-yr	127.8	6424.04	6425.8	6426.11	6426.85	0.077829	8.21	15.57	17.99	1.55
B_Reach	26800	100-yr	195.1	6424.04	6426.07	6426.48	6427.46	0.080086	9.45	20.65	19.7	1.63
B_Reach	26800	500-yr	538.2	6424.04	6427.03	6427.82	6429.6	0.077311	12.87	41.81	24.14	1.72
B_Reach	26700	2-yr	4.5	6412.2	6412.73	6412.97	6413.65	0.331546	7.69	0.58	1.99	2.5
B_Reach	26700	5-yr	21.2	6412.2	6413.09	6413.29	6413.81	0.263873	6.81	3.11	11.73	2.33
B_Reach	26700	10-yr	35.6	6412.2	6413.21	6413.47	6414.12	0.233857	7.68	4.63	13.31	2.29
B_Reach	26700	25-yr	61.9	6412.2	6413.36	6413.73	6414.68	0.222612	9.22	6.71	14.1	2.35
B_Reach	26700	50-yr	127.8	6412.2	6413.7	6414.23	6415.55	0.175662	10.93	11.69	15.83	2.24
B_Reach	26700	100-yr	195.1	6412.2	6413.95	6414.64	6416.31	0.162368	12.32	15.83	16.78	2.24
B_Reach	26700	500-yr	538.2	6412.2	6414.85	6416.08	6419.09	0.14568	16.51	32.59	20.21	2.29
B_Reach	26601.28	2-yr	4.5	6393.4	6393.75	6393.88	6394.08	0.181446	4.64	0.97	5.05	1.87
B_Reach	26601.28	5-yr	21.2	6393.4	6394.04	6394.17	6394.47	0.149847	5.25	4.04	15.21	1.8
B_Reach	26601.28	10-yr	35.6	6393.4	6394.12	6394.33	6394.85	0.197132	6.89	5.17	15.92	2.13
B_Reach	26601.28	25-yr	61.9	6393.4	6394.27	6394.56	6395.27	0.17339	8.01	7.73	17.25	2.11
B_Reach	26601.28	50-yr	127.8	6393.4	6394.48	6395	6396.4	0.215309	11.12	11.49	18.33	2.48
B_Reach	26601.28	100-yr	195.1	6393.4	6394.66	6395.37	6397.38	0.228963	13.26	14.72	18.77	2.64
B_Reach	26601.28	500-yr	538.2	6393.4	6395.34	6396.86	6401	0.232994	19.09	28.19	20.66	2.88
B_Reach	26499.46	2-yr	4.5	6378.51	6378.76	6378.82	6378.95	0.123122	3.51	1.28	7.64	1.51
B_Reach	26499.46	5-yr	21.2	6378.51	6379.01	6379.18	6379.56	0.143136	5.96	3.55	10.71	1.82
B_Reach	26499.46	10-yr	35.6	6378.51	6379.18	6379.38	6379.83	0.114274	6.48	5.49	12.32	1.71
B_Reach	26499.46	25-yr	61.9	6378.51	6379.35	6379.66	6380.33	0.125571	7.91	7.83	13.95	1.86
B_Reach	26499.46	50-yr	127.8	6378.51	6379.74	6380.2	6381.06	0.109076	9.22	13.86	17.62	1.83
B_Reach	26499.46	100-yr	195.1	6378.51	6380.1	6380.49	6381.32	0.109814	8.87	22.01	29.87	1.82
B_Reach	26499.46	500-yr	538.2	6378.51	6380.7	6381.4	6382.98	0.125605	12.1	44.47	41.7	2.07
B_Reach	26400	2-yr	4.5	6368.27	6368.65	6368.67	6368.75	0.062145	2.54	1.77	10.18	1.07
B_Reach	26400	5-yr	21.2	6368.27	6368.89	6368.96	6369.17	0.078585	4.24	5	15.74	1.33
B_Reach	26400	10-yr	35.6	6368.27	6369	6369.12	6369.43	0.094964	5.27	6.75	17.63	1.5
B_Reach	26400	25-yr	61.9	6368.27	6369.18	6369.35	6369.74	0.089544	6	10.32	21.22	1.52
B_Reach	26400	50-yr	127.8	6368.27	6369.45	6369.73	6370.35	0.103795	7.64	16.73	26.69	1.7
B_Reach	26400	100-yr	195.1	6368.27	6369.66	6370.03	6370.79	0.101526	8.51	22.92	30.56	1.73
B_Reach	26400	500-yr	538.2	6368.27	6370.37	6370.93	6372.22	0.091933	10.92	49.3	41.99	1.78
B_Reach	26300	2-yr	4.5	6359.47	6359.97	6360.07	6360.31	0.120241	4.64	0.97	3.58	1.57
B_Reach	26300	5-yr	21.2	6359.47	6360.58	6360.67	6360.89	0.087212	4.44	4.77	14.98	1.39
B_Reach	26300	10-yr	35.6	6359.47	6360.75	6360.85	6361.09	0.073312	4.66	7.64	19.64	1.32
B_Reach	26300	25-yr	61.9	6359.47	6360.91	6361.05	6361.4	0.07765	5.59	11.08	22.57	1.41
B_Reach	26300	50-yr	127.8	6359.47	6361.24	6361.47	6361.93	0.06877	6.68	19.12	27.14	1.4
B_Reach	26300	100-yr	195.1	6359.47	6361.49	6361.7	6362.3	0.070511	7.24	26.94	34.7	1.45
B_Reach	26300	500-yr	538.2	6359.47	6362.14	6362.66	6363.93	0.074917	10.75	50.06	37.06	1.63
B_Reach	26200	2-yr	4.5	6349.81	6350.08	6350.12	6350.22	0.108126	3.08	1.46	9.64	1.39
B_Reach	26200	5-yr	21.2	6349.81	6350.31	6350.43	6350.69	0.120348	4.99	4.25	14.69	1.63
B_Reach	26200	10-yr	35.6	6349.81	6350.4	6350.59	6351	0.146611	6.22	5.73	16.49	1.86
B_Reach	26200	25-yr	61.9	6349.81	6350.57	6350.81	6351.36	0.133457	7.14	8.67	18.87	1.86
B_Reach	26200	50-yr	127.8	6349.81	6350.81	6351.22	6352.21	0.145084	9.48	13.48	20.35	2.05
B_Reach	26200	100-yr	195.1	6349.81	6351.05	6351.56	6352.79	0.132332	10.59	18.42	21.92	2.04

B_Reach	26200	500-yr	538.2	6349.81	6351.89	6352.8	6354.92	0.107256	13.97	38.53	25.45	2
B_Reach	26100	2-yr	4.5	6338.71	6339.02	6339.06	6339.18	0.112753	3.24	1.39	8.79	1.43
B_Reach	26100	5-yr	21.2	6338.71	6339.27	6339.4	6339.71	0.100617	5.31	3.99	10.92	1.55
B_Reach	26100	10-yr	35.6	6338.71	6339.44	6339.6	6340.01	0.085366	6.05	5.88	11.64	1.5
B_Reach	26100	25-yr	61.9	6338.71	6339.65	6339.9	6340.5	0.089841	7.43	8.34	12.5	1.6
B_Reach	26100	50-yr	127.8	6338.71	6340.07	6340.45	6341.31	0.08408	8.96	14.27	15.17	1.63
B_Reach	26100	100-yr	195.1	6338.71	6340.35	6340.88	6342.03	0.088858	10.38	18.8	16.62	1.72
B_Reach	26100	500-yr	538.2	6338.71	6341.32	6342.34	6344.6	0.099051	14.54	37.02	21.1	1.93
B_Reach	26000	2-yr	4.5	6332.6	6333.27	6333.27	6333.44	0.045847	3.3	1.36	4.04	1
B_Reach	26000	5-yr	21.2	6332.6	6333.85	6333.85	6334.17	0.037932	4.53	4.67	7.49	1.01
B_Reach	26000	10-yr	35.6	6332.6	6334.12	6334.13	6334.53	0.037584	5.14	6.92	9.11	1.04
B_Reach	26000	25-yr	61.9	6332.6	6334.52	6334.53	6334.95	0.03628	5.25	11.78	14.8	1.04
B_Reach	26000	50-yr	127.8	6332.6	6334.98	6335.07	6335.66	0.038563	6.64	19.24	17.77	1.13
B_Reach	26000	100-yr	195.1	6332.6	6335.34	6335.47	6336.2	0.038315	7.45	26.18	20.25	1.16
B_Reach	26000	500-yr	538.2	6332.6	6336.48	6336.86	6338.13	0.040022	10.28	52.35	25.54	1.27
B_Reach	25904.13	2-yr	4.5	6314.83	6315.04	6315.31	6317.91	3.213919	13.59	0.33	2.98	7.18
B_Reach	25904.13	5-yr	21.2	6314.83	6315.19	6315.75	6323.04	4.326304	22.47	0.94	4.99	9.1
B_Reach	25904.13	10-yr	35.6	6314.83	6315.31	6315.92	6323.17	3.089209	22.51	1.58	6.48	8.03
B_Reach	25904.13	25-yr	61.9	6314.83	6315.46	6316.16	6323.34	2.104779	22.52	2.75	8.43	6.95
B_Reach	25904.13	50-yr	127.8	6314.83	6315.73	6316.54	6323.76	1.695394	22.74	5.62	14.46	6.43
B_Reach	25904.13	100-yr	195.1	6314.83	6315.89	6316.84	6324.49	1.517887	23.54	8.29	18.61	6.22
B_Reach	25904.13	500-yr	538.2	6314.83	6316.42	6317.84	6326.73	0.927307	25.77	20.89	28.14	5.27
B_Reach	25800	2-yr	4.5	6306.56	6306.95	6306.95	6307.01	0.049381	2.05	2.2	14.75	0.94
B_Reach	25800	5-yr	21.2	6306.56	6307.19	6307.19	6307.34	0.045897	3.09	6.86	23.56	1.01
B_Reach	25800	10-yr	35.6	6306.56	6307.32	6307.32	6307.51	0.042913	3.53	10.08	26.86	1.02
B_Reach	25800	25-yr	61.9	6306.56	6307.5	6307.5	6307.75	0.039276	4	15.46	31.93	1.01
B_Reach	25800	50-yr	127.8	6306.56	6307.77	6307.82	6308.18	0.042883	5.14	24.87	37.66	1.11
B_Reach	25800	100-yr	195.1	6306.56	6307.98	6308.06	6308.52	0.044651	5.89	33.11	42.01	1.17
B_Reach	25800	500-yr	538.2	6306.56	6308.69	6308.93	6309.62	0.052646	7.74	69.54	66.22	1.33
B_Reach	25700	2-yr	4.5	6298.92	6299.2	6299.24	6299.37	0.107671	3.35	1.34	7.73	1.42
B_Reach	25700	5-yr	21.2	6298.92	6299.45	6299.62	6300.03	0.13177	6.15	3.45	9.24	1.77
B_Reach	25700	10-yr	35.6	6298.92	6299.59	6299.85	6300.42	0.134945	7.32	4.86	10.15	1.87
B_Reach	25700	25-yr	61.9	6298.92	6299.8	6300.17	6300.98	0.137355	8.74	7.08	11.43	1.96
B_Reach	25700	50-yr	127.8	6298.92	6300.26	6300.74	6301.74	0.102656	9.76	13.09	14.3	1.8
B_Reach	25700	100-yr	195.1	6298.92	6300.63	6301.27	6302.31	0.088271	10.37	18.81	16.7	1.72
B_Reach	25700	500-yr	538.2	6298.92	6301.82	6302.34	6303.36	0.074138	9.95	54.08	45.32	1.61
B_Reach	25600	2-yr	4.5	6293.37	6293.65	6293.65	6293.74	0.051853	2.44	1.85	9.9	0.99
B_Reach	25600	5-yr	21.2	6293.37	6293.98	6293.98	6294.2	0.039842	3.74	5.66	13.03	1
B_Reach	25600	10-yr	35.6	6293.37	6294.17	6294.17	6294.45	0.037434	4.24	8.4	15.28	1.01
B_Reach	25600	25-yr	61.9	6293.37	6294.45	6294.45	6294.79	0.034273	4.72	13.12	19.05	1
B_Reach	25600	50-yr	127.8	6293.37	6294.81	6294.91	6295.41	0.040094	6.19	20.64	22.36	1.14
B_Reach	25600	100-yr	195.1	6293.37	6295.19	6295.31	6295.8	0.045794	6.25	31.22	37.04	1.2
B_Reach	25600	500-yr	538.2	6293.37	6295.88	6296.17	6297.04	0.052797	8.62	62.41	50.81	1.37
B_Reach	25500	2-yr	4.5	6287.83	6288.15	6288.16	6288.27	0.057785	2.78	1.62	7.8	1.07
B_Reach	25500	5-yr	21.2	6287.83	6288.44	6288.52	6288.74	0.079108	4.4	4.82	14.7	1.35
B_Reach	25500	10-yr	35.6	6287.83	6288.58	6288.68	6288.96	0.087667	4.96	7.18	19.81	1.45
B_Reach	25500	25-yr	61.9	6287.83	6288.71	6288.88	6289.31	0.099823	6.22	9.95	21.46	1.61
B_Reach	25500	50-yr	127.8	6287.83	6289.03	6289.28	6289.9	0.079285	7.51	17.02	23.22	1.55
B_Reach	25500	100-yr	195.1	6287.83	6289.31	6289.59	6290.34	0.064863	8.14	23.95	24.78	1.46
B_Reach	25500	500-yr	538.2	6287.83	6290.36	6290.79	6292.04	0.046486	10.42	51.65	28.21	1.36
B_Reach	25400	2-yr	4.5	6282.21	6282.47	6282.48	6282.56	0.056282	2.4	1.88	11.06	1.03
B_Reach	25400	5-yr	21.2	6282.21	6282.77	6282.77	6282.95	0.043687	3.46	6.12	17.16	1.02
B_Reach	25400	10-yr	35.6	6282.21	6282.92	6282.93	6283.17	0.04062	3.99	8.93	19.16	1.03
B_Reach	25400	25-yr	61.9	6282.21	6283.14	6283.15	6283.47	0.037499	4.61	13.41	21.76	1.04
B_Reach	25400	50-yr	127.8	6282.21	6283.46	6283.56	6284.04	0.043871	6.15	20.78	24.6	1.18
B_Reach	25400	100-yr	195.1	6282.21	6283.67	6283.89	6284.53	0.051535	7.46	26.15	26.07	1.31
B_Reach	25400	500-yr	538.2	6282.21	6284.4	6285.01	6286.42	0.068629	11.41	47.17	30.6	1.62
B_Reach	25300	2-yr	4.5	6276.32	6276.73	6276.74	6276.85	0.057894	2.77	1.63	7.8	1.07
B_Reach	25300	5-yr	21.2	6276.32	6277.06	6277.13	6277.34	0.074132	4.29	4.94	14.66	1.3

B_Reach	25300	10-yr	35.6	6276.32	6277.19	6277.3	6277.59	0.081117	5.07	7.02	17.34	1.4
B_Reach	25300	25-yr	61.9	6276.32	6277.35	6277.54	6277.93	0.089016	6.09	10.16	20.36	1.52
B_Reach	25300	50-yr	127.8	6276.32	6277.79	6277.92	6278.27	0.078261	5.59	22.85	47.74	1.42
B_Reach	25300	100-yr	195.1	6276.32	6277.97	6278.13	6278.54	0.068261	6.1	31.99	52.96	1.38
B_Reach	25300	500-yr	538.2	6276.32	6278.52	6278.8	6279.58	0.062769	8.26	65.14	64.19	1.45
B_Reach	25200	2-yr	4.5	6270.33	6270.55	6270.57	6270.65	0.092543	2.49	1.8	14.57	1.25
B_Reach	25200	5-yr	21.2	6270.33	6270.8	6270.82	6271	0.05463	3.55	5.97	19.05	1.12
B_Reach	25200	10-yr	35.6	6270.33	6270.94	6270.97	6271.19	0.051085	4.07	8.74	21.64	1.13
B_Reach	25200	25-yr	61.9	6270.33	6271.12	6271.17	6271.47	0.048173	4.79	12.93	24	1.15
B_Reach	25200	50-yr	127.8	6270.33	6271.42	6271.55	6272.01	0.051079	6.13	20.83	27.8	1.25
B_Reach	25200	100-yr	195.1	6270.33	6271.65	6271.86	6272.44	0.054658	7.12	27.39	30.71	1.33
B_Reach	25200	500-yr	538.2	6270.33	6272.45	6272.81	6273.77	0.053275	9.22	58.35	43.43	1.4
B_Reach	25100	2-yr	5	6263.64	6264.07	6264.08	6264.21	0.048687	2.93	1.71	6.57	1.01
B_Reach	25100	5-yr	23.4	6263.64	6264.41	6264.5	6264.78	0.070058	4.87	4.8	11.31	1.32
B_Reach	25100	10-yr	39.1	6263.64	6264.58	6264.72	6265.08	0.07243	5.7	6.86	13.04	1.39
B_Reach	25100	25-yr	67.8	6263.64	6264.81	6265.01	6265.51	0.073176	6.72	10.09	15.09	1.45
B_Reach	25100	50-yr	139.9	6263.64	6265.26	6265.54	6266.22	0.064623	7.84	17.85	19.21	1.43
B_Reach	25100	100-yr	213.2	6263.64	6265.61	6265.95	6266.73	0.058818	8.46	25.19	22.52	1.41
B_Reach	25100	500-yr	586.4	6263.64	6266.67	6267.18	6268.5	0.051495	10.85	54.04	29.89	1.42
B_Reach	25000	2-yr	5	6258.02	6258.49	6258.52	6258.64	0.064404	3.06	1.63	7.28	1.14
B_Reach	25000	5-yr	23.4	6258.02	6258.9	6258.93	6259.23	0.044857	4.61	5.07	9.13	1.09
B_Reach	25000	10-yr	39.1	6258.02	6259.13	6259.18	6259.58	0.043041	5.4	7.25	9.91	1.11
B_Reach	25000	25-yr	67.8	6258.02	6259.46	6259.54	6260.09	0.041558	6.37	10.65	10.92	1.14
B_Reach	25000	50-yr	139.9	6258.02	6260.03	6260.22	6261.05	0.04225	8.08	17.31	12.2	1.2
B_Reach	25000	100-yr	213.2	6258.02	6260.53	6260.78	6261.78	0.042002	8.99	23.72	14.05	1.22
B_Reach	25000	500-yr	586.4	6258.02	6261.99	6262.41	6263.7	0.044218	10.5	55.86	27.74	1.3
B_Reach	24900	2-yr	5	6251.47	6251.76	6251.77	6251.88	0.07074	2.81	1.78	9.84	1.16
B_Reach	24900	5-yr	23.4	6251.47	6251.98	6252.12	6252.44	0.114125	5.48	4.27	12.28	1.64
B_Reach	24900	10-yr	39.1	6251.47	6252.11	6252.32	6252.78	0.121872	6.61	5.92	13.45	1.76
B_Reach	24900	25-yr	67.8	6251.47	6252.29	6252.61	6253.28	0.128821	8	8.47	15.02	1.88
B_Reach	24900	50-yr	139.9	6251.47	6252.63	6253.07	6254.12	0.131123	9.77	14.32	18.97	1.98
B_Reach	24900	100-yr	213.2	6251.47	6252.86	6253.46	6254.87	0.130213	11.37	18.75	19.5	2.04
B_Reach	24900	500-yr	586.4	6251.47	6253.89	6254.92	6257.27	0.095531	14.74	39.79	21.38	1.9
B_Reach	24800	2-yr	5	6241.98	6242.27	6242.35	6242.52	0.128754	4.04	1.24	6.17	1.59
B_Reach	24800	5-yr	23.4	6241.98	6242.65	6242.77	6243.12	0.077426	5.53	4.23	8.79	1.41
B_Reach	24800	10-yr	39.1	6241.98	6242.85	6243.03	6243.48	0.072957	6.37	6.14	9.8	1.42
B_Reach	24800	25-yr	67.8	6241.98	6243.14	6243.38	6243.99	0.069517	7.39	9.18	11.26	1.44
B_Reach	24800	50-yr	139.9	6241.98	6243.65	6244.02	6244.92	0.067317	9.03	15.49	13.63	1.49
B_Reach	24800	100-yr	213.2	6241.98	6244.02	6244.5	6245.64	0.067351	10.23	20.85	15.12	1.54
B_Reach	24800	500-yr	586.4	6241.98	6245.14	6246.18	6248.48	0.080782	14.66	39.99	18.99	1.78
B_Reach	24700	2-yr	5	6234.33	6234.62	6234.62	6234.71	0.055273	2.45	2.04	11.52	1.02
B_Reach	24700	5-yr	23.4	6234.33	6234.85	6234.93	6235.16	0.080867	4.51	5.19	15.56	1.38
B_Reach	24700	10-yr	39.1	6234.33	6234.97	6235.11	6235.43	0.08819	5.45	7.18	17.29	1.49
B_Reach	24700	25-yr	67.8	6234.33	6235.14	6235.35	6235.81	0.096181	6.58	10.3	19.9	1.61
B_Reach	24700	50-yr	139.9	6234.33	6235.42	6235.77	6236.52	0.10601	8.42	16.62	23.86	1.78
B_Reach	24700	100-yr	213.2	6234.33	6235.64	6236.07	6237.08	0.110856	9.61	22.19	26.95	1.87
B_Reach	24700	500-yr	586.4	6234.33	6236.38	6237.26	6239.18	0.104386	13.42	43.71	30.45	1.97
B_Reach	24600	2-yr	5	6226.99	6227.35	6227.39	6227.48	0.098392	2.86	1.75	11.82	1.31
B_Reach	24600	5-yr	23.4	6226.99	6227.64	6227.68	6227.88	0.065575	3.99	5.87	17.72	1.22
B_Reach	24600	10-yr	39.1	6226.99	6227.79	6227.86	6228.09	0.061232	4.43	8.83	21.6	1.22
B_Reach	24600	25-yr	67.8	6226.99	6227.97	6228.05	6228.38	0.05805	5.12	13.24	25.02	1.24
B_Reach	24600	50-yr	139.9	6226.99	6228.28	6228.43	6228.96	0.055121	6.63	21.09	25.77	1.29
B_Reach	24600	100-yr	213.2	6226.99	6228.53	6228.75	6229.45	0.053739	7.69	27.71	26.45	1.32
B_Reach	24600	500-yr	586.4	6226.99	6229.41	6229.97	6231.39	0.057045	11.29	51.94	28.66	1.48
B_Reach	24500	2-yr	5	6218.43	6218.83	6218.87	6219.01	0.073518	3.41	1.46	6.07	1.23
B_Reach	24500	5-yr	23.4	6218.43	6219.13	6219.29	6219.65	0.105426	5.76	4.06	10.02	1.59
B_Reach	24500	10-yr	39.1	6218.43	6219.29	6219.52	6220.03	0.109382	6.93	5.64	10.82	1.69
B_Reach	24500	25-yr	67.8	6218.43	6219.51	6219.85	6220.57	0.108558	8.24	8.23	12.06	1.76
B_Reach	24500	50-yr	139.9	6218.43	6219.94	6220.44	6221.47	0.104593	9.92	14.1	15.2	1.81
B_Reach	24500	100-yr	213.2	6218.43	6220.27	6220.88	6222.13	0.102309	10.96	19.45	17.76	1.85

B_Reach	24500	500-yr	586.4	6218.43	6221.31	6222.19	6224.21	0.090437	13.66	42.93	25.43	1.85
B_Reach	24400.13	2-yr	5	6212.79	6213.14	6213.14	6213.25	0.049637	2.59	1.93	9.18	0.99
B_Reach	24400.13	5-yr	23.4	6212.79	6213.51	6213.51	6213.75	0.039099	3.91	5.99	12.74	1
B_Reach	24400.13	10-yr	39.1	6212.79	6213.72	6213.72	6214.03	0.036733	4.45	8.78	14.63	1.01
B_Reach	24400.13	25-yr	67.8	6212.79	6214.01	6214.04	6214.39	0.037778	4.92	13.79	20.26	1.05
B_Reach	24400.13	50-yr	139.9	6212.79	6214.43	6214.51	6214.95	0.041325	5.76	24.28	30.02	1.13
B_Reach	24400.13	100-yr	213.2	6212.79	6214.7	6214.81	6215.34	0.044206	6.4	33.32	37.01	1.19
B_Reach	24400.13	500-yr	586.4	6212.79	6215.38	6215.79	6216.88	0.054655	9.83	59.65	40.6	1.43
B_Reach	24300	2-yr	5	6206.76	6207.11	6207.14	6207.27	0.073051	3.23	1.55	7.02	1.21
B_Reach	24300	5-yr	23.4	6206.76	6207.42	6207.57	6207.91	0.095127	5.61	4.17	10.08	1.54
B_Reach	24300	10-yr	39.1	6206.76	6207.57	6207.79	6208.27	0.100577	6.68	5.85	11.31	1.64
B_Reach	24300	25-yr	67.8	6206.76	6207.82	6208.09	6208.74	0.090996	7.7	8.81	12.7	1.63
B_Reach	24300	50-yr	139.9	6206.76	6208.32	6208.69	6209.57	0.070297	8.98	15.58	14.44	1.52
B_Reach	24300	100-yr	213.2	6206.76	6208.75	6209.18	6210.19	0.058559	9.62	22.17	15.97	1.44
B_Reach	24300	500-yr	586.4	6206.76	6210.12	6210.51	6211.67	0.049565	10	58.67	35.3	1.37
B_Reach	24177.79	2-yr	5	6200.75	6201.09	6201.09	6201.2	0.049305	2.64	1.9	8.71	1
B_Reach	24177.79	5-yr	23.4	6200.75	6201.47	6201.47	6201.68	0.040511	3.72	6.28	14.71	1
B_Reach	24177.79	10-yr	39.1	6200.75	6201.66	6201.66	6201.93	0.038469	4.14	9.45	18.15	1.01
B_Reach	24177.79	25-yr	67.8	6200.75	6201.92	6201.92	6202.25	0.036119	4.64	14.62	22.48	1.01
B_Reach	24177.79	50-yr	139.9	6200.75	6202.28	6202.35	6202.81	0.042087	5.84	23.95	29.19	1.14
B_Reach	24177.79	100-yr	213.2	6200.75	6202.49	6202.67	6203.24	0.052039	6.98	30.54	33.38	1.29
B_Reach	24177.79	500-yr	586.4	6200.75	6203.21	6203.65	6204.78	0.064832	10.05	58.33	43.2	1.52
B_Reach	24098.35	2-yr	5	6195.59	6195.94	6195.98	6196.12	0.086131	3.4	1.47	7.02	1.31
B_Reach	24098.35	5-yr	23.4	6195.59	6196.24	6196.39	6196.73	0.106148	5.66	4.13	10.71	1.61
B_Reach	24098.35	10-yr	39.1	6195.59	6196.39	6196.61	6197.08	0.109905	6.68	5.85	12.11	1.69
B_Reach	24098.35	25-yr	67.8	6195.59	6196.61	6196.93	6197.53	0.111938	7.68	8.83	14.89	1.76
B_Reach	24098.35	50-yr	139.9	6195.59	6197.05	6197.37	6197.98	0.093124	7.73	18.1	26.3	1.64
B_Reach	24098.35	100-yr	213.2	6195.59	6197.38	6197.67	6198.25	0.076846	7.52	28.34	37.17	1.52
B_Reach	24098.35	500-yr	586.4	6195.59	6198.09	6198.48	6199.4	0.068398	9.18	63.88	56.82	1.53
B_Reach	24000	2-yr	5	6190.88	6191.26	6191.26	6191.33	0.055991	2.21	2.27	15.07	1
B_Reach	24000	5-yr	23.4	6190.88	6191.5	6191.5	6191.67	0.045875	3.24	7.23	23.28	1.02
B_Reach	24000	10-yr	39.1	6190.88	6191.63	6191.63	6191.85	0.042365	3.75	10.42	25.31	1.03
B_Reach	24000	25-yr	67.8	6190.88	6191.83	6191.83	6192.12	0.037432	4.35	15.58	27.58	1.02
B_Reach	24000	50-yr	139.9	6190.88	6192.2	6192.21	6192.63	0.034091	5.27	26.55	32.78	1.03
B_Reach	24000	100-yr	213.2	6190.88	6192.44	6192.51	6193.01	0.037938	6.06	35.19	38.02	1.11
B_Reach	24000	500-yr	586.4	6190.88	6193.23	6193.48	6194.41	0.03862	8.7	67.37	42.46	1.22
B_Reach	23900	2-yr	5	6185.51	6185.78	6185.78	6185.86	0.052576	2.26	2.22	13.57	0.98
B_Reach	23900	5-yr	23.4	6185.51	6186.01	6186.05	6186.2	0.066303	3.43	6.83	26.5	1.19
B_Reach	23900	10-yr	39.1	6185.51	6186.11	6186.16	6186.37	0.073697	4.1	9.53	30.5	1.29
B_Reach	23900	25-yr	67.8	6185.51	6186.21	6186.33	6186.65	0.08905	5.28	12.83	32.36	1.48
B_Reach	23900	50-yr	139.9	6185.51	6186.42	6186.69	6187.19	0.098527	7.03	19.91	35.27	1.65
B_Reach	23900	100-yr	213.2	6185.51	6186.67	6186.98	6187.48	0.086937	7.21	29.59	45.94	1.58
B_Reach	23900	500-yr	586.4	6185.51	6187.16	6187.56	6188.5	0.100725	9.58	67.82	111.55	1.8
B_Reach	23800	2-yr	5	6179.98	6180.25	6180.26	6180.36	0.057461	2.69	1.86	9.36	1.06
B_Reach	23800	5-yr	23.4	6179.98	6180.63	6180.64	6180.82	0.044513	3.41	6.85	19.85	1.02
B_Reach	23800	10-yr	39.1	6179.98	6180.76	6180.8	6181.01	0.052023	4	9.79	25.13	1.13
B_Reach	23800	25-yr	67.8	6179.98	6181	6181	6181.26	0.038598	4.1	16.52	32.5	1.01
B_Reach	23800	50-yr	139.9	6179.98	6181.25	6181.34	6181.71	0.049533	5.46	25.61	39.47	1.19
B_Reach	23800	100-yr	213.2	6179.98	6181.57	6181.61	6182.01	0.036269	5.33	40.02	50.6	1.06
B_Reach	23800	500-yr	586.4	6179.98	6182.31	6182.35	6182.98	0.032792	6.61	88.67	75.21	1.07
B_Reach	23700	2-yr	5	6173.6	6174.08	6174.11	6174.24	0.065372	3.17	1.58	6.76	1.16
B_Reach	23700	5-yr	23.4	6173.6	6174.39	6174.5	6174.76	0.086715	5	5.21	24.41	1.44
B_Reach	23700	10-yr	39.1	6173.6	6174.52	6174.65	6174.87	0.073213	5.16	9.05	32.74	1.36
B_Reach	23700	25-yr	67.8	6173.6	6174.61	6174.78	6175.15	0.10923	6.52	12.27	37.55	1.68
B_Reach	23700	50-yr	139.9	6173.6	6174.89	6175.01	6175.32	0.085371	5.55	26.64	66.39	1.47
B_Reach	23700	100-yr	213.2	6173.6	6174.95	6175.2	6175.71	0.133624	7.46	30.61	70.13	1.87
B_Reach	23700	500-yr	586.4	6173.6	6175.31	6175.73	6176.82	0.149195	10.79	60.47	92.61	2.14
B_Reach	23600	2-yr	5	6167.85	6168.22	6168.22	6168.34	0.05344	2.88	1.74	7.41	1.05
B_Reach	23600	5-yr	23.4	6167.85	6168.63	6168.64	6168.88	0.042039	3.96	5.91	12.98	1.03

B_Reach	23600	10-yr	39.1	6167.85	6168.81	6168.84	6169.14	0.046011	4.65	8.4	15.51	1.11
B_Reach	23600	25-yr	67.8	6167.85	6169.09	6169.12	6169.5	0.037653	5.12	13.23	18.18	1.06
B_Reach	23600	50-yr	139.9	6167.85	6169.61	6169.63	6170.08	0.035442	5.5	25.42	30.11	1.06
B_Reach	23600	100-yr	213.2	6167.85	6169.93	6169.93	6170.48	0.030206	5.97	35.71	33.19	1.01
B_Reach	23600	500-yr	586.4	6167.85	6171.03	6171.03	6171.91	0.025141	7.51	78.05	44.69	1
B_Reach	23500.27	2-yr	5	6163.15	6163.4	6163.4	6163.49	0.050964	2.4	2.09	11.42	0.99
B_Reach	23500.27	5-yr	23.4	6163.15	6163.66	6163.72	6163.95	0.058889	4.31	5.42	13.59	1.2
B_Reach	23500.27	10-yr	39.1	6163.15	6163.83	6163.91	6164.22	0.052987	4.98	7.84	14.54	1.2
B_Reach	23500.27	25-yr	67.8	6163.15	6164.02	6164.19	6164.65	0.064505	6.41	10.58	15.54	1.37
B_Reach	23500.27	50-yr	139.9	6163.15	6164.43	6164.71	6165.43	0.062201	8.02	17.44	17.63	1.42
B_Reach	23500.27	100-yr	213.2	6163.15	6164.72	6165.12	6166.08	0.067232	9.35	22.8	19.33	1.52
B_Reach	23500.27	500-yr	586.4	6163.15	6165.76	6166.37	6167.58	0.08602	10.86	54.52	48.82	1.74
B_Reach	23400	2-yr	5	6157.23	6157.63	6157.65	6157.78	0.063794	3.13	1.6	6.72	1.13
B_Reach	23400	5-yr	23.4	6157.23	6158.06	6158.12	6158.39	0.05244	4.59	5.1	10.35	1.15
B_Reach	23400	10-yr	39.1	6157.23	6158.25	6158.34	6158.7	0.057095	5.38	7.26	12.42	1.24
B_Reach	23400	25-yr	67.8	6157.23	6158.63	6158.73	6159.07	0.047587	5.34	12.71	19.38	1.16
B_Reach	23400	50-yr	139.9	6157.23	6158.99	6159.11	6159.62	0.052172	6.35	22.04	27.83	1.26
B_Reach	23400	100-yr	213.2	6157.23	6159.24	6159.42	6160.08	0.050986	7.36	28.96	28.65	1.29
B_Reach	23400	500-yr	586.4	6157.23	6160.44	6160.67	6161.53	0.041942	8.38	69.96	49.33	1.24
B_Reach	23300	2-yr	5	6152.94	6153.25	6153.23	6153.33	0.044125	2.3	2.17	11.28	0.92
B_Reach	23300	5-yr	23.4	6152.94	6153.56	6153.56	6153.8	0.040166	3.92	5.97	12.88	1.02
B_Reach	23300	10-yr	39.1	6152.94	6153.75	6153.76	6154.08	0.037771	4.61	8.49	13.68	1.03
B_Reach	23300	25-yr	67.8	6152.94	6153.97	6154.05	6154.49	0.043829	5.8	11.68	14.81	1.15
B_Reach	23300	50-yr	139.9	6152.94	6154.71	6154.74	6155.13	0.038002	5.22	26.82	36.03	1.07
B_Reach	23300	100-yr	213.2	6152.94	6154.95	6155.01	6155.48	0.039931	5.82	36.6	43.24	1.12
B_Reach	23300	500-yr	586.4	6152.94	6155.56	6155.89	6156.88	0.051283	9.21	63.67	45.36	1.37
B_Reach	23200	2-yr	5	6148.07	6148.37	6148.37	6148.46	0.053849	2.48	2.01	10.82	1.02
B_Reach	23200	5-yr	23.4	6148.07	6148.64	6148.71	6148.96	0.059026	4.54	5.15	11.88	1.21
B_Reach	23200	10-yr	39.1	6148.07	6148.8	6148.91	6149.28	0.062645	5.55	7.05	12.52	1.3
B_Reach	23200	25-yr	67.8	6148.07	6149.08	6149.21	6149.7	0.052262	6.32	10.73	13.58	1.25
B_Reach	23200	50-yr	139.9	6148.07	6149.53	6149.79	6150.55	0.054666	8.11	17.25	15.37	1.35
B_Reach	23200	100-yr	213.2	6148.07	6149.98	6150.25	6151.15	0.04552	8.67	24.6	17.15	1.28
B_Reach	23200	500-yr	586.4	6148.07	6151.69	6152.23	6153.05	0.02965	9.37	64.46	42.59	1.11
B_Reach	23100	2-yr	6.5	6141.7	6142.09	6142.13	6142.28	0.069084	3.48	1.87	7.28	1.21
B_Reach	23100	5-yr	29.7	6141.7	6142.49	6142.58	6142.91	0.061488	5.21	5.7	11	1.28
B_Reach	23100	10-yr	49.5	6141.7	6142.7	6142.84	6143.28	0.057632	6.12	8.09	11.58	1.29
B_Reach	23100	25-yr	85.2	6141.7	6142.96	6143.21	6143.86	0.063318	7.62	11.19	12.21	1.4
B_Reach	23100	50-yr	175.1	6141.7	6143.55	6143.91	6144.9	0.057258	9.33	18.76	13.65	1.4
B_Reach	23100	100-yr	266	6141.7	6143.96	6144.48	6145.78	0.060413	10.85	24.52	14.58	1.47
B_Reach	23100	500-yr	726.3	6141.7	6145.56	6146.73	6148.68	0.058199	14.19	51.27	19.8	1.54
B_Reach	23000	2-yr	6.5	6134.43	6134.76	6134.8	6134.94	0.07824	3.39	1.92	8.58	1.26
B_Reach	23000	5-yr	29.7	6134.43	6135.08	6135.27	6135.59	0.088462	5.72	5.19	11.54	1.5
B_Reach	23000	10-yr	49.5	6134.43	6135.29	6135.48	6135.89	0.09824	6.19	7.99	17.07	1.59
B_Reach	23000	25-yr	85.2	6134.43	6135.52	6135.77	6136.23	0.092109	6.76	12.6	22.38	1.59
B_Reach	23000	50-yr	175.1	6134.43	6135.86	6136.16	6136.87	0.117127	8.08	21.68	35.29	1.82
B_Reach	23000	100-yr	266	6134.43	6136.07	6136.4	6137.22	0.12324	8.62	30.87	47.4	1.88
B_Reach	23000	500-yr	726.3	6134.43	6136.52	6137.35	6139.5	0.163923	13.85	52.45	48.7	2.35
B_Reach	22900.06	2-yr	6.5	6129.07	6129.43	6129.43	6129.55	0.050065	2.76	2.35	10.26	1.02
B_Reach	22900.06	5-yr	29.7	6129.07	6129.82	6129.82	6130.06	0.039658	3.91	7.59	16.47	1.02
B_Reach	22900.06	10-yr	49.5	6129.07	6130.03	6130.03	6130.32	0.036216	4.35	11.39	19.7	1.01
B_Reach	22900.06	25-yr	85.2	6129.07	6130.29	6130.3	6130.68	0.036223	5.01	17	23.73	1.04
B_Reach	22900.06	50-yr	175.1	6129.07	6130.76	6130.78	6131.31	0.031228	5.95	29.41	28.28	1.03
B_Reach	22900.06	100-yr	266	6129.07	6131.12	6131.14	6131.8	0.029213	6.61	40.25	31.41	1.03
B_Reach	22900.06	500-yr	726.3	6129.07	6132.32	6132.41	6133.48	0.027056	8.64	84.02	41.12	1.07
B_Reach	22800	2-yr	6.5	6123.5	6123.85	6123.87	6123.99	0.062116	2.94	2.21	10.29	1.12
B_Reach	22800	5-yr	29.7	6123.5	6124.14	6124.25	6124.56	0.08055	5.18	5.74	13.85	1.42
B_Reach	22800	10-yr	49.5	6123.5	6124.29	6124.47	6124.9	0.088217	6.3	7.86	15.12	1.54
B_Reach	22800	25-yr	85.2	6123.5	6124.52	6124.77	6125.35	0.083674	7.31	11.66	17.17	1.56
B_Reach	22800	50-yr	175.1	6123.5	6124.9	6125.31	6126.25	0.091444	9.33	18.78	20.44	1.71
B_Reach	22800	100-yr	266	6123.5	6125.19	6125.72	6126.93	0.090849	10.58	25.14	22.46	1.76

B_Reach	22800	500-yr	726.3	6123.5	6126.35	6127.23	6129.21	0.069225	13.58	53.5	26.2	1.67
B_Reach	22700	2-yr	6.5	6117.9	6118.46	6118.46	6118.6	0.047144	2.97	2.19	8.06	1.01
B_Reach	22700	5-yr	29.7	6117.9	6118.92	6118.93	6119.22	0.037507	4.35	6.83	11.84	1.01
B_Reach	22700	10-yr	49.5	6117.9	6119.18	6119.18	6119.55	0.035134	4.89	10.11	13.95	1.01
B_Reach	22700	25-yr	85.2	6117.9	6119.48	6119.51	6120.01	0.036006	5.84	14.59	15.61	1.07
B_Reach	22700	50-yr	175.1	6117.9	6120.06	6120.14	6120.87	0.03367	7.23	24.22	17.67	1.09
B_Reach	22700	100-yr	266	6117.9	6120.51	6120.64	6121.55	0.033391	8.16	32.59	19.56	1.11
B_Reach	22700	500-yr	726.3	6117.9	6121.9	6122.37	6123.98	0.037792	11.57	62.77	23.95	1.26
B_Reach	22600	2-yr	6.5	6111.48	6111.79	6111.84	6111.97	0.099748	3.41	1.9	10.12	1.39
B_Reach	22600	5-yr	29.7	6111.48	6112.03	6112.23	6112.7	0.137691	6.54	4.54	11.49	1.83
B_Reach	22600	10-yr	49.5	6111.48	6112.18	6112.48	6113.16	0.145783	7.98	6.2	12.11	1.96
B_Reach	22600	25-yr	85.2	6111.48	6112.42	6112.82	6113.73	0.130693	9.21	9.26	13.35	1.95
B_Reach	22600	50-yr	175.1	6111.48	6112.84	6113.47	6114.86	0.128659	11.41	15.34	15.73	2.04
B_Reach	22600	100-yr	266	6111.48	6113.18	6114.06	6115.65	0.121844	12.63	21.06	17.76	2.04
B_Reach	22600	500-yr	726.3	6111.48	6114.36	6115.36	6117.72	0.116294	14.71	49.36	31.96	2.09
B_Reach	22500	2-yr	6.5	6106.02	6106.39	6106.39	6106.5	0.048385	2.66	2.44	11	0.99
B_Reach	22500	5-yr	29.7	6106.02	6106.73	6106.73	6106.93	0.040533	3.6	8.25	20.61	1
B_Reach	22500	10-yr	49.5	6106.02	6106.89	6106.9	6107.17	0.038522	4.2	11.79	22.48	1.02
B_Reach	22500	25-yr	85.2	6106.02	6107.13	6107.14	6107.5	0.035478	4.88	17.47	24.97	1.03
B_Reach	22500	50-yr	175.1	6106.02	6107.53	6107.61	6108.13	0.037292	6.19	28.3	29.34	1.11
B_Reach	22500	100-yr	266	6106.02	6107.82	6107.95	6108.61	0.040774	7.14	37.26	33.29	1.19
B_Reach	22500	500-yr	726.3	6106.02	6108.74	6109.17	6110.35	0.044942	10.19	71.26	40.12	1.35
B_Reach	22400	2-yr	6.5	6100.71	6101.12	6101.14	6101.28	0.056173	3.25	2	7.42	1.1
B_Reach	22400	5-yr	29.7	6100.71	6101.51	6101.62	6101.96	0.061692	5.38	5.52	10.23	1.29
B_Reach	22400	10-yr	49.5	6100.71	6101.73	6101.89	6102.34	0.062679	6.29	7.87	11.62	1.35
B_Reach	22400	25-yr	85.2	6100.71	6102.03	6102.26	6102.85	0.062038	7.29	11.69	13.67	1.39
B_Reach	22400	50-yr	175.1	6100.71	6102.6	6102.94	6103.69	0.052245	8.42	21.6	23.96	1.35
B_Reach	22400	100-yr	266	6100.71	6102.99	6103.39	6104.21	0.046586	9.11	31.77	32.89	1.31
B_Reach	22400	500-yr	726.3	6100.71	6103.83	6104.34	6105.55	0.051293	11.91	80.94	78.78	1.44
B_Reach	22300	2-yr	6.5	6095.25	6095.63	6095.64	6095.76	0.05405	2.93	2.22	9.34	1.06
B_Reach	22300	5-yr	29.7	6095.25	6096	6096.05	6096.33	0.050939	4.63	6.42	12.99	1.16
B_Reach	22300	10-yr	49.5	6095.25	6096.2	6096.29	6096.65	0.051122	5.42	9.13	14.58	1.21
B_Reach	22300	25-yr	85.2	6095.25	6096.46	6096.61	6097.11	0.052479	6.48	13.14	16.32	1.27
B_Reach	22300	50-yr	175.1	6095.25	6096.87	6097.18	6098.02	0.061553	8.62	20.32	18.4	1.45
B_Reach	22300	100-yr	266	6095.25	6097.19	6097.65	6098.75	0.063999	10.02	26.55	19.62	1.52
B_Reach	22300	500-yr	726.3	6095.25	6098.68	6099.39	6100.72	0.044928	11.56	66.88	56.86	1.37
B_Reach	22200	2-yr	6.5	6089.27	6089.58	6089.61	6089.74	0.067345	3.24	2.01	8.54	1.18
B_Reach	22200	5-yr	29.7	6089.27	6089.93	6090.05	6090.41	0.069214	5.56	5.34	10.17	1.35
B_Reach	22200	10-yr	49.5	6089.27	6090.15	6090.32	6090.8	0.067032	6.51	7.61	11.09	1.38
B_Reach	22200	25-yr	85.2	6089.27	6090.45	6090.69	6091.36	0.062664	7.63	11.16	12	1.39
B_Reach	22200	50-yr	175.1	6089.27	6091.09	6091.42	6092.37	0.051783	9.07	19.3	13.5	1.34
B_Reach	22200	100-yr	266	6089.27	6091.58	6091.98	6093.18	0.048782	10.13	26.25	14.6	1.33
B_Reach	22200	500-yr	726.3	6089.27	6093.29	6094.59	6096.03	0.047575	13.28	54.69	19.26	1.39
B_Reach	22100	2-yr	6.5	6083.42	6083.9	6083.91	6084.06	0.048605	3.28	1.98	6.44	1.04
B_Reach	22100	5-yr	29.7	6083.42	6084.39	6084.44	6084.77	0.046437	4.91	6.05	10.25	1.13
B_Reach	22100	10-yr	49.5	6083.42	6084.61	6084.71	6085.15	0.04786	5.86	8.44	11.12	1.19
B_Reach	22100	25-yr	85.2	6083.42	6084.91	6085.08	6085.71	0.050659	7.14	11.92	12.05	1.27
B_Reach	22100	50-yr	175.1	6083.42	6085.43	6085.82	6086.82	0.059628	9.46	18.5	13.65	1.43
B_Reach	22100	100-yr	266	6083.42	6085.84	6086.39	6087.68	0.062024	10.86	24.49	14.99	1.5
B_Reach	22100	500-yr	726.3	6083.42	6087.32	6088.3	6090.55	0.062611	14.41	50.39	19.87	1.59
B_Reach	22000	2-yr	6.5	6076.15	6076.52	6076.59	6076.77	0.121375	4.03	1.61	7.71	1.55
B_Reach	22000	5-yr	29.7	6076.15	6076.83	6077.05	6077.52	0.127232	6.63	4.48	10.38	1.78
B_Reach	22000	10-yr	49.5	6076.15	6077.02	6077.3	6077.91	0.120282	7.59	6.53	11.83	1.8
B_Reach	22000	25-yr	85.2	6076.15	6077.28	6077.66	6078.43	0.111515	8.63	9.87	13.87	1.8
B_Reach	22000	50-yr	175.1	6076.15	6077.78	6078.23	6079.23	0.099839	9.64	18.15	19.89	1.78
B_Reach	22000	100-yr	266	6076.15	6078.09	6078.65	6079.87	0.10075	10.72	24.82	23.37	1.83
B_Reach	22000	500-yr	726.3	6076.15	6079	6080.07	6082.44	0.108478	14.9	48.75	29.49	2.04
B_Reach	21900	2-yr	6.5	6070.3	6070.66	6070.66	6070.74	0.054624	2.36	2.76	16.29	1.01
B_Reach	21900	5-yr	29.7	6070.3	6070.95	6070.95	6071.16	0.040245	3.66	8.12	19.59	1

B_Reach	21900	10-yr	49.5	6070.3	6071.11	6071.12	6071.4	0.038958	4.35	11.38	20.62	1.03
B_Reach	21900	25-yr	85.2	6070.3	6071.32	6071.38	6071.77	0.041994	5.39	15.79	21.88	1.12
B_Reach	21900	50-yr	175.1	6070.3	6071.7	6071.86	6072.48	0.046258	7.07	24.76	24.47	1.24
B_Reach	21900	100-yr	266	6070.3	6072.06	6072.3	6073.01	0.046624	7.83	33.97	28.89	1.27
B_Reach	21900	500-yr	726.3	6070.3	6073.02	6073.49	6074.81	0.050406	10.74	67.63	37.67	1.41
B_Reach	21800	2-yr	6.5	6063	6063.44	6063.53	6063.74	0.092673	4.34	1.5	5.15	1.42
B_Reach	21800	5-yr	29.7	6063	6063.85	6064.11	6064.68	0.117892	7.3	4.07	7.55	1.75
B_Reach	21800	10-yr	49.5	6063	6064.09	6064.41	6065.15	0.112519	8.29	5.97	8.73	1.77
B_Reach	21800	25-yr	85.2	6063	6064.44	6064.83	6065.72	0.091429	9.07	9.39	10.11	1.66
B_Reach	21800	50-yr	175.1	6063	6065.13	6065.62	6066.79	0.069387	10.32	16.97	11.91	1.52
B_Reach	21800	100-yr	266	6063	6065.67	6066.23	6067.61	0.061041	11.16	23.84	13.28	1.47
B_Reach	21800	500-yr	726.3	6063	6067.85	6068.48	6070.29	0.039813	12.52	58.03	18.97	1.26
B_Reach	21701.8	2-yr	6.5	6051	6051.57	6051.73	6052.06	0.157217	5.62	1.16	3.94	1.83
B_Reach	21701.8	5-yr	29.7	6051	6052.06	6052.3	6052.79	0.123905	6.85	4.34	9.31	1.77
B_Reach	21701.8	10-yr	49.5	6051	6052.25	6052.54	6053.19	0.131673	7.75	6.38	11.95	1.87
B_Reach	21701.8	25-yr	85.2	6051	6052.44	6052.87	6053.9	0.164916	9.73	8.76	13.81	2.15
B_Reach	21701.8	50-yr	175.1	6051	6052.72	6053.52	6055.57	0.215871	13.53	12.94	15.11	2.58
B_Reach	21701.8	100-yr	266	6051	6052.96	6053.96	6056.9	0.234774	15.91	16.72	16.24	2.76
B_Reach	21701.8	500-yr	726.3	6051	6053.78	6055.56	6061.49	0.281799	22.28	32.59	21.8	3.21
B_Reach	21600	2-yr	6.5	6040.3	6040.73	6040.8	6040.94	0.079264	3.67	1.77	7.09	1.29
B_Reach	21600	5-yr	29.7	6040.3	6041.04	6041.16	6041.44	0.098958	5.07	5.86	16.9	1.52
B_Reach	21600	10-yr	49.5	6040.3	6041.18	6041.35	6041.73	0.095641	5.9	8.39	18.68	1.55
B_Reach	21600	25-yr	85.2	6040.3	6041.41	6041.6	6042.08	0.083284	6.53	13.05	22.45	1.51
B_Reach	21600	50-yr	175.1	6040.3	6041.79	6042.05	6042.73	0.076719	7.77	22.53	27.9	1.52
B_Reach	21600	100-yr	266	6040.3	6042.03	6042.39	6043.28	0.078227	8.95	29.71	30.14	1.59
B_Reach	21600	500-yr	726.3	6040.3	6042.83	6043.66	6045.56	0.085178	13.26	54.77	32.42	1.8
B_Reach	21500	2-yr	6.5	6030.47	6030.91	6030.99	6031.17	0.123138	4.05	1.61	7.63	1.55
B_Reach	21500	5-yr	29.7	6030.47	6031.27	6031.43	6031.81	0.093524	5.92	5.02	10.94	1.54
B_Reach	21500	10-yr	49.5	6030.47	6031.45	6031.67	6032.2	0.094608	6.96	7.11	12.23	1.61
B_Reach	21500	25-yr	85.2	6030.47	6031.68	6032.06	6032.78	0.103376	8.43	10.11	13.91	1.74
B_Reach	21500	50-yr	175.1	6030.47	6032.13	6032.58	6033.63	0.10812	9.82	17.83	20.02	1.83
B_Reach	21500	100-yr	266	6030.47	6032.43	6033.01	6034.36	0.101012	11.14	23.87	20.89	1.84
B_Reach	21500	500-yr	726.3	6030.47	6033.55	6034.6	6036.93	0.086389	14.75	49.24	24.51	1.83
B_Reach	21400	2-yr	6.5	6023.21	6023.66	6023.68	6023.82	0.056473	3.16	2.06	7.95	1.09
B_Reach	21400	5-yr	29.7	6023.21	6024.06	6024.13	6024.43	0.058996	4.86	6.11	12.69	1.23
B_Reach	21400	10-yr	49.5	6023.21	6024.25	6024.36	6024.76	0.059123	5.74	8.62	13.93	1.29
B_Reach	21400	25-yr	85.2	6023.21	6024.52	6024.68	6025.24	0.055923	6.8	12.53	14.95	1.31
B_Reach	21400	50-yr	175.1	6023.21	6025.02	6025.31	6026.16	0.053393	8.54	20.5	16.52	1.35
B_Reach	21400	100-yr	266	6023.21	6025.4	6025.83	6026.91	0.055487	9.87	26.95	17.84	1.42
B_Reach	21400	500-yr	726.3	6023.21	6026.68	6027.58	6029.58	0.060994	13.67	53.13	22.81	1.58
B_Reach	21300	2-yr	6.5	6015.99	6016.4	6016.47	6016.63	0.094283	3.84	1.69	7.15	1.39
B_Reach	21300	5-yr	29.7	6015.99	6016.77	6016.92	6017.28	0.088018	5.71	5.2	11.5	1.5
B_Reach	21300	10-yr	49.5	6015.99	6016.96	6017.15	6017.61	0.087614	6.49	7.63	13.81	1.54
B_Reach	21300	25-yr	85.2	6015.99	6017.18	6017.47	6018.14	0.092325	7.86	10.84	15.24	1.64
B_Reach	21300	50-yr	175.1	6015.99	6017.59	6018.06	6019.14	0.095212	9.98	17.55	17.47	1.75
B_Reach	21300	100-yr	266	6015.99	6017.93	6018.5	6019.84	0.091904	11.1	23.97	19.63	1.77
B_Reach	21300	500-yr	726.3	6015.99	6019.11	6020.16	6022.55	0.080488	14.89	48.76	22.49	1.78
B_Reach	21200	2-yr	6.5	6009.86	6010.2	6010.2	6010.3	0.053135	2.53	2.57	13.36	1.02
B_Reach	21200	5-yr	29.7	6009.86	6010.51	6010.54	6010.77	0.04908	4.06	7.31	17.41	1.11
B_Reach	21200	10-yr	49.5	6009.86	6010.68	6010.73	6011.03	0.050112	4.75	10.42	19.85	1.16
B_Reach	21200	25-yr	85.2	6009.86	6010.91	6011	6011.39	0.049733	5.57	15.31	22.78	1.2
B_Reach	21200	50-yr	175.1	6009.86	6011.3	6011.47	6012.06	0.051445	7	25.03	26.86	1.28
B_Reach	21200	100-yr	266	6009.86	6011.6	6011.88	6012.57	0.055016	7.87	33.78	31.83	1.35
B_Reach	21200	500-yr	726.3	6009.86	6012.35	6012.98	6014.46	0.073779	11.65	62.35	40.59	1.66
B_Reach	21100	2-yr	6.5	6002.4	6003.46	6003.47	6003.56	0.073583	2.46	2.64	17.55	1.12
B_Reach	21100	5-yr	29.7	6002.4	6003.66	6003.74	6003.97	0.100164	4.46	6.66	23.02	1.46
B_Reach	21100	10-yr	49.5	6002.4	6003.77	6003.89	6004.21	0.097811	5.31	9.32	24.39	1.51
B_Reach	21100	25-yr	85.2	6002.4	6003.93	6004.1	6004.55	0.099523	6.35	13.41	27.16	1.59
B_Reach	21100	50-yr	175.1	6002.4	6004.22	6004.51	6005.26	0.093195	8.18	21.39	28.09	1.65
B_Reach	21100	100-yr	266	6002.4	6004.47	6004.86	6005.8	0.084066	9.26	28.71	28.85	1.64

B_Reach	21100	500-yr	726.3	6002.4	6005.52	6006.15	6007.74	0.061177	11.98	60.63	32.19	1.54
B_Reach	21000	2-yr	6.5	5993.14	5993.59	5993.65	5993.81	0.108427	3.79	1.71	8.12	1.46
B_Reach	21000	5-yr	29.7	5993.14	5993.94	5994.09	5994.47	0.089781	5.85	5.08	10.86	1.51
B_Reach	21000	10-yr	49.5	5993.14	5994.13	5994.34	5994.87	0.088676	6.9	7.17	11.79	1.56
B_Reach	21000	25-yr	85.2	5993.14	5994.4	5994.73	5995.41	0.08345	8.09	10.53	12.98	1.58
B_Reach	21000	50-yr	175.1	5993.14	5994.89	5995.34	5996.4	0.083432	9.85	17.78	16.22	1.66
B_Reach	21000	100-yr	266	5993.14	5995.22	5995.84	5997.25	0.085763	11.43	23.28	17.19	1.73
B_Reach	21000	500-yr	726.3	5993.14	5996.42	5997.62	6000.28	0.088855	15.77	46.06	21.09	1.88
B_Reach	20900	2-yr	6.5	5981.53	5981.96	5982.04	5982.18	0.124979	3.79	1.72	9.18	1.55
B_Reach	20900	5-yr	29.7	5981.53	5982.23	5982.38	5982.71	0.160066	5.54	5.36	19.55	1.86
B_Reach	20900	10-yr	49.5	5981.53	5982.34	5982.54	5983	0.166001	6.49	7.62	22.5	1.97
B_Reach	20900	25-yr	85.2	5981.53	5982.47	5982.76	5983.45	0.18487	7.94	10.73	25.36	2.15
B_Reach	20900	50-yr	175.1	5981.53	5982.72	5983.16	5984.25	0.192786	9.94	17.62	30.58	2.31
B_Reach	20900	100-yr	266	5981.53	5982.9	5983.44	5984.86	0.193412	11.22	23.7	34.31	2.38
B_Reach	20900	500-yr	726.3	5981.53	5983.48	5984.45	5987.19	0.209569	15.47	46.96	44.43	2.65
B_Reach	20800	2-yr	6.5	5973.15	5973.71	5973.73	5973.84	0.059364	2.91	2.23	10.07	1.09
B_Reach	20800	5-yr	29.7	5973.15	5974.04	5974.06	5974.26	0.051484	3.69	8.05	23.04	1.1
B_Reach	20800	10-yr	49.5	5973.15	5974.18	5974.24	5974.47	0.050747	4.3	11.51	25.88	1.14
B_Reach	20800	25-yr	85.2	5973.15	5974.38	5974.44	5974.78	0.048573	5.04	16.91	28.91	1.16
B_Reach	20800	50-yr	175.1	5973.15	5974.73	5974.84	5975.32	0.048884	6.16	28.43	36.07	1.22
B_Reach	20800	100-yr	266	5973.15	5974.96	5975.14	5975.77	0.049668	7.19	37.02	37.67	1.28
B_Reach	20800	500-yr	726.3	5973.15	5975.81	5976.26	5977.43	0.050959	10.21	71.14	43.4	1.41
B_Reach	20700	2-yr	6.5	5966.34	5967.16	5967.2	5967.32	0.071768	3.27	1.99	8.49	1.19
B_Reach	20700	5-yr	29.7	5966.34	5967.49	5967.62	5967.9	0.079949	5.14	5.77	13.73	1.4
B_Reach	20700	10-yr	49.5	5966.34	5967.66	5967.81	5968.2	0.078973	5.87	8.44	16.34	1.44
B_Reach	20700	25-yr	85.2	5966.34	5967.88	5968.09	5968.64	0.078764	6.99	12.19	18.09	1.5
B_Reach	20700	50-yr	175.1	5966.34	5968.31	5968.64	5969.47	0.070098	8.64	20.27	19.9	1.51
B_Reach	20700	100-yr	266	5966.34	5968.66	5969.07	5970.11	0.063451	9.65	27.55	21.09	1.49
B_Reach	20700	500-yr	726.3	5966.34	5970.02	5970.66	5972.37	0.04876	12.3	59.06	25.14	1.41
B_Reach	20601.18	2-yr	6.5	5956.73	5957.17	5957.25	5957.45	0.183181	4.27	1.52	9.03	1.83
B_Reach	20601.18	5-yr	29.7	5956.73	5957.47	5957.67	5958.15	0.124397	6.59	4.51	10.29	1.75
B_Reach	20601.18	10-yr	49.5	5956.73	5957.64	5957.93	5958.6	0.121044	7.84	6.31	10.78	1.81
B_Reach	20601.18	25-yr	85.2	5956.73	5957.9	5958.31	5959.25	0.115375	9.33	9.13	11.46	1.84
B_Reach	20601.18	50-yr	175.1	5956.73	5958.36	5959.03	5960.57	0.116523	11.94	14.67	12.54	1.94
B_Reach	20601.18	100-yr	266	5956.73	5958.72	5959.62	5961.64	0.117485	13.69	19.42	13.4	2
B_Reach	20601.18	500-yr	726.3	5956.73	5960.11	5961.58	5965.12	0.11148	17.96	40.44	17.26	2.07
B_Reach	20500	2-yr	6.5	5948.01	5948.39	5948.39	5948.51	0.051442	2.87	2.27	9.53	1.04
B_Reach	20500	5-yr	29.7	5948.01	5948.77	5948.82	5949.03	0.066692	4.1	7.24	21.61	1.25
B_Reach	20500	10-yr	49.5	5948.01	5948.89	5948.98	5949.27	0.070072	4.96	9.98	23.22	1.33
B_Reach	20500	25-yr	85.2	5948.01	5949.05	5949.21	5949.63	0.076077	6.11	13.93	25.16	1.45
B_Reach	20500	50-yr	175.1	5948.01	5949.36	5949.65	5950.33	0.082702	7.94	22.06	28.59	1.59
B_Reach	20500	100-yr	266	5948.01	5949.58	5949.98	5950.92	0.088095	9.32	28.54	30.45	1.7
B_Reach	20500	500-yr	726.3	5948.01	5950.27	5951.2	5953.4	0.109267	14.18	51.22	33.96	2.03
B_Reach	20400	2-yr	6.5	5938.07	5938.61	5938.75	5939.05	0.226434	5.33	1.22	5.95	2.08
B_Reach	20400	5-yr	29.7	5938.07	5938.99	5939.22	5939.64	0.140331	6.47	4.59	11.82	1.83
B_Reach	20400	10-yr	49.5	5938.07	5939.2	5939.4	5939.86	0.132076	6.5	7.62	18.73	1.8
B_Reach	20400	25-yr	85.2	5938.07	5939.39	5939.66	5940.26	0.117535	7.47	11.4	20.82	1.78
B_Reach	20400	50-yr	175.1	5938.07	5939.74	5940.13	5941.04	0.10448	9.13	19.17	23.58	1.79
B_Reach	20400	100-yr	266	5938.07	5940.02	5940.5	5941.65	0.097199	10.24	25.97	25.36	1.78
B_Reach	20400	500-yr	726.3	5938.07	5941.02	5941.9	5943.93	0.081818	13.7	53.03	29.04	1.79
B_Reach	20300	2-yr	6.5	5928.24	5928.61	5928.62	5928.74	0.057878	2.99	2.17	9.32	1.09
B_Reach	20300	5-yr	29.7	5928.24	5928.91	5929.03	5929.34	0.078022	5.26	5.64	12.94	1.4
B_Reach	20300	10-yr	49.5	5928.24	5929.08	5929.26	5929.68	0.080485	6.22	7.95	14.51	1.48
B_Reach	20300	25-yr	85.2	5928.24	5929.29	5929.57	5930.2	0.086958	7.62	11.18	15.87	1.6
B_Reach	20300	50-yr	175.1	5928.24	5929.69	5930.13	5931.18	0.092873	9.79	17.89	18.23	1.74
B_Reach	20300	100-yr	266	5928.24	5929.99	5930.58	5931.96	0.095834	11.27	23.6	19.82	1.82
B_Reach	20300	500-yr	726.3	5928.24	5931.03	5932.23	5934.96	0.096504	15.89	45.71	22.4	1.96
B_Reach	20200	2-yr	6.5	5919.54	5919.87	5919.97	5920.18	0.138878	4.47	1.45	6.56	1.67
B_Reach	20200	5-yr	29.7	5919.54	5920.29	5920.47	5920.88	0.091855	6.16	4.82	9.78	1.55

B_Reach	20200	10-yr	49.5	5919.54	5920.5	5920.74	5921.27	0.087854	7.03	7.04	11.27	1.57
B_Reach	20200	25-yr	85.2	5919.54	5920.81	5921.09	5921.76	0.081827	7.84	10.86	14.01	1.57
B_Reach	20200	50-yr	175.1	5919.54	5921.29	5921.71	5922.7	0.077234	9.55	18.33	16.71	1.61
B_Reach	20200	100-yr	266	5919.54	5921.65	5922.21	5923.45	0.075264	10.77	24.69	18.34	1.64
B_Reach	20200	500-yr	726.3	5919.54	5922.84	5923.9	5926.17	0.07741	14.62	49.67	23.5	1.77
B_Reach	20100	2-yr	6.5	5910.38	5910.9	5910.94	5911.11	0.06358	3.63	1.79	5.9	1.16
B_Reach	20100	5-yr	29.7	5910.38	5911.3	5911.49	5911.95	0.08663	6.45	4.6	8.01	1.5
B_Reach	20100	10-yr	49.5	5910.38	5911.53	5911.8	5912.42	0.088849	7.58	6.53	9.07	1.57
B_Reach	20100	25-yr	85.2	5910.38	5911.83	5912.22	5913.09	0.091474	8.99	9.48	10.36	1.66
B_Reach	20100	50-yr	175.1	5910.38	5912.39	5912.99	5914.27	0.091259	11.02	15.89	12.68	1.74
B_Reach	20100	100-yr	266	5910.38	5912.81	5913.56	5915.16	0.090496	12.28	21.66	14.55	1.77
B_Reach	20100	500-yr	726.3	5910.38	5914.22	5915.44	5917.97	0.086013	15.53	46.76	21.17	1.84
B_Reach	20000	2-yr	6.5	5900.49	5900.79	5900.89	5901.14	0.211579	4.76	1.36	7.71	2
B_Reach	20000	5-yr	29.7	5900.49	5901.13	5901.3	5901.72	0.12231	6.17	4.82	12.21	1.73
B_Reach	20000	10-yr	49.5	5900.49	5901.28	5901.53	5902.12	0.120222	7.34	6.75	12.96	1.79
B_Reach	20000	25-yr	85.2	5900.49	5901.5	5901.88	5902.7	0.118574	8.78	9.7	14.02	1.86
B_Reach	20000	50-yr	175.1	5900.49	5901.91	5902.48	5903.79	0.121505	11.02	15.89	16.53	1.98
B_Reach	20000	100-yr	266	5900.49	5902.21	5902.96	5904.72	0.121259	12.74	20.88	17.26	2.04
B_Reach	20000	500-yr	726.3	5900.49	5903.32	5904.73	5907.98	0.115092	17.33	41.91	20.42	2.13
B_Reach	19900	2-yr	6.5	5891.36	5891.96	5891.97	5892.14	0.049093	3.38	1.92	5.93	1.05
B_Reach	19900	5-yr	29.7	5891.36	5892.39	5892.51	5892.9	0.066249	5.74	5.17	8.9	1.33
B_Reach	19900	10-yr	49.5	5891.36	5892.62	5892.81	5893.34	0.066596	6.78	7.3	9.73	1.38
B_Reach	19900	25-yr	85.2	5891.36	5892.94	5893.22	5893.94	0.066627	8.02	10.63	10.91	1.43
B_Reach	19900	50-yr	175.1	5891.36	5893.55	5894	5895.03	0.064596	9.76	17.94	13.19	1.47
B_Reach	19900	100-yr	266	5891.36	5894.01	5894.56	5895.85	0.065162	10.9	24.41	15.23	1.52
B_Reach	19900	500-yr	726.3	5891.36	5895.41	5896.68	5898.8	0.069472	14.78	49.14	19.97	1.66
B_Reach	19800	2-yr	6.5	5881.93	5882.23	5882.38	5882.74	0.244439	5.77	1.13	5.27	2.2
B_Reach	19800	5-yr	29.7	5881.93	5882.65	5882.9	5883.46	0.143843	7.23	4.11	9.17	1.9
B_Reach	19800	10-yr	49.5	5881.93	5882.83	5883.18	5883.95	0.140546	8.46	5.85	10.06	1.96
B_Reach	19800	25-yr	85.2	5881.93	5883.09	5883.55	5884.61	0.138073	9.88	8.62	11.47	2.01
B_Reach	19800	50-yr	175.1	5881.93	5883.54	5884.26	5885.92	0.13478	12.38	14.14	12.91	2.08
B_Reach	19800	100-yr	266	5881.93	5883.92	5884.82	5886.9	0.126707	13.85	19.21	13.94	2.08
B_Reach	19800	500-yr	726.3	5881.93	5885.31	5886.79	5890.1	0.108141	17.56	41.36	17.98	2.04
B_Reach	19700	2-yr	6.5	5875.11	5875.57	5875.57	5875.69	0.047594	2.82	2.3	9.17	0.99
B_Reach	19700	5-yr	29.7	5875.11	5875.98	5876.01	5876.32	0.041354	4.64	6.41	10.74	1.06
B_Reach	19700	10-yr	49.5	5875.11	5876.21	5876.27	5876.69	0.042451	5.53	8.96	11.69	1.11
B_Reach	19700	25-yr	85.2	5875.11	5876.53	5876.64	5877.21	0.043632	6.64	12.83	12.88	1.17
B_Reach	19700	50-yr	175.1	5875.11	5877.09	5877.34	5878.21	0.046069	8.49	20.63	14.72	1.26
B_Reach	19700	100-yr	266	5875.11	5877.5	5877.88	5879.02	0.048951	9.87	26.94	15.85	1.33
B_Reach	19700	500-yr	726.3	5875.11	5878.92	5880.22	5881.98	0.056366	14.04	51.74	19.16	1.51
B_Reach	19600	2-yr	6.5	5867.64	5868.17	5868.29	5868.5	0.120375	4.56	1.43	5.42	1.57
B_Reach	19600	5-yr	29.7	5867.64	5868.46	5868.63	5869.04	0.159085	6.12	4.85	14.9	1.89
B_Reach	19600	10-yr	49.5	5867.64	5868.58	5868.82	5869.41	0.150579	7.27	6.81	15.48	1.93
B_Reach	19600	25-yr	85.2	5867.64	5868.77	5869.12	5869.94	0.141482	8.67	9.83	16.33	1.97
B_Reach	19600	50-yr	175.1	5867.64	5869.15	5869.69	5870.95	0.127718	10.76	16.28	18.01	1.99
B_Reach	19600	100-yr	266	5867.64	5869.46	5870.2	5871.7	0.117861	12	22.17	19.54	1.99
B_Reach	19600	500-yr	726.3	5867.64	5870.49	5871.58	5874.3	0.108012	15.87	47.8	31.12	2.04
B_Reach	19500.97	2-yr	6.5	5857.92	5858.42	5858.47	5858.62	0.083206	3.58	1.81	7.76	1.31
B_Reach	19500.97	5-yr	29.7	5857.92	5858.79	5858.86	5859.12	0.067975	4.61	6.44	16.21	1.29
B_Reach	19500.97	10-yr	49.5	5857.92	5858.93	5859.05	5859.42	0.070982	5.63	8.8	16.89	1.37
B_Reach	19500.97	25-yr	85.2	5857.92	5859.13	5859.34	5859.88	0.074866	6.94	12.27	17.84	1.47
B_Reach	19500.97	50-yr	175.1	5857.92	5859.5	5859.91	5860.8	0.081727	9.15	19.14	19.5	1.63
B_Reach	19500.97	100-yr	266	5857.92	5859.78	5860.34	5861.54	0.087545	10.65	24.98	21.3	1.73
B_Reach	19500.97	500-yr	726.3	5857.92	5860.76	5861.79	5864.17	0.094961	14.82	49	26.67	1.93
B_Reach	19397.08	2-yr	6.5	5849.55	5849.95	5849.97	5850.05	0.081265	2.49	2.61	19.08	1.19
B_Reach	19397.08	5-yr	29.7	5849.55	5850.14	5850.23	5850.49	0.103812	4.77	6.23	20.66	1.53
B_Reach	19397.08	10-yr	49.5	5849.55	5850.25	5850.39	5850.76	0.099154	5.71	8.67	21.1	1.57
B_Reach	19397.08	25-yr	85.2	5849.55	5850.42	5850.64	5851.16	0.094505	6.9	12.35	21.76	1.61
B_Reach	19397.08	50-yr	175.1	5849.55	5850.77	5851.11	5851.92	0.088358	8.61	20.35	24.32	1.66
B_Reach	19397.08	100-yr	266	5849.55	5851.04	5851.49	5852.54	0.08424	9.8	27.13	25.63	1.68

B_Reach	19397.08	500-yr	726.3	5849.55	5851.99	5852.88	5854.87	0.081542	13.62	53.31	29.6	1.79
B_Reach	19300	2-yr	6.5	5842.93	5843.19	5843.19	5843.28	0.062212	2.29	2.84	19.34	1.05
B_Reach	19300	5-yr	29.7	5842.93	5843.44	5843.46	5843.65	0.050484	3.63	8.18	23.85	1.09
B_Reach	19300	10-yr	49.5	5842.93	5843.57	5843.62	5843.86	0.052643	4.34	11.4	26.21	1.16
B_Reach	19300	25-yr	85.2	5842.93	5843.76	5843.84	5844.15	0.055496	5.01	17.02	32.87	1.23
B_Reach	19300	50-yr	175.1	5842.93	5844.04	5844.21	5844.7	0.061092	6.52	26.84	37.45	1.36
B_Reach	19300	100-yr	266	5842.93	5844.24	5844.49	5845.15	0.065968	7.65	34.76	40.41	1.45
B_Reach	19300	500-yr	726.3	5842.93	5844.93	5845.5	5846.85	0.077838	11.14	65.18	48.7	1.7
B_Reach	19200	2-yr	6.5	5834.87	5835.25	5835.31	5835.46	0.100798	3.74	1.74	8.13	1.42
B_Reach	19200	5-yr	29.7	5834.87	5835.55	5835.73	5836.11	0.122898	5.97	4.98	13.36	1.72
B_Reach	19200	10-yr	49.5	5834.87	5835.73	5835.92	5836.35	0.114586	6.35	7.8	18.1	1.7
B_Reach	19200	25-yr	85.2	5834.87	5835.94	5836.18	5836.72	0.103367	7.11	11.98	21.71	1.69
B_Reach	19200	50-yr	175.1	5834.87	5836.32	5836.64	5837.4	0.087411	8.37	20.93	26.17	1.65
B_Reach	19200	100-yr	266	5834.87	5836.6	5836.99	5837.94	0.078182	9.28	28.65	28.08	1.62
B_Reach	19200	500-yr	726.3	5834.87	5837.63	5838.39	5839.96	0.060765	12.25	59.3	31.14	1.56
B_Reach	19100	2-yr	6.5	5828.49	5828.84	5828.84	5828.96	0.049653	2.69	2.42	10.88	1
B_Reach	19100	5-yr	29.7	5828.49	5829.21	5829.22	5829.5	0.040371	4.32	6.88	12.86	1.04
B_Reach	19100	10-yr	49.5	5828.49	5829.41	5829.45	5829.83	0.041405	5.19	9.54	13.7	1.1
B_Reach	19100	25-yr	85.2	5828.49	5829.69	5829.79	5830.31	0.043078	6.28	13.57	14.97	1.16
B_Reach	19100	50-yr	175.1	5828.49	5830.2	5830.43	5831.22	0.045771	8.12	21.57	16.72	1.26
B_Reach	19100	100-yr	266	5828.49	5830.59	5830.93	5831.95	0.047244	9.36	28.43	18.09	1.32
B_Reach	19100	500-yr	726.3	5828.49	5831.98	5832.72	5834.52	0.048681	12.8	56.74	22.52	1.42
B_Reach	19000	2-yr	6.5	5822.6	5823.01	5823.03	5823.16	0.068552	3.11	2.09	9.61	1.18
B_Reach	19000	5-yr	29.7	5822.6	5823.34	5823.43	5823.69	0.091023	4.74	6.27	18.95	1.45
B_Reach	19000	10-yr	49.5	5822.6	5823.47	5823.6	5823.94	0.08992	5.53	8.95	21.28	1.5
B_Reach	19000	25-yr	85.2	5822.6	5823.64	5823.84	5824.33	0.08836	6.63	12.84	22.9	1.56
B_Reach	19000	50-yr	175.1	5822.6	5823.97	5824.3	5825.09	0.08604	8.51	20.57	24.63	1.64
B_Reach	19000	100-yr	266	5822.6	5824.22	5824.67	5825.73	0.085378	9.84	27.04	25.81	1.69
B_Reach	19000	500-yr	726.3	5822.6	5825.14	5826.07	5828.17	0.084719	13.97	52	28.62	1.83
B_Reach	18900	2-yr	6.5	5816.92	5817.38	5817.38	5817.53	0.047024	3.13	2.08	7.12	1.02
B_Reach	18900	5-yr	29.7	5816.92	5817.89	5817.89	5818.23	0.037998	4.68	6.35	9.9	1.03
B_Reach	18900	10-yr	49.5	5816.92	5818.23	5818.23	5818.56	0.03773	4.59	10.78	17.24	1.02
B_Reach	18900	25-yr	85.2	5816.92	5818.55	5818.55	5818.85	0.040365	4.39	19.43	35.33	1.04
B_Reach	18900	50-yr	175.1	5816.92	5818.87	5818.92	5819.37	0.03865	5.69	30.75	36.34	1.09
B_Reach	18900	100-yr	266	5816.92	5819.1	5819.2	5819.81	0.040498	6.77	39.28	36.88	1.16
B_Reach	18900	500-yr	726.3	5816.92	5819.92	5820.34	5821.57	0.047081	10.3	70.54	38.91	1.35
B_Reach	18800	2-yr	6.5	5810.85	5811.13	5811.18	5811.29	0.086468	3.21	2.03	10.62	1.29
B_Reach	18800	5-yr	29.7	5810.85	5811.38	5811.55	5811.94	0.122166	6.03	4.92	12.91	1.72
B_Reach	18800	10-yr	49.5	5810.85	5811.53	5811.77	5812.31	0.120329	7.1	6.97	14.12	1.78
B_Reach	18800	25-yr	85.2	5810.85	5811.78	5812.08	5812.75	0.099582	7.91	10.77	16.06	1.7
B_Reach	18800	50-yr	175.1	5810.85	5812.23	5812.66	5813.57	0.093059	9.28	18.86	20.97	1.72
B_Reach	18800	100-yr	266	5810.85	5812.58	5813.12	5814.1	0.083306	9.9	26.88	24.98	1.68
B_Reach	18800	500-yr	726.3	5810.85	5813.66	5814.32	5815.86	0.069318	11.9	61.04	37.26	1.64
B_Reach	18700	2-yr	6.5	5804.43	5804.72	5804.72	5804.79	0.057881	2.09	3.11	23	1
B_Reach	18700	5-yr	29.7	5804.43	5804.95	5804.97	5805.14	0.04222	3.43	8.66	23.86	1
B_Reach	18700	10-yr	49.5	5804.43	5805.08	5805.1	5805.36	0.043722	4.21	11.77	24.44	1.07
B_Reach	18700	25-yr	85.2	5804.43	5805.25	5805.33	5805.69	0.050752	5.37	15.87	25.52	1.2
B_Reach	18700	50-yr	175.1	5804.43	5805.59	5805.79	5806.36	0.055138	7.04	24.88	28.21	1.32
B_Reach	18700	100-yr	266	5804.43	5805.84	5806.14	5806.88	0.060906	8.16	32.61	31.81	1.42
B_Reach	18700	500-yr	726.3	5804.43	5806.71	5807.27	5808.64	0.073489	11.15	65.17	45.29	1.64
B_Reach	18600	2-yr	6.5	5798.75	5799.32	5799.32	5799.47	0.048913	3.18	2.04	6.93	1.03
B_Reach	18600	5-yr	29.7	5798.75	5799.75	5799.86	5800.15	0.059446	5.06	5.87	11.45	1.25
B_Reach	18600	10-yr	49.5	5798.75	5799.99	5800.08	5800.45	0.055193	5.43	9.12	15.22	1.24
B_Reach	18600	25-yr	85.2	5798.75	5800.31	5800.39	5800.82	0.046703	5.71	14.91	20.31	1.18
B_Reach	18600	50-yr	175.1	5798.75	5800.77	5800.9	5801.56	0.042174	7.13	24.57	22.08	1.19
B_Reach	18600	100-yr	266	5798.75	5801.17	5801.34	5802.14	0.03759	7.92	33.6	23.46	1.17
B_Reach	18600	500-yr	726.3	5798.75	5802.61	5802.79	5804.09	0.029414	9.77	74.34	31.01	1.11
B_Reach	18500	2-yr	6.5	5792.25	5792.69	5792.74	5792.86	0.094598	3.3	1.97	10.57	1.35
B_Reach	18500	5-yr	29.7	5792.25	5793	5793.11	5793.43	0.076494	5.3	5.61	12.48	1.39

B_Reach	18500	10-yr	49.5	5792.25	5793.16	5793.34	5793.81	0.080782	6.47	7.65	13.05	1.49
B_Reach	18500	25-yr	85.2	5792.25	5793.37	5793.68	5794.4	0.091958	8.15	10.45	13.82	1.65
B_Reach	18500	50-yr	175.1	5792.25	5793.81	5794.32	5795.47	0.092179	10.33	16.95	15.59	1.75
B_Reach	18500	100-yr	266	5792.25	5794.14	5794.82	5796.33	0.095828	11.88	22.39	17.11	1.83
B_Reach	18500	500-yr	726.3	5792.25	5795.4	5796.59	5799.17	0.086606	15.58	46.62	21.41	1.86
B_Reach	18400	2-yr	6.5	5783.78	5784.27	5784.32	5784.5	0.07429	3.83	1.7	5.96	1.27
B_Reach	18400	5-yr	29.7	5783.78	5784.69	5784.85	5785.23	0.087949	5.89	5.05	10.48	1.5
B_Reach	18400	10-yr	49.5	5783.78	5784.9	5785.09	5785.58	0.083638	6.61	7.48	12.53	1.51
B_Reach	18400	25-yr	85.2	5783.78	5785.18	5785.44	5786.1	0.074554	7.73	11.02	13.24	1.49
B_Reach	18400	50-yr	175.1	5783.78	5785.66	5786.11	5787.17	0.074326	9.87	17.75	14.5	1.57
B_Reach	18400	100-yr	266	5783.78	5786.06	5786.65	5788	0.071862	11.17	23.8	15.54	1.59
B_Reach	18400	500-yr	726.3	5783.78	5787.57	5788.42	5790.28	0.084789	13.23	54.91	31.75	1.77
B_Reach	18300	2-yr	6.5	5774.94	5775.27	5775.36	5775.55	0.131654	4.27	1.52	7.08	1.62
B_Reach	18300	5-yr	29.7	5774.94	5775.64	5775.81	5776.22	0.091964	6.11	4.86	9.87	1.54
B_Reach	18300	10-yr	49.5	5774.94	5775.82	5776.08	5776.67	0.094756	7.39	6.7	10.36	1.62
B_Reach	18300	25-yr	85.2	5774.94	5776.07	5776.46	5777.37	0.102791	9.14	9.32	11.02	1.75
B_Reach	18300	50-yr	175.1	5774.94	5776.59	5777.24	5778.6	0.098494	11.4	15.36	12.35	1.8
B_Reach	18300	100-yr	266	5774.94	5777	5778.04	5779.53	0.100003	12.77	20.83	14.24	1.86
B_Reach	18300	500-yr	726.3	5774.94	5778.44	5779.29	5781.28	0.095462	13.51	53.74	33.54	1.88
B_Reach	18200	2-yr	6.5	5766.96	5767.41	5767.42	5767.54	0.053398	2.92	2.23	9.36	1.05
B_Reach	18200	5-yr	29.7	5766.96	5767.71	5767.81	5768.1	0.071444	5	5.94	13.76	1.34
B_Reach	18200	10-yr	49.5	5766.96	5767.88	5768.02	5768.44	0.070896	5.99	8.27	14.42	1.39
B_Reach	18200	25-yr	85.2	5766.96	5768.13	5768.33	5768.9	0.068543	7.06	12.07	15.94	1.43
B_Reach	18200	50-yr	175.1	5766.96	5768.54	5768.93	5769.88	0.074411	9.31	18.81	17.23	1.57
B_Reach	18200	100-yr	266	5766.96	5768.87	5769.41	5770.66	0.075372	10.75	24.75	18.3	1.63
B_Reach	18200	500-yr	726.3	5766.96	5770.17	5771.14	5773.28	0.067591	14.16	51.29	22.58	1.66
B_Reach	18100	2-yr	6.5	5757.17	5757.43	5757.54	5757.8	0.314699	4.89	1.33	9.74	2.33
B_Reach	18100	5-yr	29.7	5757.17	5757.73	5757.93	5758.38	0.138885	6.47	4.59	11.84	1.83
B_Reach	18100	10-yr	49.5	5757.17	5757.88	5758.15	5758.81	0.13681	7.74	6.39	12.4	1.9
B_Reach	18100	25-yr	85.2	5757.17	5758.09	5758.5	5759.45	0.136568	9.36	9.1	13.16	1.98
B_Reach	18100	50-yr	175.1	5757.17	5758.54	5759.15	5760.53	0.119244	11.31	15.48	15.02	1.96
B_Reach	18100	100-yr	266	5757.17	5758.89	5759.65	5761.39	0.115012	12.69	20.97	16.57	1.99
B_Reach	18100	500-yr	726.3	5757.17	5760.05	5761.42	5764.59	0.111724	17.1	42.48	20.56	2.1
B_Reach	18000	2-yr	6.5	5748.35	5749.15	5749.15	5749.33	0.045723	3.38	1.92	5.48	1
B_Reach	18000	5-yr	29.7	5748.35	5749.69	5749.72	5749.91	0.055651	3.76	7.9	23.15	1.13
B_Reach	18000	10-yr	49.5	5748.35	5749.81	5749.87	5750.14	0.057688	4.56	10.87	24.48	1.21
B_Reach	18000	25-yr	85.2	5748.35	5749.99	5750.1	5750.46	0.060373	5.49	15.51	27.31	1.29
B_Reach	18000	50-yr	175.1	5748.35	5750.27	5750.5	5751.13	0.071294	7.44	23.53	29.75	1.47
B_Reach	18000	100-yr	266	5748.35	5750.49	5750.84	5751.7	0.076813	8.84	30.08	30.99	1.58
B_Reach	18000	500-yr	726.3	5748.35	5751.24	5752.1	5753.95	0.091495	13.22	54.95	35.15	1.86
B_Reach	17900	2-yr	6.5	5741.26	5741.63	5741.69	5741.81	0.146357	3.4	1.91	13.57	1.6
B_Reach	17900	5-yr	29.7	5741.26	5741.84	5741.92	5742.13	0.115813	4.35	6.82	28.1	1.56
B_Reach	17900	10-yr	49.5	5741.26	5741.94	5742.05	5742.33	0.111179	5	9.89	32.06	1.59
B_Reach	17900	25-yr	85.2	5741.26	5742.08	5742.24	5742.6	0.106114	5.83	14.61	36.34	1.62
B_Reach	17900	50-yr	175.1	5741.26	5742.34	5742.56	5743.09	0.090436	6.96	25.15	42.41	1.59
B_Reach	17900	100-yr	266	5741.26	5742.54	5742.83	5743.49	0.086222	7.82	34.03	46.46	1.61
B_Reach	17900	500-yr	726.3	5741.26	5743.19	5743.73	5744.98	0.082889	10.71	67.79	55.66	1.71
B_Reach	17800	2-yr	6.5	5734.34	5734.79	5734.79	5734.9	0.052265	2.64	2.47	11.85	1.02
B_Reach	17800	5-yr	29.7	5734.34	5735.14	5735.14	5735.29	0.044714	3.14	9.46	31.11	1
B_Reach	17800	10-yr	49.5	5734.34	5735.26	5735.28	5735.47	0.045888	3.71	13.35	34.81	1.06
B_Reach	17800	25-yr	85.2	5734.34	5735.41	5735.44	5735.72	0.0475	4.44	19.17	39.07	1.12
B_Reach	17800	50-yr	175.1	5734.34	5735.67	5735.78	5736.2	0.053296	5.87	29.84	43.58	1.25
B_Reach	17800	100-yr	266	5734.34	5735.87	5736.03	5736.6	0.055347	6.87	38.72	45.84	1.32
B_Reach	17800	500-yr	726.3	5734.34	5736.57	5737.01	5738.15	0.056342	10.07	72.14	48.48	1.45
B_Reach	17700	2-yr	6.5	5727.2	5727.56	5727.61	5727.76	0.102947	3.53	1.84	9.48	1.41
B_Reach	17700	5-yr	29.7	5727.2	5727.84	5728.02	5728.4	0.117645	6.01	4.94	12.67	1.7
B_Reach	17700	10-yr	49.5	5727.2	5728.02	5728.24	5728.74	0.106082	6.82	7.26	14.24	1.68
B_Reach	17700	25-yr	85.2	5727.2	5728.27	5728.55	5729.16	0.094235	7.55	11.28	17.35	1.65
B_Reach	17700	50-yr	175.1	5727.2	5728.73	5729.08	5729.89	0.074385	8.62	20.31	21.34	1.56
B_Reach	17700	100-yr	266	5727.2	5729.08	5729.51	5730.46	0.067016	9.4	28.3	24.11	1.53

B_Reach	17700	500-yr	726.3	5727.2	5730.3	5730.81	5732.04	0.065999	10.6	68.5	48.35	1.57
B_Reach	17600	2-yr	6.5	5721.99	5722.4	5722.4	5722.54	0.050149	2.9	2.24	9.06	1.03
B_Reach	17600	5-yr	29.7	5721.99	5722.85	5722.85	5723.06	0.040035	3.68	8.06	19.22	1
B_Reach	17600	10-yr	49.5	5721.99	5723.05	5723.05	5723.29	0.04119	3.93	12.59	27.84	1.03
B_Reach	17600	25-yr	85.2	5721.99	5723.28	5723.28	5723.56	0.038687	4.23	20.15	38.11	1.02
B_Reach	17600	50-yr	175.1	5721.99	5723.54	5723.61	5724.06	0.044217	5.78	30.28	39.48	1.16
B_Reach	17600	100-yr	266	5721.99	5723.73	5723.89	5724.5	0.050193	7.03	37.85	40.45	1.28
B_Reach	17600	500-yr	726.3	5721.99	5724.51	5724.94	5726.14	0.052413	10.25	70.87	44.11	1.42
B_Reach	17500	2-yr	6.5	5717.11	5717.45	5717.45	5717.52	0.065043	2.19	2.97	22.35	1.06
B_Reach	17500	5-yr	29.7	5717.11	5717.64	5717.69	5717.82	0.071329	3.43	8.67	35.61	1.22
B_Reach	17500	10-yr	49.5	5717.11	5717.74	5717.79	5717.99	0.070654	4.04	12.24	38.87	1.27
B_Reach	17500	25-yr	85.2	5717.11	5717.86	5717.96	5718.24	0.077754	4.91	17.35	44.22	1.38
B_Reach	17500	50-yr	175.1	5717.11	5718.12	5718.24	5718.64	0.068262	5.79	30.22	54.42	1.37
B_Reach	17500	100-yr	266	5717.11	5718.31	5718.47	5718.97	0.06045	6.52	40.79	56.11	1.35
B_Reach	17500	500-yr	726.3	5717.11	5718.9	5719.29	5720.3	0.063655	9.47	76.71	62.56	1.51
B_Reach	17400	2-yr	6.5	5711.8	5712.21	5712.21	5712.31	0.049354	2.62	2.48	11.54	1
B_Reach	17400	5-yr	29.7	5711.8	5712.57	5712.57	5712.81	0.039076	3.96	7.51	15.78	1.01
B_Reach	17400	10-yr	49.5	5711.8	5712.76	5712.79	5713.09	0.039219	4.62	10.72	17.88	1.05
B_Reach	17400	25-yr	85.2	5711.8	5713.08	5713.08	5713.42	0.035959	4.7	18.14	27.64	1.02
B_Reach	17400	50-yr	175.1	5711.8	5713.48	5713.5	5714.01	0.033396	5.86	29.9	30.89	1.05
B_Reach	17400	100-yr	266	5711.8	5713.77	5713.85	5714.49	0.034473	6.79	39.18	33.16	1.1
B_Reach	17400	500-yr	726.3	5711.8	5714.95	5715.08	5716.14	0.02858	8.76	82.88	41.3	1.09
B_Reach	17300	2-yr	6.5	5707.25	5707.65	5707.63	5707.73	0.035724	2.29	2.84	12.7	0.85
B_Reach	17300	5-yr	29.7	5707.25	5707.92	5707.97	5708.22	0.054425	4.38	6.78	15.63	1.17
B_Reach	17300	10-yr	49.5	5707.25	5708.09	5708.18	5708.51	0.05407	5.19	9.54	16.95	1.22
B_Reach	17300	25-yr	85.2	5707.25	5708.32	5708.5	5708.93	0.056782	6.28	13.56	18.73	1.3
B_Reach	17300	50-yr	175.1	5707.25	5708.76	5709	5709.63	0.058985	7.49	23.39	26.09	1.38
B_Reach	17300	100-yr	266	5707.25	5709.06	5709.44	5710.14	0.055444	8.39	32.81	40.16	1.38
B_Reach	17300	500-yr	726.3	5707.25	5709.72	5710.32	5711.71	0.073749	12.03	69.44	64.79	1.68
B_Reach	17200	2-yr	6.5	5703.1	5703.5	5703.5	5703.56	0.04912	1.96	3.32	23.91	0.93
B_Reach	17200	5-yr	29.7	5703.1	5703.73	5703.73	5703.87	0.041922	2.95	10.07	34.79	0.97
B_Reach	17200	10-yr	49.5	5703.1	5703.84	5703.84	5704.04	0.042095	3.59	13.78	35.47	1.02
B_Reach	17200	25-yr	85.2	5703.1	5704.01	5704.01	5704.29	0.037166	4.25	20.05	36.5	1.01
B_Reach	17200	50-yr	175.1	5703.1	5704.31	5704.36	5704.8	0.038535	5.61	31.19	38.32	1.1
B_Reach	17200	100-yr	266	5703.1	5704.53	5704.64	5705.22	0.042045	6.69	39.75	40.02	1.18
B_Reach	17200	500-yr	726.3	5703.1	5705.52	5705.8	5706.62	0.034012	8.5	90.07	77.39	1.16
B_Reach	17100	2-yr	6.5	5697.7	5698.1	5698.1	5698.2	0.058659	2.58	2.52	13.69	1.06
B_Reach	17100	5-yr	29.7	5697.7	5698.36	5698.41	5698.63	0.066865	4.15	7.15	20.97	1.25
B_Reach	17100	10-yr	49.5	5697.7	5698.5	5698.58	5698.87	0.064539	4.92	10.06	22.27	1.29
B_Reach	17100	25-yr	85.2	5697.7	5698.66	5698.82	5699.25	0.071161	6.15	13.84	23.52	1.41
B_Reach	17100	50-yr	175.1	5697.7	5699.03	5699.26	5699.92	0.062442	7.57	23.14	26.04	1.41
B_Reach	17100	100-yr	266	5697.7	5699.36	5699.63	5700.45	0.053731	8.38	31.73	27.17	1.37
B_Reach	17100	500-yr	726.3	5697.7	5700.41	5701.18	5702.42	0.050337	11.48	66.19	49.8	1.43
B_Reach	17000	2-yr	6.5	5692.43	5692.95	5692.94	5693.06	0.044236	2.71	2.4	9.79	0.96
B_Reach	17000	5-yr	29.7	5692.43	5693.34	5693.34	5693.52	0.044911	3.45	8.61	24.7	1.03
B_Reach	17000	10-yr	49.5	5692.43	5693.48	5693.49	5693.73	0.044993	4.02	12.32	28.08	1.07
B_Reach	17000	25-yr	85.2	5692.43	5693.71	5693.72	5693.99	0.039231	4.23	20.16	38.48	1.03
B_Reach	17000	50-yr	175.1	5692.43	5693.97	5694.04	5694.46	0.046312	5.63	31.09	43.64	1.18
B_Reach	17000	100-yr	266	5692.43	5694.13	5694.31	5694.88	0.055659	6.96	38.21	44.77	1.33
B_Reach	17000	500-yr	726.3	5692.43	5694.77	5695.31	5696.52	0.068215	10.61	68.45	49.5	1.59
B_Reach	16900	2-yr	6.5	5687.66	5688.36	5688.36	5688.47	0.047453	2.66	2.44	10.67	0.98
B_Reach	16900	5-yr	29.7	5687.66	5688.68	5688.69	5688.87	0.048842	3.54	8.4	24.65	1.07
B_Reach	16900	10-yr	49.5	5687.66	5688.82	5688.85	5689.08	0.048026	4.11	12.03	27.77	1.1
B_Reach	16900	25-yr	85.2	5687.66	5688.99	5689.07	5689.36	0.055124	4.91	17.34	34	1.21
B_Reach	16900	50-yr	175.1	5687.66	5689.33	5689.4	5689.83	0.046463	5.65	30.98	43.32	1.18
B_Reach	16900	100-yr	266	5687.66	5689.6	5689.7	5690.2	0.039321	6.21	42.88	47.53	1.13
B_Reach	16900	500-yr	726.3	5687.66	5690.32	5690.59	5691.38	0.037396	8.52	92.52	76.48	1.2
B_Reach	16800	2-yr	6.5	5683.03	5683.34	5683.34	5683.42	0.053882	2.2	2.96	19.15	0.99
B_Reach	16800	5-yr	29.7	5683.03	5683.58	5683.59	5683.74	0.053931	3.19	9.32	34.55	1.08

B_Reach	16800	10-yr	49.5	5683.03	5683.68	5683.72	5683.91	0.055788	3.82	12.96	37.53	1.15
B_Reach	16800	25-yr	85.2	5683.03	5683.85	5683.88	5684.13	0.049323	4.29	19.87	44.1	1.13
B_Reach	16800	50-yr	175.1	5683.03	5684.06	5684.19	5684.61	0.058845	5.93	29.52	45.93	1.3
B_Reach	16800	100-yr	266	5683.03	5684.21	5684.44	5685.04	0.069754	7.3	36.45	47.2	1.46
B_Reach	16800	500-yr	726.3	5683.03	5685.02	5685.47	5686.33	0.070935	9.18	79.51	81.77	1.56
B_Reach	16700	2-yr	6.5	5677.13	5677.56	5677.58	5677.72	0.060224	3.27	1.99	7.66	1.13
B_Reach	16700	5-yr	29.7	5677.13	5678.04	5678.07	5678.25	0.055685	3.66	8.12	25.11	1.13
B_Reach	16700	10-yr	49.5	5677.13	5678.17	5678.21	5678.46	0.053208	4.32	11.45	26.58	1.16
B_Reach	16700	25-yr	85.2	5677.13	5678.33	5678.42	5678.78	0.057942	5.4	15.78	27.94	1.27
B_Reach	16700	50-yr	175.1	5677.13	5678.71	5678.84	5679.37	0.046864	6.49	27	30.85	1.22
B_Reach	16700	100-yr	266	5677.13	5679.07	5679.19	5679.8	0.040339	6.86	38.77	36.35	1.17
B_Reach	16700	500-yr	726.3	5677.13	5680.09	5680.57	5681.28	0.037281	8.76	82.97	52.15	1.21
B_Reach	16600	2-yr	6.5	5671.95	5672.33	5672.31	5672.4	0.032033	2.16	3.01	13.55	0.81
B_Reach	16600	5-yr	29.7	5671.95	5672.59	5672.63	5672.87	0.05199	4.22	7.03	16.59	1.14
B_Reach	16600	10-yr	49.5	5671.95	5672.79	5672.85	5673.1	0.053993	4.44	11.15	25.14	1.17
B_Reach	16600	25-yr	85.2	5671.95	5672.99	5673.06	5673.41	0.049833	5.21	16.36	27.32	1.19
B_Reach	16600	50-yr	175.1	5671.95	5673.3	5673.49	5674.02	0.061397	6.81	25.72	33.57	1.37
B_Reach	16600	100-yr	266	5671.95	5673.5	5673.78	5674.55	0.070047	8.22	32.35	35.04	1.51
B_Reach	16600	500-yr	726.3	5671.95	5674.34	5674.94	5676.4	0.06404	11.53	62.99	37.92	1.58
B_Reach	16501.18	2-yr	6.5	5667.95	5668.33	5668.33	5668.41	0.052494	2.37	2.74	15.51	1
B_Reach	16501.18	5-yr	29.7	5667.95	5668.62	5668.62	5668.8	0.041539	3.42	8.69	23.91	1
B_Reach	16501.18	10-yr	49.5	5667.95	5668.77	5668.77	5669.02	0.038171	4.02	12.33	24.93	1.01
B_Reach	16501.18	25-yr	85.2	5667.95	5668.99	5669	5669.34	0.034426	4.72	18.06	26.46	1.01
B_Reach	16501.18	50-yr	175.1	5667.95	5669.42	5669.48	5669.91	0.029295	5.67	32.43	41.06	0.99
B_Reach	16501.18	100-yr	266	5667.95	5669.71	5669.82	5670.27	0.027774	6.23	48.44	62.7	0.99
B_Reach	16501.18	500-yr	726.3	5667.95	5670.35	5670.6	5671.45	0.036248	9.09	90.58	67.17	1.2
B_Reach	16400	2-yr	6.5	5662.5	5662.96	5662.97	5663.09	0.052806	2.84	2.29	9.91	1.04
B_Reach	16400	5-yr	29.7	5662.5	5663.29	5663.38	5663.68	0.062385	5.04	5.89	12.14	1.27
B_Reach	16400	10-yr	49.5	5662.5	5663.47	5663.62	5664.04	0.065684	6.04	8.19	13.3	1.36
B_Reach	16400	25-yr	85.2	5662.5	5663.77	5664	5664.44	0.071953	6.55	13.01	20.15	1.44
B_Reach	16400	50-yr	175.1	5662.5	5664.13	5664.42	5665.1	0.087443	7.91	22.15	29.99	1.62
B_Reach	16400	100-yr	266	5662.5	5664.37	5664.79	5665.62	0.086282	8.99	29.59	32.71	1.67
B_Reach	16400	500-yr	726.3	5662.5	5665.3	5665.77	5666.86	0.056864	10.35	77.64	73.57	1.47
B_Reach	16300	2-yr	6.5	5657.83	5658.16	5658.14	5658.26	0.037897	2.52	2.58	10.46	0.89
B_Reach	16300	5-yr	29.7	5657.83	5658.55	5658.55	5658.76	0.041458	3.67	8.09	19.96	1.02
B_Reach	16300	10-yr	49.5	5657.83	5658.72	5658.73	5658.99	0.038799	4.17	11.88	23.03	1.02
B_Reach	16300	25-yr	85.2	5657.83	5658.96	5658.97	5659.32	0.037125	4.8	17.76	26.93	1.04
B_Reach	16300	50-yr	175.1	5657.83	5659.41	5659.43	5659.89	0.033112	5.56	31.52	35.13	1.03
B_Reach	16300	100-yr	266	5657.83	5659.73	5659.78	5660.29	0.033879	6.01	44.23	44.46	1.06
B_Reach	16300	500-yr	726.3	5657.83	5660.45	5660.75	5661.44	0.048591	8.13	94.43	98.3	1.31
B_Reach	16200	2-yr	6.5	5653.49	5653.96	5653.96	5654.09	0.046101	2.94	2.21	8.15	1
B_Reach	16200	5-yr	29.7	5653.49	5654.39	5654.41	5654.65	0.040518	4.14	7.18	14.44	1.03
B_Reach	16200	10-yr	49.5	5653.49	5654.69	5654.71	5654.9	0.042759	3.68	13.43	33.52	1.03
B_Reach	16200	25-yr	85.2	5653.49	5654.86	5654.88	5655.14	0.046873	4.23	20.16	43.84	1.1
B_Reach	16200	50-yr	175.1	5653.49	5655.08	5655.19	5655.6	0.057609	5.78	30.29	47.93	1.28
B_Reach	16200	100-yr	266	5653.49	5655.28	5655.44	5655.96	0.056919	6.62	40.16	51.25	1.32
B_Reach	16200	500-yr	726.3	5653.49	5656.12	5656.38	5657.13	0.038417	8.11	91.38	88.03	1.19
B_Reach	16100	2-yr	6.5	5648.9	5649.14	5649.13	5649.18	0.041552	1.95	3.92	32.43	0.87
B_Reach	16100	5-yr	29.7	5648.9	5649.35	5649.31	5649.45	0.029526	1.97	12	43.11	0.76
B_Reach	16100	10-yr	49.5	5648.9	5649.38	5649.43	5649.61	0.0672	3.01	12.98	44.54	1.16
B_Reach	16100	25-yr	85.2	5648.9	5649.51	5649.57	5649.82	0.060828	3.04	19.75	54.43	1.12
B_Reach	16100	50-yr	175.1	5648.9	5649.76	5649.86	5650.17	0.050704	3.43	36.09	75.05	1.08
B_Reach	16100	100-yr	266	5648.9	5649.91	5650.05	5650.45	0.052707	4.38	47.12	77.57	1.16
B_Reach	16100	500-yr	726.3	5648.9	5650.32	5650.72	5651.55	0.087715	7.91	82.63	97.72	1.63
B_Reach	16000	2-yr	6.5	5644.62	5645.14	5645.11	5645.26	0.036947	2.79	2.33	7.79	0.9
B_Reach	16000	5-yr	29.7	5644.62	5645.56	5645.56	5645.69	0.04905	2.98	9.95	37.83	1.02
B_Reach	16000	10-yr	49.5	5644.62	5645.67	5645.67	5645.84	0.048587	3.36	14.74	46.57	1.05
B_Reach	16000	25-yr	85.2	5644.62	5645.85	5645.85	5646.04	0.03341	3.57	25.12	76.27	0.93
B_Reach	16000	50-yr	175.1	5644.62	5646.09	5646.09	5646.34	0.029426	4.15	45.83	89.09	0.92
B_Reach	16000	100-yr	266	5644.62	5646.2	5646.26	5646.58	0.038727	5.14	55.82	92.86	1.07

B_Reach	16000	500-yr	726.3	5644.62	5646.81	5646.81	5647.38	0.029708	6.17	121.14	111.45	1.02
B_Reach	15900	2-yr	6.5	5640.54	5640.91	5640.91	5641.01	0.049466	2.59	2.51	11.94	1
B_Reach	15900	5-yr	29.7	5640.54	5641.3	5641.27	5641.45	0.036812	3.14	9.47	27.05	0.93
B_Reach	15900	10-yr	49.5	5640.54	5641.46	5641.43	5641.63	0.034708	3.29	15.03	38.12	0.92
B_Reach	15900	25-yr	85.2	5640.54	5641.56	5641.62	5641.88	0.056302	4.52	18.84	42.69	1.2
B_Reach	15900	50-yr	175.1	5640.54	5641.82	5641.92	5642.27	0.058995	5.38	32.55	59.5	1.28
B_Reach	15900	100-yr	266	5640.54	5642.06	5642.13	5642.56	0.041547	5.63	47.41	62.64	1.13
B_Reach	15900	500-yr	726.3	5640.54	5642.64	5642.97	5643.71	0.045065	8.42	92.63	100.33	1.29
B_Reach	15800	2-yr	6.5	5636.54	5637.15	5637.04	5637.22	0.022257	2.07	3.14	11.31	0.69
B_Reach	15800	5-yr	29.7	5636.54	5637.46	5637.44	5637.57	0.040736	2.67	11.13	44.43	0.93
B_Reach	15800	10-yr	49.5	5636.54	5637.55	5637.55	5637.71	0.044592	3.23	15.46	51.88	1.01
B_Reach	15800	25-yr	85.2	5636.54	5637.72	5637.69	5637.9	0.031985	3.49	25.47	66.73	0.91
B_Reach	15800	50-yr	175.1	5636.54	5637.94	5637.95	5638.24	0.031805	4.51	41.69	76.87	0.96
B_Reach	15800	100-yr	266	5636.54	5638.07	5638.15	5638.52	0.039009	5.58	52.08	82.33	1.1
B_Reach	15800	500-yr	726.3	5636.54	5638.66	5638.8	5639.47	0.038559	7.58	102.29	89.97	1.17
B_Reach	15700	2-yr	14.5	5633.37	5633.45	5633.45	5633.54	0.048383	1.04	5.89	32.06	0.79
B_Reach	15700	5-yr	66.6	5633.37	5633.77	5633.77	5633.99	0.033821	2.25	18.65	45.2	0.83
B_Reach	15700	10-yr	111.2	5633.37	5633.97	5634.02	5634.25	0.031054	2.14	28.82	66.54	0.8
B_Reach	15700	25-yr	186.5	5633.37	5634.15	5634.21	5634.51	0.031539	3.04	41.82	71.83	0.87
B_Reach	15700	50-yr	361.4	5633.37	5634.46	5634.54	5635	0.032609	4.34	65.13	77.73	0.97
B_Reach	15700	100-yr	540.8	5633.37	5634.78	5634.84	5635.38	0.028232	4.89	90.71	85.7	0.94
B_Reach	15700	500-yr	1393.8	5633.37	5635.83	5635.89	5636.65	0.024451	6.15	198.2	128.35	0.95
B_Reach	15600	2-yr	14.5	5627.46	5628.02	5628.07	5628.24	0.058162	3.71	3.9	12.19	1.16
B_Reach	15600	5-yr	66.6	5627.46	5628.42	5628.55	5628.88	0.085287	5.46	12.21	28.48	1.47
B_Reach	15600	10-yr	111.2	5627.46	5628.58	5628.76	5629.23	0.092613	6.46	17.21	33.13	1.58
B_Reach	15600	25-yr	186.5	5627.46	5628.8	5629.05	5629.68	0.080844	7.51	24.84	34.35	1.56
B_Reach	15600	50-yr	361.4	5627.46	5629.24	5629.66	5630.48	0.063951	8.95	40.88	42.2	1.48
B_Reach	15600	100-yr	540.8	5627.46	5629.53	5630.12	5631.14	0.066159	10.36	55.92	58.61	1.55
B_Reach	15600	500-yr	1393.8	5627.46	5630.47	5631.05	5632.39	0.085361	11.95	131.4	121.84	1.77
B_Reach	15500	2-yr	14.5	5622.03	5622.64	5622.55	5622.75	0.030935	2.69	5.4	16.98	0.84
B_Reach	15500	5-yr	66.6	5622.03	5623.1	5623.1	5623.38	0.037744	4.26	15.65	28.54	1.01
B_Reach	15500	10-yr	111.2	5622.03	5623.38	5623.38	5623.69	0.035685	4.47	24.89	40.48	1
B_Reach	15500	25-yr	186.5	5622.03	5623.61	5623.64	5624.05	0.039876	5.32	35.04	47.59	1.09
B_Reach	15500	50-yr	361.4	5622.03	5623.93	5624.1	5624.69	0.050293	6.97	51.84	55.81	1.27
B_Reach	15500	100-yr	540.8	5622.03	5624.22	5624.44	5625.18	0.05083	7.89	68.52	61.75	1.32
B_Reach	15500	500-yr	1393.8	5622.03	5625.28	5625.61	5626.84	0.037795	10.03	138.94	69.74	1.25
B_Reach	15399.64	2-yr	14.5	5618.14	5618.75	5618.75	5618.87	0.049903	2.74	5.29	23.03	1.01
B_Reach	15399.64	5-yr	66.6	5618.14	5619.1	5619.11	5619.38	0.042291	4.2	15.87	32.2	1.05
B_Reach	15399.64	10-yr	111.2	5618.14	5619.28	5619.32	5619.69	0.044533	5.17	21.53	33.21	1.13
B_Reach	15399.64	25-yr	186.5	5618.14	5619.57	5619.62	5620.11	0.038347	5.94	31.38	35.01	1.11
B_Reach	15399.64	50-yr	361.4	5618.14	5620.14	5620.17	5620.87	0.02973	6.85	52.75	39.19	1.04
B_Reach	15399.64	100-yr	540.8	5618.14	5620.63	5620.66	5621.45	0.027892	7.27	74.42	48.27	1.03
B_Reach	15399.64	500-yr	1393.8	5618.14	5621.8	5622.06	5623.42	0.030882	10.2	136.62	57.34	1.16
B_Reach	15300	2-yr	14.5	5608.14	5608.53	5608.67	5609.05	0.274666	5.78	2.51	12.95	2.31
B_Reach	15300	5-yr	66.6	5608.14	5608.79	5609.07	5609.95	0.358397	8.63	7.71	26.6	2.83
B_Reach	15300	10-yr	111.2	5608.14	5608.92	5609.3	5610.41	0.291689	9.79	11.36	27.75	2.7
B_Reach	15300	25-yr	186.5	5608.14	5609.05	5609.66	5611.44	0.330237	12.39	15.05	28.3	2.99
B_Reach	15300	50-yr	361.4	5608.14	5609.3	5610.19	5613.4	0.355548	16.25	22.24	29.31	3.29
B_Reach	15300	100-yr	540.8	5608.14	5609.58	5610.67	5614.33	0.342004	17.5	30.91	35.31	3.3
B_Reach	15300	500-yr	1393.8	5608.14	5610.56	5612	5616.58	0.207015	19.69	70.8	45.8	2.79
B_Reach	15199.69	2-yr	14.5	5601.69	5602.72	5602.34	5602.76	0.005557	1.43	10.12	22.58	0.38
B_Reach	15199.69	5-yr	66.6	5601.69	5603.32	5602.94	5603.39	0.006617	2.03	32.79	49.32	0.44
B_Reach	15199.69	10-yr	111.2	5601.69	5603.59	5603.15	5603.67	0.006488	2.38	46.82	54.71	0.45
B_Reach	15199.69	25-yr	186.5	5601.69	5603.9	5603.42	5604.03	0.006845	2.9	64.36	57.88	0.48
B_Reach	15199.69	50-yr	361.4	5601.69	5604.43	5603.84	5604.65	0.007502	3.73	96.83	63.45	0.53
B_Reach	15199.69	100-yr	540.8	5601.69	5604.87	5604.18	5605.16	0.007911	4.3	125.84	69.24	0.56
B_Reach	15199.69	500-yr	1393.8	5601.69	5606.12	5605.41	5606.73	0.011052	6.28	222.06	88.54	0.7
B_Reach	15100	2-yr	14.5	5600.99	5601.4	5601.4	5601.52	0.047649	2.69	5.38	23.52	0.99
B_Reach	15100	5-yr	66.6	5600.99	5601.79	5601.79	5602.06	0.036634	4.18	15.95	29.58	1

B_Reach	15100	10-yr	111.2	5600.99	5602.05	5602.05	5602.36	0.037416	4.49	24.76	41.72	1.03
B_Reach	15100	25-yr	186.5	5600.99	5602.33	5602.33	5602.7	0.033656	4.93	37.85	51.15	1.01
B_Reach	15100	50-yr	361.4	5600.99	5602.76	5602.76	5603.29	0.029784	5.88	61.5	57.95	1.01
B_Reach	15100	100-yr	540.8	5600.99	5603.1	5603.1	5603.77	0.028082	6.57	82.37	62.69	1.01
B_Reach	15100	500-yr	1393.8	5600.99	5604.78		5605.52	0.013077	6.94	200.96	78.23	0.76
B_Reach	15000	2-yr	14.5	5597.92	5599.23	5598.31	5599.23	0.000192	0.44	32.62	33.67	0.08
B_Reach	15000	5-yr	66.6	5597.92	5599.96	5598.69	5599.98	0.000672	1.13	58.76	37.96	0.16
B_Reach	15000	10-yr	111.2	5597.92	5600.34	5598.92	5600.38	0.000932	1.51	73.67	39.42	0.19
B_Reach	15000	25-yr	186.5	5597.92	5600.85	5599.24	5600.91	0.00129	1.98	94.31	42.78	0.23
B_Reach	15000	50-yr	361.4	5597.92	5601.84	5599.8	5601.93	0.002215	2.3	157.18	85.79	0.3
B_Reach	15000	100-yr	540.8	5597.92	5602.53	5600.27	5602.63	0.001772	2.5	216.71	88.17	0.28
B_Reach	15000	500-yr	1393.8	5597.92	5604.88		5605.04	0.001339	3.2	435.7	98.15	0.27
B_Reach	14908.52	2-yr	14.5	5598.61	5599.13		5599.17	0.009129	1.6	9.05	24.79	0.47
B_Reach	14908.52	5-yr	66.6	5598.61	5599.7		5599.82	0.009337	2.74	24.31	30.09	0.54
B_Reach	14908.52	10-yr	111.2	5598.61	5600		5600.17	0.009743	3.29	33.79	32.72	0.57
B_Reach	14908.52	25-yr	186.5	5598.61	5600.39		5600.63	0.009874	3.98	46.89	34.35	0.6
B_Reach	14908.52	50-yr	361.4	5598.61	5601.19		5601.54	0.008748	4.74	76.27	38.99	0.6
B_Reach	14908.52	100-yr	540.8	5598.61	5601.87		5602.29	0.007795	5.2	103.93	42.14	0.58
B_Reach	14908.52	500-yr	1393.8	5598.61	5604.25		5604.77	0.006497	5.81	240	72.34	0.56
B_Reach	14800	2-yr	14.5	5596.88	5597.38	5597.35	5597.48	0.031856	2.54	5.71	19.88	0.83
B_Reach	14800	5-yr	66.6	5596.88	5597.84	5597.8	5598.14	0.02929	4.38	15.22	21.8	0.92
B_Reach	14800	10-yr	111.2	5596.88	5598.16	5598.08	5598.54	0.024651	4.98	22.33	23.03	0.89
B_Reach	14800	25-yr	186.5	5596.88	5598.61	5598.47	5599.1	0.020939	5.64	33.06	24.83	0.86
B_Reach	14800	50-yr	361.4	5596.88	5599.27	5599.17	5600.07	0.022415	7.17	50.43	27.6	0.93
B_Reach	14800	100-yr	540.8	5596.88	5599.76	5599.75	5600.85	0.024287	8.38	64.56	29.51	1
B_Reach	14800	500-yr	1393.8	5596.88	5601.81	5601.81	5603.47	0.021715	10.36	134.47	40.74	1.01
B_Reach	14700	2-yr	14.5	5594.05	5594.73	5594.64	5594.85	0.021962	2.86	5.07	11.09	0.75
B_Reach	14700	5-yr	66.6	5594.05	5595.5		5595.77	0.01931	4.2	15.84	17.57	0.78
B_Reach	14700	10-yr	111.2	5594.05	5595.87	5595.75	5596.21	0.021901	4.67	23.81	24.84	0.84
B_Reach	14700	25-yr	186.5	5594.05	5596.16	5596.12	5596.72	0.027324	6.01	31.05	26.14	0.97
B_Reach	14700	50-yr	361.4	5594.05	5596.81	5596.81	5597.65	0.026067	7.35	49.14	29.3	1
B_Reach	14700	100-yr	540.8	5594.05	5597.36	5597.36	5598.4	0.024407	8.19	66.01	31.71	1
B_Reach	14700	500-yr	1393.8	5594.05	5598.95	5599.24	5601.01	0.027284	11.52	120.99	37.21	1.13
B_Reach	14600	2-yr	14.5	5591.95	5592.46		5592.56	0.023824	2.52	5.76	16.37	0.75
B_Reach	14600	5-yr	66.6	5591.95	5592.96	5592.95	5593.26	0.034064	4.36	15.27	24.75	0.98
B_Reach	14600	10-yr	111.2	5591.95	5593.22	5593.21	5593.61	0.030992	5	22.22	27.25	0.98
B_Reach	14600	25-yr	186.5	5591.95	5593.62	5593.54	5594.1	0.024691	5.59	33.35	29.04	0.92
B_Reach	14600	50-yr	361.4	5591.95	5594.25	5594.18	5594.98	0.023463	6.86	52.65	32.26	0.95
B_Reach	14600	100-yr	540.8	5591.95	5594.6	5594.7	5595.7	0.029352	8.42	64.23	34.18	1.08
B_Reach	14600	500-yr	1393.8	5591.95	5596.15	5596.49	5598.13	0.029979	11.3	123.33	42.39	1.17
B_Reach	14500	2-yr	14.5	5589.33	5589.82	5589.78	5589.94	0.02894	2.8	5.18	14.47	0.82
B_Reach	14500	5-yr	66.6	5589.33	5590.5		5590.78	0.018679	4.26	15.65	16.31	0.77
B_Reach	14500	10-yr	111.2	5589.33	5590.88		5591.28	0.018292	5.04	22.05	17.31	0.79
B_Reach	14500	25-yr	186.5	5589.33	5591.37		5591.94	0.019059	6.06	30.79	18.68	0.83
B_Reach	14500	50-yr	361.4	5589.33	5592.38		5592.91	0.01756	5.85	61.73	37.65	0.81
B_Reach	14500	100-yr	540.8	5589.33	5592.93	5592.59	5593.59	0.015668	6.54	82.69	38.85	0.79
B_Reach	14500	500-yr	1393.8	5589.33	5594.87	5594.25	5596	0.013178	8.53	163.34	44.38	0.78
B_Reach	14400	2-yr	14.5	5586.85	5587.51		5587.62	0.018964	2.59	5.59	12.84	0.69
B_Reach	14400	5-yr	66.6	5586.85	5588.04	5588.02	5588.45	0.0297	5.11	13.03	14.9	0.96
B_Reach	14400	10-yr	111.2	5586.85	5588.38	5588.38	5588.96	0.029915	6.08	18.28	16.03	1
B_Reach	14400	25-yr	186.5	5586.85	5588.88	5588.88	5589.64	0.02775	7	26.64	17.69	1.01
B_Reach	14400	50-yr	361.4	5586.85	5589.82	5589.82	5590.78	0.025491	7.86	46	24	1
B_Reach	14400	100-yr	540.8	5586.85	5590.48	5590.48	5591.6	0.02472	8.5	63.62	28.81	1.01
B_Reach	14400	500-yr	1393.8	5586.85	5592.47	5592.47	5594.27	0.021584	10.75	129.68	36.75	1.01
B_Reach	14300	2-yr	14.5	5584.19	5584.78	5584.77	5584.91	0.041268	2.91	4.98	17.31	0.96
B_Reach	14300	5-yr	66.6	5584.19	5585.33	5585.25	5585.64	0.025952	4.47	14.9	18.9	0.89
B_Reach	14300	10-yr	111.2	5584.19	5585.67	5585.57	5586.09	0.023139	5.18	21.48	19.84	0.88
B_Reach	14300	25-yr	186.5	5584.19	5586.12	5585.99	5586.69	0.021592	6.06	30.79	21.11	0.88
B_Reach	14300	50-yr	361.4	5584.19	5586.58	5586.77	5587.8	0.034639	8.86	40.78	22.24	1.15
B_Reach	14300	100-yr	540.8	5584.19	5587.17	5587.42	5588.71	0.033238	9.97	54.23	23.71	1.16

B_Reach	14300	500-yr	1393.8	5584.19	5589.28	5589.69	5591.73	0.028714	12.55	111.04	29.95	1.15
B_Reach	14200	2-yr	14.5	5582.4	5583.01		5583.07	0.010276	1.99	7.27	15.68	0.52
B_Reach	14200	5-yr	66.6	5582.4	5583.67		5583.86	0.012601	3.44	19.39	21.41	0.64
B_Reach	14200	10-yr	111.2	5582.4	5584		5584.26	0.014062	4.15	26.77	24.07	0.69
B_Reach	14200	25-yr	186.5	5582.4	5584.37		5584.79	0.016268	5.18	35.97	25.69	0.77
B_Reach	14200	50-yr	361.4	5582.4	5585.16	5584.97	5585.64	0.019641	5.55	65.17	48.54	0.84
B_Reach	14200	100-yr	540.8	5582.4	5585.52	5585.43	5586.15	0.022308	6.38	84.72	56.24	0.92
B_Reach	14200	500-yr	1393.8	5582.4	5586.25	5586.69	5588.12	0.042019	10.97	127.06	60	1.33
B_Reach	14100	2-yr	14.5	5580.52	5581.03	5581.03	5581.17	0.046445	3.02	4.81	17.32	1.01
B_Reach	14100	5-yr	66.6	5580.52	5581.52	5581.52	5581.84	0.036431	4.51	14.78	24.24	1.02
B_Reach	14100	10-yr	111.2	5580.52	5581.81	5581.81	5582.17	0.034471	4.78	23.25	33.5	1.01
B_Reach	14100	25-yr	186.5	5580.52	5582.14	5582.14	5582.57	0.032335	5.25	35.5	42.39	1.01
B_Reach	14100	50-yr	361.4	5580.52	5582.7	5582.7	5583.19	0.03128	5.63	64.22	67.52	1.02
B_Reach	14100	100-yr	540.8	5580.52	5583.02	5583.02	5583.62	0.028762	6.2	87.18	74.32	1.01
B_Reach	14100	500-yr	1393.8	5580.52	5584.06	5584.06	5585.15	0.023421	8.39	166.58	77.94	1.01
B_Reach	14000	2-yr	14.5	5577.39	5578.24	5578.03	5578.31	0.011704	2.08	6.98	15.52	0.55
B_Reach	14000	5-yr	66.6	5577.39	5578.8	5578.62	5578.94	0.015704	3.01	22.09	35.06	0.67
B_Reach	14000	10-yr	111.2	5577.39	5579.03	5578.85	5579.23	0.017019	3.59	30.97	40.12	0.72
B_Reach	14000	25-yr	186.5	5577.39	5579.32	5579.17	5579.6	0.020298	4.26	43.73	49.97	0.8
B_Reach	14000	50-yr	361.4	5577.39	5579.75	5579.62	5580.21	0.021943	5.42	66.64	56.28	0.88
B_Reach	14000	100-yr	540.8	5577.39	5579.99	5580.02	5580.68	0.029898	6.69	80.87	62.93	1.04
B_Reach	14000	500-yr	1393.8	5577.39	5580.94	5581.18	5582.39	0.032087	9.68	144.51	69.74	1.17
B_Reach	13903.54	2-yr	14.5	5575.66	5576.12	5576.12	5576.21	0.053362	2.34	6.19	36.13	1
B_Reach	13903.54	5-yr	66.6	5575.66	5576.41	5576.41	5576.62	0.040672	3.65	18.23	44.54	1.01
B_Reach	13903.54	10-yr	111.2	5575.66	5576.59	5576.59	5576.86	0.038393	4.21	26.39	49.79	1.02
B_Reach	13903.54	25-yr	186.5	5575.66	5576.85	5576.83	5577.18	0.031472	4.58	40.72	58.37	0.97
B_Reach	13903.54	50-yr	361.4	5575.66	5577.22	5577.22	5577.72	0.030555	5.65	63.98	65.35	1.01
B_Reach	13903.54	100-yr	540.8	5575.66	5577.56	5577.53	5578.17	0.025993	6.26	86.33	66.74	0.97
B_Reach	13903.54	500-yr	1393.8	5575.66	5578.64	5578.72	5579.72	0.022304	8.44	172.04	91.23	0.99
B_Reach	13800	2-yr	14.5	5572.24	5573.12	5572.84	5573.18	0.007908	1.96	7.39	13.36	0.46
B_Reach	13800	5-yr	66.6	5572.24	5573.78	5573.5	5573.98	0.01343	3.59	18.53	20.03	0.66
B_Reach	13800	10-yr	111.2	5572.24	5574.12	5573.85	5574.41	0.01532	4.27	26.02	23.96	0.72
B_Reach	13800	25-yr	186.5	5572.24	5574.75		5574.98	0.014974	3.84	48.54	51.79	0.7
B_Reach	13800	50-yr	361.4	5572.24	5575.32	5574.99	5575.63	0.013166	4.45	81.3	62.94	0.69
B_Reach	13800	100-yr	540.8	5572.24	5575.82		5576.13	0.014251	4.53	119.39	95.51	0.71
B_Reach	13800	500-yr	1393.8	5572.24	5576.68	5576.45	5577.39	0.017202	6.77	205.73	103.3	0.85
B_Reach	13700	2-yr	14.5	5571.27	5571.69		5571.77	0.031904	2.26	6.42	27.07	0.82
B_Reach	13700	5-yr	66.6	5571.27	5572.13		5572.32	0.020957	3.47	19.21	30.91	0.78
B_Reach	13700	10-yr	111.2	5571.27	5572.39		5572.64	0.020668	4.03	27.56	34.93	0.8
B_Reach	13700	25-yr	186.5	5571.27	5572.62	5572.56	5573.04	0.025994	5.16	36.14	37.59	0.93
B_Reach	13700	50-yr	361.4	5571.27	5573.16	5573.16	5573.68	0.031231	5.77	62.59	63.02	1.02
B_Reach	13700	100-yr	540.8	5571.27	5573.56	5573.56	5574.07	0.031735	5.71	94.64	98.13	1.03
B_Reach	13700	500-yr	1393.8	5571.27	5574.45	5574.44	5575.34	0.024547	7.56	184.46	103.49	1
B_Reach	13600	2-yr	14.5	5568.57	5569.1		5569.2	0.021181	2.6	5.58	13.75	0.72
B_Reach	13600	5-yr	66.6	5568.57	5569.67	5569.62	5569.9	0.02823	3.83	17.39	29.61	0.88
B_Reach	13600	10-yr	111.2	5568.57	5569.94	5569.89	5570.21	0.029152	4.14	26.88	41.83	0.91
B_Reach	13600	25-yr	186.5	5568.57	5570.29		5570.59	0.02248	4.38	42.62	49.99	0.84
B_Reach	13600	50-yr	361.4	5568.57	5570.88	5570.69	5571.19	0.017029	4.45	81.25	75.67	0.76
B_Reach	13600	100-yr	540.8	5568.57	5571.21	5570.97	5571.61	0.015956	5.1	106.05	76.37	0.76
B_Reach	13600	500-yr	1393.8	5568.57	5572.08	5572.01	5573.02	0.021939	7.75	179.9	87.76	0.95
B_Reach	13500	2-yr	14.5	5566.21	5566.83		5566.93	0.024242	2.57	5.65	15.81	0.76
B_Reach	13500	5-yr	66.6	5566.21	5567.39		5567.57	0.019445	3.39	19.62	30.34	0.74
B_Reach	13500	10-yr	111.2	5566.21	5567.71		5567.92	0.018342	3.67	30.34	40.03	0.74
B_Reach	13500	25-yr	186.5	5566.21	5567.92	5567.82	5568.28	0.023373	4.78	38.99	41.34	0.87
B_Reach	13500	50-yr	361.4	5566.21	5568.32	5568.32	5568.97	0.028987	6.48	55.77	43.94	1.01
B_Reach	13500	100-yr	540.8	5566.21	5568.87	5568.87	5569.52	0.02802	6.45	83.88	65.24	1
B_Reach	13500	500-yr	1393.8	5566.21	5570.29		5571.07	0.016746	7.08	196.77	89.87	0.84
B_Reach	13400	2-yr	14.5	5563.88	5564.72	5564.6	5564.83	0.018231	2.65	5.48	11.76	0.68
B_Reach	13400	5-yr	66.6	5563.88	5565.47	5565.27	5565.71	0.017889	3.89	17.1	20.16	0.75

B_Reach	13400	10-yr	111.2	5563.88	5565.98		5566.16	0.016663	3.38	32.94	46.13	0.7
B_Reach	13400	25-yr	186.5	5563.88	5566.34		5566.56	0.012727	3.75	49.72	48.47	0.65
B_Reach	13400	50-yr	361.4	5563.88	5567.02	5566.5	5567.31	0.009188	4.31	83.76	51.61	0.6
B_Reach	13400	100-yr	540.8	5563.88	5567.57	5566.88	5567.93	0.008171	4.78	113.07	54.52	0.59
B_Reach	13400	500-yr	1393.8	5563.88	5569.2		5569.85	0.008757	6.43	216.91	70.59	0.65
B_Reach	13300	2-yr	14.5	5562.17	5562.75		5562.87	0.020983	2.7	5.38	12.58	0.73
B_Reach	13300	5-yr	66.6	5562.17	5563.4	5563.28	5563.71	0.02241	4.48	14.88	16.88	0.84
B_Reach	13300	10-yr	111.2	5562.17	5563.75	5563.65	5564.18	0.023343	5.25	21.19	19.46	0.89
B_Reach	13300	25-yr	186.5	5562.17	5564.15	5564.1	5564.77	0.025393	6.3	29.62	21.93	0.95
B_Reach	13300	50-yr	361.4	5562.17	5564.88	5564.88	5565.8	0.02611	7.7	46.91	26.04	1.01
B_Reach	13300	100-yr	540.8	5562.17	5565.57	5565.49	5566.6	0.021966	8.14	66.48	30.09	0.96
B_Reach	13300	500-yr	1393.8	5562.17	5567.72	5567.72	5568.79	0.011957	8.76	191.12	91.81	0.78
B_Reach	13200	2-yr	14.5	5559.79	5560.4	5560.35	5560.5	0.026767	2.61	5.55	16.26	0.79
B_Reach	13200	5-yr	66.6	5559.79	5560.92	5560.86	5561.25	0.027398	4.6	14.49	18.33	0.91
B_Reach	13200	10-yr	111.2	5559.79	5561.23	5561.18	5561.69	0.026467	5.42	20.51	19.59	0.93
B_Reach	13200	25-yr	186.5	5559.79	5561.69	5561.61	5562.3	0.02416	6.29	29.67	21	0.93
B_Reach	13200	50-yr	361.4	5559.79	5562.54	5562.39	5563.39	0.020747	7.41	48.78	23.69	0.91
B_Reach	13200	100-yr	540.8	5559.79	5563.03	5563.03	5564.26	0.024562	8.92	60.66	25.54	1.01
B_Reach	13200	500-yr	1393.8	5559.79	5564.23	5565.01	5566.76	0.033773	13.43	122.6	65.01	1.26
B_Reach	13100	2-yr	15.2	5556.39	5557.02	5557.02	5557.25	0.039871	3.81	3.99	8.89	1
B_Reach	13100	5-yr	69.2	5556.39	5557.77	5557.77	5558.27	0.032128	5.67	12.2	12.45	1.01
B_Reach	13100	10-yr	115.6	5556.39	5558.18	5558.18	5558.86	0.030006	6.6	17.53	13.24	1.01
B_Reach	13100	25-yr	193.5	5556.39	5558.75	5558.75	5559.66	0.028332	7.64	25.33	14.32	1.01
B_Reach	13100	50-yr	374.8	5556.39	5559.88	5559.88	5561.03	0.026358	8.59	43.65	19.36	1.01
B_Reach	13100	100-yr	560.6	5556.39	5560.55	5560.83	5561.85	0.023615	9.37	66.34	41.27	0.98
B_Reach	13100	500-yr	1443.2	5556.39	5562.39	5562.48	5564.02	0.019023	11.11	147.07	45.97	0.93
B_Reach	13000	2-yr	15.2	5553.48	5554.08	5553.98	5554.19	0.019266	2.64	5.76	13.04	0.7
B_Reach	13000	5-yr	69.2	5553.48	5554.74	5554.59	5555	0.020477	4.12	16.8	20.22	0.8
B_Reach	13000	10-yr	115.6	5553.48	5555.01	5554.91	5555.42	0.022776	5.13	22.51	20.88	0.87
B_Reach	13000	25-yr	193.5	5553.48	5555.12	5555.33	5556.07	0.047384	7.81	24.77	21.14	1.27
B_Reach	13000	50-yr	374.8	5553.48	5555.67	5556.11	5557.29	0.053988	10.23	36.63	22.67	1.42
B_Reach	13000	100-yr	560.6	5553.48	5556.13	5556.76	5558.29	0.055939	11.8	47.52	24.21	1.48
B_Reach	13000	500-yr	1443.2	5553.48	5557.8	5558.82	5561.03	0.04667	14.77	107.61	53.89	1.46
B_Reach	12900	2-yr	15.2	5550.73	5551.54	5551.51	5551.67	0.034439	2.84	5.35	16.71	0.89
B_Reach	12900	5-yr	69.2	5550.73	5552.03	5552.03	5552.32	0.036546	4.36	15.89	27.27	1.01
B_Reach	12900	10-yr	115.6	5550.73	5552.26	5552.26	5552.67	0.033854	5.13	22.55	28.54	1.02
B_Reach	12900	25-yr	193.5	5550.73	5552.6	5552.6	5553.15	0.030682	5.98	32.37	30.1	1.02
B_Reach	12900	50-yr	374.8	5550.73	5553.22	5553.22	5554.03	0.0271	7.2	52.03	33.1	1.01
B_Reach	12900	100-yr	560.6	5550.73	5553.74	5553.76	5554.74	0.025198	8.01	70	35.83	1.01
B_Reach	12900	500-yr	1443.2	5550.73	5555.12	5555.61	5556.83	0.030695	10.69	145.76	82.48	1.17
B_Reach	12800	2-yr	15.2	5547.19	5547.63	5547.63	5547.79	0.043939	3.18	4.78	15.29	1
B_Reach	12800	5-yr	69.2	5547.19	5548.13	5548.16	5548.53	0.038897	5.04	13.73	19.98	1.07
B_Reach	12800	10-yr	115.6	5547.19	5548.38	5548.47	5548.96	0.040872	6.12	18.89	21.23	1.14
B_Reach	12800	25-yr	193.5	5547.19	5548.73	5548.89	5549.54	0.042568	7.2	26.86	24.32	1.21
B_Reach	12800	50-yr	374.8	5547.19	5549.3	5549.59	5550.56	0.044238	9.04	41.45	27.29	1.29
B_Reach	12800	100-yr	560.6	5547.19	5549.74	5550.17	5551.42	0.044621	10.38	54	28.87	1.34
B_Reach	12800	500-yr	1443.2	5547.19	5551.96	5552.23	5553.91	0.02734	11.21	128.76	41.87	1.13
B_Reach	12700	2-yr	15.2	5543.36	5543.97	5543.92	5544.12	0.026364	3.05	4.99	11.41	0.81
B_Reach	12700	5-yr	69.2	5543.36	5544.6	5544.58	5545.06	0.030779	5.46	12.67	13.19	0.98
B_Reach	12700	10-yr	115.6	5543.36	5544.99	5544.99	5545.63	0.030397	6.44	17.94	14.22	1.01
B_Reach	12700	25-yr	193.5	5543.36	5545.71	5545.72	5546.33	0.030039	6.29	30.77	25.47	1.01
B_Reach	12700	50-yr	374.8	5543.36	5546.4	5546.4	5547.3	0.027064	7.6	49.29	28.09	1.01
B_Reach	12700	100-yr	560.6	5543.36	5546.97	5546.97	5548.1	0.025361	8.53	65.7	29.73	1.01
B_Reach	12700	500-yr	1443.2	5543.36	5548.49	5549.08	5550.93	0.031602	12.58	116.39	37.85	1.2
B_Reach	12600	2-yr	15.2	5540.45	5540.93	5540.91	5541.07	0.035585	2.99	5.08	15.07	0.91
B_Reach	12600	5-yr	69.2	5540.45	5541.45	5541.45	5541.83	0.033436	4.97	13.92	18.15	1
B_Reach	12600	10-yr	115.6	5540.45	5541.72	5541.77	5542.3	0.036729	6.13	18.87	19.13	1.09
B_Reach	12600	25-yr	193.5	5540.45	5542.09	5542.23	5542.93	0.038507	7.36	26.3	20.84	1.15
B_Reach	12600	50-yr	374.8	5540.45	5542.76	5543.03	5544.02	0.039415	9.01	41.59	24.5	1.22
B_Reach	12600	100-yr	560.6	5540.45	5543.27	5543.63	5544.91	0.040613	10.27	54.56	26.81	1.27

B_Reach	12600	500-yr	1443.2	5540.45	5545.25	5545.75	5547.75	0.032072	12.7	113.66	33.1	1.21
B_Reach	12500	2-yr	15.2	5536.5	5537.02	5537.02	5537.19	0.042392	3.31	4.6	13.48	1
B_Reach	12500	5-yr	69.2	5536.5	5537.52	5537.59	5538.01	0.043956	5.6	12.37	16.72	1.15
B_Reach	12500	10-yr	115.6	5536.5	5537.84	5537.94	5538.49	0.039518	6.43	17.99	18.11	1.14
B_Reach	12500	25-yr	193.5	5536.5	5538.27	5538.4	5539.12	0.037736	7.43	26.03	20.19	1.15
B_Reach	12500	50-yr	374.8	5536.5	5539.05	5539.26	5540.17	0.036984	8.51	44.05	27.35	1.18
B_Reach	12500	100-yr	560.6	5536.5	5539.55	5539.84	5540.96	0.037097	9.51	58.93	30.93	1.21
B_Reach	12500	500-yr	1443.2	5536.5	5540.89	5541.71	5543.89	0.046151	13.91	103.74	35.65	1.44
B_Reach	12400	2-yr	15.2	5533.1	5533.9	5533.78	5534.03	0.019182	2.89	5.26	10.15	0.71
B_Reach	12400	5-yr	69.2	5533.1	5534.62	5534.52	5535.02	0.02389	5.07	13.66	13.11	0.87
B_Reach	12400	10-yr	115.6	5533.1	5534.99	5534.94	5535.58	0.027457	6.16	18.75	14.8	0.97
B_Reach	12400	25-yr	193.5	5533.1	5535.51	5535.51	5536.3	0.027776	7.15	27.08	17.15	1
B_Reach	12400	50-yr	374.8	5533.1	5536.53	5536.53	5537.3	0.027258	7.01	53.47	35.26	1
B_Reach	12400	100-yr	560.6	5533.1	5537.01	5537.03	5537.99	0.026079	7.94	70.62	37.24	1.02
B_Reach	12400	500-yr	1443.2	5533.1	5538.93	5538.73	5540.41	0.018399	9.76	147.84	43.05	0.93
B_Reach	12300	2-yr	15.2	5530.59	5531.12	5531.12	5531.31	0.04127	3.55	4.28	11	1
B_Reach	12300	5-yr	69.2	5530.59	5531.79	5531.79	5532.21	0.033563	5.19	13.34	16.42	1.01
B_Reach	12300	10-yr	115.6	5530.59	5532.15	5532.15	5532.69	0.030119	5.9	19.58	18.17	1
B_Reach	12300	25-yr	193.5	5530.59	5532.54	5532.6	5533.34	0.031808	7.14	27.1	19.52	1.07
B_Reach	12300	50-yr	374.8	5530.59	5533.36	5533.44	5534.48	0.028459	8.48	44.21	22.3	1.06
B_Reach	12300	100-yr	560.6	5530.59	5534.05	5534.11	5535.4	0.025659	9.32	60.14	23.98	1.04
B_Reach	12300	500-yr	1443.2	5530.59	5536.71	5536.71	5538.4	0.021528	10.43	138.35	40.73	1
B_Reach	12200	2-yr	15.2	5527.43	5527.97		5528.1	0.025522	2.87	5.29	13.03	0.8
B_Reach	12200	5-yr	69.2	5527.43	5528.63	5528.52	5528.93	0.022428	4.41	15.69	18.29	0.84
B_Reach	12200	10-yr	115.6	5527.43	5528.97	5528.87	5529.38	0.024243	5.16	22.4	21.82	0.9
B_Reach	12200	25-yr	193.5	5527.43	5529.23	5529.33	5529.94	0.035877	6.74	28.7	25.11	1.11
B_Reach	12200	50-yr	374.8	5527.43	5529.74	5530.02	5530.93	0.045626	8.76	42.8	30.23	1.3
B_Reach	12200	100-yr	560.6	5527.43	5530.08	5530.56	5531.78	0.053547	10.47	53.53	32.53	1.44
B_Reach	12200	500-yr	1443.2	5527.43	5531.27	5532.4	5534.76	0.064344	14.98	96.33	38.94	1.68
B_Reach	12100	2-yr	15.2	5524.85	5525.52		5525.61	0.023957	2.35	6.46	20.33	0.74
B_Reach	12100	5-yr	69.2	5524.85	5525.91	5525.91	5526.14	0.035167	3.87	17.86	35.48	0.96
B_Reach	12100	10-yr	115.6	5524.85	5526.09	5526.09	5526.44	0.036046	4.74	24.37	36.31	1.02
B_Reach	12100	25-yr	193.5	5524.85	5526.38	5526.38	5526.85	0.031834	5.55	34.88	37.24	1.01
B_Reach	12100	50-yr	374.8	5524.85	5526.9	5526.9	5527.62	0.028273	6.82	54.98	39.12	1.01
B_Reach	12100	100-yr	560.6	5524.85	5527.34	5527.36	5528.27	0.026222	7.73	72.51	40.03	1.01
B_Reach	12100	500-yr	1443.2	5524.85	5528.93	5528.97	5530.62	0.022977	10.44	138.27	42.69	1.02
B_Reach	12000	2-yr	15.2	5521.38	5522.21	5522.21	5522.36	0.04609	3.14	4.84	16.26	1.01
B_Reach	12000	5-yr	69.2	5521.38	5522.78	5522.7	5522.98	0.026917	3.59	19.28	35.4	0.86
B_Reach	12000	10-yr	115.6	5521.38	5523.03	5522.94	5523.27	0.024104	3.88	29.8	44.83	0.84
B_Reach	12000	25-yr	193.5	5521.38	5523.11	5523.21	5523.63	0.049402	5.78	33.49	47.45	1.21
B_Reach	12000	50-yr	374.8	5521.38	5523.56	5523.66	5524.21	0.041505	6.5	57.68	60.11	1.17
B_Reach	12000	100-yr	560.6	5521.38	5523.76	5524	5524.76	0.050754	8.02	69.89	61.69	1.33
B_Reach	12000	500-yr	1443.2	5521.38	5524.49	5525.19	5526.9	0.066635	12.46	115.83	64.44	1.64
B_Reach	11900	2-yr	15.2	5519.1	5519.76		5519.85	0.01566	2.47	6.15	13.18	0.64
B_Reach	11900	5-yr	69.2	5519.1	5520.42	5520.25	5520.68	0.01984	4.06	17.04	20.65	0.79
B_Reach	11900	10-yr	115.6	5519.1	5520.89	5520.75	5521.05	0.020173	3.25	35.52	61.01	0.75
B_Reach	11900	25-yr	193.5	5519.1	5521.13	5520.98	5521.35	0.019314	3.79	51.1	67.53	0.77
B_Reach	11900	50-yr	374.8	5519.1	5521.49	5521.37	5521.87	0.02081	4.91	76.34	71.94	0.84
B_Reach	11900	100-yr	560.6	5519.1	5521.75	5521.65	5522.29	0.023519	5.91	94.92	74.07	0.92
B_Reach	11900	500-yr	1443.2	5519.1	5522.77	5522.78	5523.82	0.024501	8.22	175.54	85.34	1.01
B_Reach	11800	2-yr	15.2	5516.78	5517.25	5517.25	5517.4	0.043765	3.15	4.82	15.6	1
B_Reach	11800	5-yr	69.2	5516.78	5517.78	5517.78	5518.11	0.034193	4.64	14.91	22.37	1
B_Reach	11800	10-yr	115.6	5516.78	5518.1	5518.1	5518.48	0.033025	4.97	23.28	30.76	1.01
B_Reach	11800	25-yr	193.5	5516.78	5518.5	5518.5	5518.82	0.034215	4.53	42.69	66.56	1
B_Reach	11800	50-yr	374.8	5516.78	5518.88	5518.88	5519.3	0.032182	5.24	71.52	85.6	1.01
B_Reach	11800	100-yr	560.6	5516.78	5519.15	5519.15	5519.68	0.029179	5.81	96.52	91.94	1
B_Reach	11800	500-yr	1443.2	5516.78	5519.95	5520.1	5521	0.033177	8.21	175.85	109.58	1.14
B_Reach	11700	2-yr	15.2	5513.5	5514.03	5513.9	5514.11	0.01559	2.25	6.76	16.67	0.62
B_Reach	11700	5-yr	69.2	5513.5	5514.61	5514.45	5514.85	0.018143	3.93	17.6	20.87	0.75

B_Reach	11700	10-yr	115.6	5513.5	5514.99	5514.77	5515.28	0.018909	4.31	26.83	28.41	0.78
B_Reach	11700	25-yr	193.5	5513.5	5515.44	5515.24	5515.75	0.020442	4.45	43.48	46.44	0.81
B_Reach	11700	50-yr	374.8	5513.5	5515.94	5515.83	5516.35	0.022984	5.12	73.17	68.96	0.88
B_Reach	11700	100-yr	560.6	5513.5	5516.22	5516.15	5516.79	0.025345	6.05	92.7	73.01	0.95
B_Reach	11700	500-yr	1443.2	5513.5	5517.23	5517.23	5518.26	0.025316	8.16	176.85	88.03	1.01
B_Reach	11600	2-yr	15.2	5511.09	5511.5	5511.5	5511.65	0.043511	3.21	4.74	14.84	1
B_Reach	11600	5-yr	69.2	5511.09	5512.04	5512.04	5512.42	0.033702	4.94	14	18.78	1.01
B_Reach	11600	10-yr	115.6	5511.09	5512.47	5512.47	5512.83	0.033072	4.77	24.23	33.83	0.99
B_Reach	11600	25-yr	193.5	5511.09	5512.83	5512.83	5513.15	0.034271	4.59	42.14	64.14	1
B_Reach	11600	50-yr	374.8	5511.09	5513.2	5513.2	5513.65	0.032212	5.34	70.22	81.16	1.01
B_Reach	11600	100-yr	560.6	5511.09	5513.52	5513.52	5514.02	0.029974	5.69	98.6	98.05	1
B_Reach	11600	500-yr	1443.2	5511.09	5514.73	5514.43	5515.34	0.016407	6.28	230.54	131.18	0.82
B_Reach	11514.61	2-yr	15.2	5508.1	5508.67	5508.59	5508.75	0.02148	2.23	6.81	21.64	0.7
B_Reach	11514.61	5-yr	69.2	5508.1	5509.15	5509.04	5509.35	0.021864	3.62	19.14	29.65	0.79
B_Reach	11514.61	10-yr	115.6	5508.1	5509.42	5509.29	5509.69	0.021768	4.2	27.53	33.84	0.82
B_Reach	11514.61	25-yr	193.5	5508.1	5509.71	5509.62	5510.11	0.023217	5.08	38.1	36.88	0.88
B_Reach	11514.61	50-yr	374.8	5508.1	5510.09	5510.16	5510.88	0.031951	7.12	52.65	38.88	1.08
B_Reach	11514.61	100-yr	560.6	5508.1	5510.59	5510.6	5511.53	0.026282	7.76	72.2	40.08	1.02
B_Reach	11514.61	500-yr	1443.2	5508.1	5512.53	5512.53	5513.62	0.023994	8.35	172.8	79.96	1
B_Reach	11400	2-yr	15.2	5505.49	5505.98		5506.07	0.025377	2.43	6.24	19.8	0.76
B_Reach	11400	5-yr	69.2	5505.49	5506.39	5506.33	5506.56	0.027317	3.33	20.79	43.49	0.85
B_Reach	11400	10-yr	115.6	5505.49	5506.56	5506.52	5506.81	0.029124	4.02	28.77	47.51	0.91
B_Reach	11400	25-yr	193.5	5505.49	5506.81	5506.77	5507.14	0.028766	4.67	41.46	54.12	0.94
B_Reach	11400	50-yr	374.8	5505.49	5507.18	5507.18	5507.75	0.029508	6.04	62.03	55.89	1.01
B_Reach	11400	100-yr	560.6	5505.49	5507.48	5507.53	5508.26	0.030114	7.07	79.27	57.13	1.06
B_Reach	11400	500-yr	1443.2	5505.49	5508.58	5508.94	5509.99	0.042646	9.54	151.26	90.18	1.3
B_Reach	11300	2-yr	15.2	5502.86	5503.38		5503.45	0.02676	2.11	7.2	29.26	0.75
B_Reach	11300	5-yr	69.2	5502.86	5503.78	5503.69	5503.92	0.025364	3.03	22.87	51.81	0.8
B_Reach	11300	10-yr	115.6	5502.86	5503.96	5503.87	5504.15	0.024268	3.58	32.28	54.84	0.82
B_Reach	11300	25-yr	193.5	5502.86	5504.17	5504.09	5504.46	0.024925	4.3	45.04	59.26	0.87
B_Reach	11300	50-yr	374.8	5502.86	5504.59	5504.51	5505.01	0.024799	5.22	71.84	70.14	0.91
B_Reach	11300	100-yr	560.6	5502.86	5505	5504.88	5505.44	0.02282	5.37	104.38	91.66	0.89
B_Reach	11300	500-yr	1443.2	5502.86	5506.21	5505.9	5506.7	0.012441	5.75	264.87	155.54	0.72
B_Reach	11200	2-yr	15.2	5499.38	5500.03	5500.02	5500.21	0.039748	3.42	4.45	11.73	0.98
B_Reach	11200	5-yr	69.2	5499.38	5500.59	5500.59	5500.88	0.036765	4.29	16.13	28.45	1
B_Reach	11200	10-yr	115.6	5499.38	5500.85	5500.85	5501.19	0.036813	4.69	24.66	38.09	1.03
B_Reach	11200	25-yr	193.5	5499.38	5501.12	5501.12	5501.59	0.032985	5.49	35.22	39.32	1.02
B_Reach	11200	50-yr	374.8	5499.38	5501.63	5501.63	5502.33	0.028572	6.7	55.93	41.36	1.02
B_Reach	11200	100-yr	560.6	5499.38	5502.07	5502.07	5502.95	0.026186	7.54	74.35	42.92	1.01
B_Reach	11200	500-yr	1443.2	5499.38	5503.8	5503.8	5504.99	0.022555	8.74	166.27	76.88	0.98
B_Reach	11100	2-yr	15.2	5496.99	5497.55		5497.63	0.017723	2.23	6.82	18.73	0.65
B_Reach	11100	5-yr	69.2	5496.99	5498.2	5497.99	5498.26	0.01351	2.04	33.98	87.25	0.58
B_Reach	11100	10-yr	115.6	5496.99	5498.37	5498.18	5498.45	0.012828	2.26	51.11	107.85	0.58
B_Reach	11100	25-yr	193.5	5496.99	5498.58	5498.37	5498.68	0.012803	2.56	75.71	132.82	0.6
B_Reach	11100	50-yr	374.8	5496.99	5498.82	5498.63	5499	0.015425	3.41	109.86	143.51	0.69
B_Reach	11100	100-yr	560.6	5496.99	5499.01	5498.82	5499.27	0.016576	4.06	138.08	146.46	0.74
B_Reach	11100	500-yr	1443.2	5496.99	5499.02	5499.5	5500.69	0.107494	10.38	139.01	146.53	1.88
B_Reach	11000	2-yr	15.2	5494.94	5495.52		5495.64	0.022238	2.76	5.5	12.78	0.74
B_Reach	11000	5-yr	69.2	5494.94	5496.21	5496.15	5496.39	0.027664	3.37	20.53	41.83	0.85
B_Reach	11000	10-yr	115.6	5494.94	5496.41	5496.33	5496.66	0.026385	4.02	28.76	43.33	0.87
B_Reach	11000	25-yr	193.5	5494.94	5496.83	5496.72	5496.99	0.02288	3.24	59.75	113.05	0.79
B_Reach	11000	50-yr	374.8	5494.94	5497.17		5497.38	0.017147	3.67	102.09	128.83	0.73
B_Reach	11000	100-yr	560.6	5494.94	5497.43		5497.69	0.015065	4.1	136.75	132.56	0.71
B_Reach	11000	500-yr	1443.2	5494.94	5498.18	5497.95	5498.76	0.016322	6.09	237.13	134.25	0.81
B_Reach	10894.39	2-yr	15.2	5492.22	5492.93		5493.02	0.02787	2.43	6.25	21.17	0.79
B_Reach	10894.39	5-yr	69.2	5492.22	5493.4		5493.64	0.024279	3.93	17.6	26.09	0.84
B_Reach	10894.39	10-yr	115.6	5492.22	5493.68	5493.59	5494.01	0.023824	4.55	25.38	29.75	0.87
B_Reach	10894.39	25-yr	193.5	5492.22	5494.11	5494	5494.46	0.024743	4.75	40.77	46.31	0.89
B_Reach	10894.39	50-yr	374.8	5492.22	5494.6	5494.55	5495.1	0.02691	5.68	66.02	60.93	0.96
B_Reach	10894.39	100-yr	560.6	5492.22	5495.07	5495.04	5495.53	0.029153	5.4	103.88	110.07	0.98

B_Reach	10894.39	500-yr	1443.2	5492.22	5495.93	5495.85	5496.72	0.022677	7.13	202.47	116.5	0.95
B_Reach	10800	2-yr	15.2	5490.1	5490.58		5490.67	0.022498	2.43	6.27	18.23	0.73
B_Reach	10800	5-yr	69.2	5490.1	5491.09	5491.01	5491.31	0.025169	3.71	18.64	31.15	0.85
B_Reach	10800	10-yr	115.6	5490.1	5491.33	5491.26	5491.62	0.0267	4.39	26.36	35.86	0.9
B_Reach	10800	25-yr	193.5	5490.1	5491.66	5491.6	5492.01	0.027399	4.7	41.15	51.38	0.93
B_Reach	10800	50-yr	374.8	5490.1	5492.13	5492.09	5492.56	0.026327	5.25	71.4	73.35	0.94
B_Reach	10800	100-yr	560.6	5490.1	5492.43	5492.38	5492.99	0.024642	5.98	93.76	75.31	0.94
B_Reach	10800	500-yr	1443.2	5490.1	5493.44	5493.43	5494.53	0.023149	8.36	172.59	79.46	1
B_Reach	10700	2-yr	15.2	5487.39	5487.94	5487.89	5488.06	0.030552	2.84	5.36	15.5	0.85
B_Reach	10700	5-yr	69.2	5487.39	5488.43	5488.38	5488.66	0.027836	3.83	18.07	30.84	0.88
B_Reach	10700	10-yr	115.6	5487.39	5488.69	5488.61	5488.99	0.026034	4.4	26.28	34.46	0.89
B_Reach	10700	25-yr	193.5	5487.39	5489.04	5488.95	5489.39	0.02524	4.75	40.78	46.52	0.89
B_Reach	10700	50-yr	374.8	5487.39	5489.54	5489.45	5490.04	0.024117	5.67	66.04	55.42	0.92
B_Reach	10700	100-yr	560.6	5487.39	5489.93	5489.85	5490.54	0.024367	6.25	89.7	65.53	0.94
B_Reach	10700	500-yr	1443.2	5487.39	5491.06	5491.06	5492.17	0.024148	8.44	170.99	78.37	1.01
B_Reach	10600	2-yr	15.2	5485.59	5486.2		5486.24	0.011803	1.6	9.48	31.47	0.51
B_Reach	10600	5-yr	69.2	5485.59	5486.61		5486.72	0.01388	2.65	26.11	45.93	0.62
B_Reach	10600	10-yr	115.6	5485.59	5486.82		5486.98	0.015363	3.15	36.74	53.91	0.67
B_Reach	10600	25-yr	193.5	5485.59	5487.08		5487.3	0.017002	3.75	51.56	62.67	0.73
B_Reach	10600	50-yr	374.8	5485.59	5487.46		5487.8	0.01987	4.68	80.06	78.45	0.82
B_Reach	10600	100-yr	560.6	5485.59	5487.71	5487.6	5488.2	0.021783	5.62	99.72	79.46	0.88
B_Reach	10600	500-yr	1443.2	5485.59	5488.61	5488.66	5489.6	0.026952	8.01	180.26	98.8	1.04
B_Reach	10500	2-yr	15.2	5483.58	5483.97	5483.97	5484.05	0.05345	2.32	6.57	39.16	1
B_Reach	10500	5-yr	69.2	5483.58	5484.24	5484.24	5484.41	0.045177	3.26	21.24	66.69	1.02
B_Reach	10500	10-yr	115.6	5483.58	5484.38	5484.38	5484.59	0.041379	3.67	31.53	77.52	1.01
B_Reach	10500	25-yr	193.5	5483.58	5484.56	5484.56	5484.83	0.038748	4.2	46.12	88.13	1.02
B_Reach	10500	50-yr	374.8	5483.58	5484.88	5484.88	5485.26	0.033725	4.92	76.16	103.14	1.01
B_Reach	10500	100-yr	560.6	5483.58	5485.13	5485.13	5485.59	0.031711	5.45	102.83	114.02	1.01
B_Reach	10500	500-yr	1443.2	5483.58	5485.87	5485.92	5486.77	0.029212	7.65	188.76	118.21	1.07
B_Reach	10400	2-yr	15.2	5479.63	5480.34	5480.16	5480.4	0.012092	1.85	8.22	22.18	0.54
B_Reach	10400	5-yr	69.2	5479.63	5480.88	5480.67	5481	0.013405	2.72	25.47	41.43	0.61
B_Reach	10400	10-yr	115.6	5479.63	5481.1	5480.89	5481.27	0.015314	3.29	35.12	47.29	0.67
B_Reach	10400	25-yr	193.5	5479.63	5481.32	5481.18	5481.59	0.021012	4.15	46.66	56.37	0.8
B_Reach	10400	50-yr	374.8	5479.63	5481.77	5481.65	5482.15	0.023374	4.92	76.11	77.18	0.87
B_Reach	10400	100-yr	560.6	5479.63	5482.07	5481.98	5482.55	0.024371	5.56	100.79	88.01	0.92
B_Reach	10400	500-yr	1443.2	5479.63	5482.9	5482.98	5483.84	0.029497	7.77	185.74	113.67	1.07
B_Reach	10300	2-yr	15.2	5477.53	5478.15	5478.15	5478.29	0.045664	2.97	5.12	18.55	0.99
B_Reach	10300	5-yr	69.2	5477.53	5478.62	5478.62	5478.85	0.038761	3.9	17.74	37.62	1
B_Reach	10300	10-yr	115.6	5477.53	5478.87	5478.86	5479.09	0.033352	3.77	30.68	61.27	0.94
B_Reach	10300	25-yr	193.5	5477.53	5479.17	5479.08	5479.38	0.023107	3.69	52.43	82.02	0.81
B_Reach	10300	50-yr	374.8	5477.53	5479.52	5479.41	5479.83	0.022795	4.46	84.13	98.08	0.85
B_Reach	10300	100-yr	560.6	5477.53	5479.78	5479.67	5480.18	0.022756	5.03	111.37	107.9	0.87
B_Reach	10300	500-yr	1443.2	5477.53	5480.73	5480.52	5481.42	0.017593	6.68	216.14	112.52	0.85
B_Reach	10200	2-yr	15.2	5474.06	5474.9	5474.73	5475	0.013783	2.51	6.06	11.4	0.61
B_Reach	10200	5-yr	69.2	5474.06	5475.67	5475.52	5475.88	0.020176	3.74	18.49	25.35	0.77
B_Reach	10200	10-yr	115.6	5474.06	5475.94	5475.82	5476.24	0.024459	4.4	26.26	32.64	0.86
B_Reach	10200	25-yr	193.5	5474.06	5476.28	5476.26	5476.64	0.032542	4.76	40.65	56	0.98
B_Reach	10200	50-yr	374.8	5474.06	5476.68	5476.68	5477.19	0.03049	5.73	65.37	64.84	1.01
B_Reach	10200	100-yr	560.6	5474.06	5477	5477	5477.65	0.027545	6.48	86.54	66.09	1
B_Reach	10200	500-yr	1443.2	5474.06	5478.14	5478.14	5479.35	0.023558	8.81	163.8	69.38	1.01
B_Reach	10100	2-yr	15.2	5471.98	5472.51	5472.51	5472.63	0.049541	2.85	5.33	21.78	1.02
B_Reach	10100	5-yr	69.2	5471.98	5472.91	5472.91	5473.17	0.038601	4.04	17.12	34.3	1.01
B_Reach	10100	10-yr	115.6	5471.98	5473.16	5473.13	5473.46	0.03207	4.4	26.28	40.32	0.96
B_Reach	10100	25-yr	193.5	5471.98	5473.48	5473.4	5473.84	0.02409	4.81	40.25	43.48	0.88
B_Reach	10100	50-yr	374.8	5471.98	5474.21	5473.88	5474.62	0.015042	5.14	72.97	49.81	0.75
B_Reach	10100	100-yr	560.6	5471.98	5474.8	5474.32	5475.25	0.011978	5.35	104.75	56.62	0.69
B_Reach	10100	500-yr	1443.2	5471.98	5476.71	5475.68	5477.38	0.007931	6.6	218.73	62.3	0.62
B_Reach	10000	2-yr	15.2	5468.68	5469.32	5469.19	5469.43	0.01741	2.69	5.66	11.29	0.67
B_Reach	10000	5-yr	69.2	5468.68	5470.05	5469.87	5470.39	0.019451	4.65	14.88	13.85	0.79

B_Reach	10000	10-yr	115.6	5468.68	5470.47	5470.28	5470.94	0.019992	5.51	20.98	15.33	0.83
B_Reach	10000	25-yr	193.5	5468.68	5471.1		5471.68	0.019107	6.1	31.72	19.26	0.84
B_Reach	10000	50-yr	374.8	5468.68	5471.98	5471.84	5472.77	0.022088	7.13	52.58	28.5	0.92
B_Reach	10000	100-yr	560.6	5468.68	5472.51	5472.47	5473.55	0.023843	8.18	68.5	31.92	0.98
B_Reach	10000	500-yr	1443.2	5468.68	5474.39	5474.39	5476.05	0.021902	10.34	139.58	42.68	1.01
B_Reach	9900	2-yr	15.2	5466.72	5467.29		5467.41	0.023961	2.76	5.51	13.72	0.77
B_Reach	9900	5-yr	69.2	5466.72	5467.92	5467.83	5468.24	0.023594	4.55	15.2	17.31	0.86
B_Reach	9900	10-yr	115.6	5466.72	5468.24	5468.17	5468.72	0.024939	5.52	20.96	18.51	0.91
B_Reach	9900	25-yr	193.5	5466.72	5468.63	5468.63	5469.35	0.028581	6.84	28.29	19.85	1.01
B_Reach	9900	50-yr	374.8	5466.72	5469.46	5469.46	5470.33	0.027021	7.47	50.14	29.53	1.01
B_Reach	9900	100-yr	560.6	5466.72	5470.03	5470.03	5471.1	0.025168	8.28	67.74	32.32	1.01
B_Reach	9900	500-yr	1443.2	5466.72	5471.41	5471.86	5473.2	0.038239	10.75	134.23	60.36	1.27
B_Reach	9800	2-yr	15.2	5464.23	5464.81	5464.75	5464.88	0.026465	2.23	6.82	25.2	0.75
B_Reach	9800	5-yr	69.2	5464.23	5465.17	5465.14	5465.42	0.03403	3.99	17.34	32.1	0.96
B_Reach	9800	10-yr	115.6	5464.23	5465.38	5465.38	5465.73	0.035352	4.74	24.39	35.81	1.01
B_Reach	9800	25-yr	193.5	5464.23	5465.68	5465.71	5466.12	0.035683	5.31	36.46	45.42	1.04
B_Reach	9800	50-yr	374.8	5464.23	5465.99	5466.16	5466.81	0.048142	7.24	51.75	50.42	1.26
B_Reach	9800	100-yr	560.6	5464.23	5466.22	5466.54	5467.43	0.056683	8.8	63.68	52.08	1.4
B_Reach	9800	500-yr	1443.2	5464.23	5467.43	5467.84	5469.21	0.041708	10.7	134.91	64.71	1.31
B_Reach	9700	2-yr	15.2	5461	5461.46	5461.45	5461.62	0.041167	3.14	4.84	14.91	0.97
B_Reach	9700	5-yr	69.2	5461	5462.07	5462.01	5462.41	0.026532	4.69	14.75	17.67	0.9
B_Reach	9700	10-yr	115.6	5461	5462.48	5462.35	5462.9	0.021139	5.18	22.3	19.23	0.85
B_Reach	9700	25-yr	193.5	5461	5463.01	5462.81	5463.54	0.020655	5.81	33.29	23.68	0.86
B_Reach	9700	50-yr	374.8	5461	5463.83	5463.7	5464.34	0.02197	5.73	65.38	50.21	0.89
B_Reach	9700	100-yr	560.6	5461	5464.3	5464.18	5464.84	0.021797	5.92	94.75	69.27	0.89
B_Reach	9700	500-yr	1443.2	5461	5465.32	5465.32	5466.48	0.023386	8.63	167.18	72.53	1
B_Reach	9600	2-yr	15.2	5458.13	5458.91	5458.78	5459.02	0.017637	2.74	5.55	11.06	0.68
B_Reach	9600	5-yr	69.2	5458.13	5459.59	5459.48	5459.96	0.022816	4.85	14.28	14.41	0.86
B_Reach	9600	10-yr	115.6	5458.13	5459.91	5459.88	5460.48	0.027626	6.06	19.09	15.84	0.97
B_Reach	9600	25-yr	193.5	5458.13	5460.51	5460.51	5461.05	0.030601	5.86	33	31.35	1.01
B_Reach	9600	50-yr	374.8	5458.13	5461.23	5461.23	5461.83	0.028647	6.26	59.88	49.23	1
B_Reach	9600	100-yr	560.6	5458.13	5461.62	5461.62	5462.35	0.0282	6.86	81.71	57.89	1.02
B_Reach	9600	500-yr	1443.2	5458.13	5462.94	5462.95	5464.13	0.023281	8.77	164.48	69.47	1
B_Reach	9500	2-yr	15.2	5456.14	5456.64		5456.74	0.030783	2.6	5.85	19.43	0.83
B_Reach	9500	5-yr	69.2	5456.14	5457.12	5457.08	5457.37	0.029056	3.97	17.44	29.24	0.91
B_Reach	9500	10-yr	115.6	5456.14	5457.37	5457.31	5457.7	0.026632	4.64	24.91	30.87	0.91
B_Reach	9500	25-yr	193.5	5456.14	5457.69	5457.64	5458.16	0.02567	5.46	35.41	33.34	0.93
B_Reach	9500	50-yr	374.8	5456.14	5458.29	5458.22	5458.98	0.023321	6.65	56.32	36.52	0.94
B_Reach	9500	100-yr	560.6	5456.14	5458.86	5458.75	5459.65	0.021905	7.16	78.33	43.33	0.94
B_Reach	9500	500-yr	1443.2	5456.14	5460.31	5460.39	5461.72	0.024601	9.54	151.31	58.98	1.05
B_Reach	9400	2-yr	15.2	5453.42	5454.02		5454.13	0.022356	2.74	5.54	13.17	0.74
B_Reach	9400	5-yr	69.2	5453.42	5454.71		5455.02	0.019378	4.44	15.6	15.89	0.79
B_Reach	9400	10-yr	115.6	5453.42	5455.15		5455.54	0.01791	5.02	23.01	18.24	0.79
B_Reach	9400	25-yr	193.5	5453.42	5455.84		5456.18	0.01527	4.68	41.36	32.72	0.73
B_Reach	9400	50-yr	374.8	5453.42	5456.47		5457.02	0.016018	5.96	62.9	35.71	0.79
B_Reach	9400	100-yr	560.6	5453.42	5456.98		5457.71	0.017053	6.83	82.04	39.69	0.84
B_Reach	9400	500-yr	1443.2	5453.42	5458.49	5458.51	5459.58	0.018196	8.62	180.11	84.01	0.91
B_Reach	9300	2-yr	15.2	5451.3	5451.97		5452.08	0.019009	2.74	5.55	11.77	0.7
B_Reach	9300	5-yr	69.2	5451.3	5452.67		5453.01	0.020769	4.72	14.67	14.38	0.82
B_Reach	9300	10-yr	115.6	5451.3	5453.08	5452.94	5453.54	0.022123	5.47	21.13	17.35	0.87
B_Reach	9300	25-yr	193.5	5451.3	5453.66	5453.49	5454.19	0.026515	5.87	32.99	28.16	0.96
B_Reach	9300	50-yr	374.8	5451.3	5454.39	5454.34	5455	0.026178	6.27	59.82	46.12	0.97
B_Reach	9300	100-yr	560.6	5451.3	5454.84	5454.84	5455.53	0.028532	6.65	84.31	64.64	1.02
B_Reach	9300	500-yr	1443.2	5451.3	5455.7	5456.07	5457.14	0.033214	9.84	156.18	93.71	1.19
B_Reach	9200	2-yr	15.2	5449.23	5449.9	5449.81	5450.03	0.022468	2.87	5.3	11.8	0.75
B_Reach	9200	5-yr	69.2	5449.23	5450.58		5450.89	0.021366	4.46	15.5	16.95	0.82
B_Reach	9200	10-yr	115.6	5449.23	5450.97		5451.38	0.02085	5.16	22.38	19.25	0.84
B_Reach	9200	25-yr	193.5	5449.23	5451.55	5451.31	5452.02	0.01786	5.48	35.38	27.14	0.81
B_Reach	9200	50-yr	374.8	5449.23	5452.21	5452.21	5452.85	0.017922	6.62	62.82	52.79	0.85
B_Reach	9200	100-yr	560.6	5449.23	5452.7	5452.7	5453.35	0.016911	6.91	93.95	67.23	0.84

B_Reach	9200	500-yr	1443.2	5449.23	5454.1	5453.91	5454.85	0.018451	6.98	207.36	105.72	0.88
B_Reach	9100	2-yr	15.2	5447.39	5448.01		5448.1	0.016672	2.31	6.57	16.32	0.64
B_Reach	9100	5-yr	69.2	5447.39	5448.58		5448.83	0.019588	3.97	17.43	21.59	0.78
B_Reach	9100	10-yr	115.6	5447.39	5448.86	5448.75	5449.23	0.021967	4.89	23.66	23.36	0.86
B_Reach	9100	25-yr	193.5	5447.39	5449.16	5449.16	5449.76	0.029302	6.24	31.02	26.3	1.01
B_Reach	9100	50-yr	374.8	5447.39	5449.85	5449.85	5450.69	0.026089	7.35	51.01	30.88	1.01
B_Reach	9100	100-yr	560.6	5447.39	5450.59	5450.59	5451.38	0.023243	7.14	79.02	50.28	0.96
B_Reach	9100	500-yr	1443.2	5447.39	5451.89	5451.89	5452.91	0.019876	8.41	184.13	89.77	0.94
B_Reach	9000	2-yr	15.7	5444.97	5445.59	5445.57	5445.75	0.034882	3.19	4.92	13.06	0.92
B_Reach	9000	5-yr	71.4	5444.97	5446.29	5446.2	5446.6	0.025442	4.46	16.01	20.2	0.88
B_Reach	9000	10-yr	119.1	5444.97	5446.8		5447.05	0.021126	4.05	29.39	37.23	0.8
B_Reach	9000	25-yr	199.4	5444.97	5447.21	5447	5447.49	0.01686	4.2	47.51	48.16	0.74
B_Reach	9000	50-yr	385.9	5444.97	5447.88	5447.48	5448.23	0.011841	4.75	81.24	52.27	0.67
B_Reach	9000	100-yr	576.9	5444.97	5448.4	5447.88	5448.83	0.010982	5.29	109	56.28	0.67
B_Reach	9000	500-yr	1483.8	5444.97	5449.84	5449.46	5450.57	0.011883	6.92	225.41	108.02	0.74
B_Reach	8900	2-yr	15.7	5442.5	5443.13		5443.25	0.01877	2.7	5.81	12.39	0.7
B_Reach	8900	5-yr	71.4	5442.5	5443.78	5443.68	5444.14	0.023685	4.87	14.66	15.14	0.87
B_Reach	8900	10-yr	119.1	5442.5	5444.14	5444.09	5444.66	0.026546	5.78	20.6	17.82	0.95
B_Reach	8900	25-yr	199.4	5442.5	5444.58	5444.58	5445.32	0.02763	6.91	28.87	19.53	1
B_Reach	8900	50-yr	385.9	5442.5	5445.43	5445.43	5446.47	0.026275	8.19	47.13	23.57	1.02
B_Reach	8900	100-yr	576.9	5442.5	5446.27	5446.27	5447.16	0.026495	7.57	76.24	43.73	1.01
B_Reach	8900	500-yr	1483.8	5442.5	5447.99	5447.99	5449.09	0.017667	8.56	185.19	93.77	0.89
B_Reach	8800	2-yr	15.7	5439.63	5440.35	5440.34	5440.52	0.042881	3.35	4.69	13.52	1
B_Reach	8800	5-yr	71.4	5439.63	5440.94	5440.94	5441.34	0.033733	5.06	14.11	18.16	1.01
B_Reach	8800	10-yr	119.1	5439.63	5441.28	5441.28	5441.8	0.031145	5.75	20.72	20.7	1.01
B_Reach	8800	25-yr	199.4	5439.63	5441.71	5441.74	5442.39	0.030223	6.62	30.12	23.66	1.03
B_Reach	8800	50-yr	385.9	5439.63	5442.3	5442.58	5443.42	0.036897	8.5	45.38	28.31	1.18
B_Reach	8800	100-yr	576.9	5439.63	5442.86	5443.07	5444.11	0.035091	9	64.1	35.31	1.18
B_Reach	8800	500-yr	1483.8	5439.63	5444.39	5444.9	5446.6	0.035019	11.91	124.53	44.59	1.26
B_Reach	8700	2-yr	15.7	5435.92	5436.7	5436.67	5436.88	0.031233	3.41	4.61	10.12	0.89
B_Reach	8700	5-yr	71.4	5435.92	5437.36	5437.4	5437.87	0.035488	5.68	12.56	13.95	1.06
B_Reach	8700	10-yr	119.1	5435.92	5437.72	5437.8	5438.41	0.037016	6.67	17.87	16.05	1.11
B_Reach	8700	25-yr	199.4	5435.92	5438.19	5438.3	5439.12	0.035044	7.74	25.76	17.52	1.12
B_Reach	8700	50-yr	385.9	5435.92	5439.2	5439.2	5440.32	0.026553	8.49	45.45	21.53	1.03
B_Reach	8700	100-yr	576.9	5435.92	5440	5440	5441.18	0.024521	8.73	66.07	28.28	1.01
B_Reach	8700	500-yr	1483.8	5435.92	5442.36	5442.48	5443.97	0.018211	10.25	150.35	59.1	0.93
B_Reach	8600	2-yr	15.7	5432.53	5433.11	5433.11	5433.31	0.041289	3.61	4.35	10.92	1.01
B_Reach	8600	5-yr	71.4	5432.53	5433.77	5433.81	5434.3	0.035878	5.84	12.23	13.06	1.06
B_Reach	8600	10-yr	119.1	5432.53	5434.16	5434.22	5434.87	0.033827	6.75	17.65	14.34	1.07
B_Reach	8600	25-yr	199.4	5432.53	5434.66	5434.78	5435.63	0.034421	7.92	25.19	16.13	1.12
B_Reach	8600	50-yr	385.9	5432.53	5435.38	5435.75	5437.02	0.040613	10.28	37.54	18.06	1.26
B_Reach	8600	100-yr	576.9	5432.53	5436.08	5436.53	5438.06	0.038852	11.3	51.03	20.4	1.26
B_Reach	8600	500-yr	1483.8	5432.53	5438.36	5439.42	5441.45	0.032297	14.15	108.63	41.04	1.22
B_Reach	8500	2-yr	15.7	5426.21	5426.76	5426.84	5427.04	0.106217	4.2	3.74	15.19	1.49
B_Reach	8500	5-yr	71.4	5426.21	5427.1	5427.38	5428.05	0.131757	7.86	9.08	16.82	1.88
B_Reach	8500	10-yr	119.1	5426.21	5427.29	5427.72	5428.72	0.139759	9.6	12.4	17.7	2.02
B_Reach	8500	25-yr	199.4	5426.21	5427.59	5428.15	5429.47	0.134226	11	18.12	20.38	2.06
B_Reach	8500	50-yr	385.9	5426.21	5428.15	5428.91	5430.68	0.108378	12.76	30.25	22.98	1.96
B_Reach	8500	100-yr	576.9	5426.21	5428.54	5429.54	5431.88	0.107109	14.66	39.35	23.75	2.01
B_Reach	8500	500-yr	1483.8	5426.21	5429.98	5431.79	5435.95	0.098191	19.6	75.69	26.69	2.05
B_Reach	8400	2-yr	15.7	5421.03	5421.98	5421.93	5422.16	0.031629	3.4	4.61	10.07	0.89
B_Reach	8400	5-yr	71.4	5421.03	5422.6	5422.6	5423.02	0.03455	5.22	13.69	16.84	1.02
B_Reach	8400	10-yr	119.1	5421.03	5422.95	5422.95	5423.5	0.031171	5.95	20.01	18.62	1.01
B_Reach	8400	25-yr	199.4	5421.03	5423.5	5423.5	5424.12	0.029824	6.36	31.37	25.58	1.01
B_Reach	8400	50-yr	385.9	5421.03	5424.15	5424.21	5425.11	0.029561	7.87	49.01	28.62	1.06
B_Reach	8400	100-yr	576.9	5421.03	5424.61	5424.79	5425.92	0.031995	9.2	62.71	30.66	1.13
B_Reach	8400	500-yr	1483.8	5421.03	5426.01	5426.9	5428.79	0.04274	13.38	110.92	38.18	1.38
B_Reach	8300	2-yr	15.7	5417.59	5418.26	5418.26	5418.42	0.04502	3.17	4.96	16.15	1.01
B_Reach	8300	5-yr	71.4	5417.59	5418.76	5418.81	5419.16	0.043241	5.09	14.03	21.69	1.12

B_Reach	8300	10-yr	119.1	5417.59	5418.97	5419.11	5419.59	0.050663	6.31	18.88	23.82	1.25
B_Reach	8300	25-yr	199.4	5417.59	5419.27	5419.56	5420.15	0.054704	7.51	26.54	27.26	1.34
B_Reach	8300	50-yr	385.9	5417.59	5419.79	5420.13	5420.93	0.062751	8.54	45.17	42.5	1.46
B_Reach	8300	100-yr	576.9	5417.59	5420.13	5420.55	5421.53	0.063594	9.49	60.8	49.24	1.5
B_Reach	8300	500-yr	1483.8	5417.59	5421.14	5421.88	5423.64	0.061135	12.69	116.92	58.7	1.58
B_Reach	8200	2-yr	15.7	5413.95	5414.65	5414.54	5414.78	0.021023	2.95	5.32	10.86	0.74
B_Reach	8200	5-yr	71.4	5413.95	5415.34	5415.26	5415.64	0.0258	4.39	16.27	21.11	0.88
B_Reach	8200	10-yr	119.1	5413.95	5415.67	5415.6	5416.04	0.027152	4.89	24.37	27.88	0.92
B_Reach	8200	25-yr	199.4	5413.95	5416.1	5416.03	5416.5	0.026489	5.07	39.35	42.03	0.92
B_Reach	8200	50-yr	385.9	5413.95	5416.63	5416.6	5417.18	0.027304	5.98	64.57	55.02	0.97
B_Reach	8200	100-yr	576.9	5413.95	5417	5416.98	5417.69	0.026039	6.67	86.44	60.2	0.98
B_Reach	8200	500-yr	1483.8	5413.95	5418.12	5418.22	5419.4	0.02673	9.08	163.46	72.85	1.07
B_Reach	8100	2-yr	15.7	5411.21	5411.76	5411.75	5411.92	0.041239	3.28	4.79	13.91	0.98
B_Reach	8100	5-yr	71.4	5411.21	5412.32	5412.32	5412.69	0.033822	4.92	14.52	19.68	1.01
B_Reach	8100	10-yr	119.1	5411.21	5412.67	5412.67	5413.12	0.031421	5.42	21.98	24.24	1
B_Reach	8100	25-yr	199.4	5411.21	5413.09	5413.09	5413.6	0.031537	5.75	34.67	35.04	1.02
B_Reach	8100	50-yr	385.9	5411.21	5413.65	5413.65	5414.41	0.027666	6.99	55.23	37.59	1.02
B_Reach	8100	100-yr	576.9	5411.21	5414.13	5414.13	5415.08	0.025661	7.84	73.61	39.71	1.01
B_Reach	8100	500-yr	1483.8	5411.21	5415.89	5415.75	5417.18	0.0191	9.09	163.35	56.72	0.94
B_Reach	8000	2-yr	15.7	5406.97	5407.55	5407.55	5407.74	0.042559	3.47	4.53	12.35	1.01
B_Reach	8000	5-yr	71.4	5406.97	5408.08	5408.18	5408.66	0.047893	6.11	11.68	14.62	1.21
B_Reach	8000	10-yr	119.1	5406.97	5408.38	5408.57	5409.21	0.048614	7.29	16.34	15.75	1.26
B_Reach	8000	25-yr	199.4	5406.97	5408.86	5409.08	5409.91	0.042335	8.2	24.33	17.53	1.23
B_Reach	8000	50-yr	385.9	5406.97	5409.67	5409.98	5411.14	0.03881	9.72	39.71	20.45	1.23
B_Reach	8000	100-yr	576.9	5406.97	5410.39	5410.69	5412.09	0.033541	10.44	55.23	22.59	1.18
B_Reach	8000	500-yr	1483.8	5406.97	5413.16	5413.16	5415.1	0.021258	11.18	132.69	34.41	1
B_Reach	7900	2-yr	15.7	5402.76	5403.37	5403.38	5403.54	0.041366	3.3	4.76	13.72	0.99
B_Reach	7900	5-yr	71.4	5402.76	5403.95	5403.97	5404.32	0.03845	4.93	14.47	21.52	1.06
B_Reach	7900	10-yr	119.1	5402.76	5404.2	5404.27	5404.74	0.03977	5.87	20.3	23.83	1.12
B_Reach	7900	25-yr	199.4	5402.76	5404.53	5404.69	5405.27	0.048981	6.91	28.86	30.96	1.26
B_Reach	7900	50-yr	385.9	5402.76	5404.91	5405.28	5406.26	0.061992	9.33	41.36	33.62	1.48
B_Reach	7900	100-yr	576.9	5402.76	5405.17	5405.78	5407.22	0.07546	11.5	50.18	34.41	1.68
B_Reach	7900	500-yr	1483.8	5402.76	5406.15	5407.55	5410.84	0.095578	17.38	85.37	36.98	2.02
B_Reach	7800	2-yr	15.7	5398.8	5399.38	5399.35	5399.55	0.03265	3.34	4.7	11.03	0.9
B_Reach	7800	5-yr	71.4	5398.8	5400	5400.04	5400.51	0.037361	5.78	12.36	13.86	1.08
B_Reach	7800	10-yr	119.1	5398.8	5400.39	5400.44	5401.06	0.033915	6.57	18.13	15.45	1.07
B_Reach	7800	25-yr	199.4	5398.8	5401.01	5401.01	5401.72	0.028296	6.77	29.44	20.91	1.01
B_Reach	7800	50-yr	385.9	5398.8	5401.84	5401.84	5402.79	0.025971	7.84	49.19	26.19	1.01
B_Reach	7800	100-yr	576.9	5398.8	5402.45	5402.47	5403.64	0.024552	8.76	65.89	28.31	1.01
B_Reach	7800	500-yr	1483.8	5398.8	5404.6	5404.6	5406.43	0.021333	10.86	136.62	37.85	1.01
B_Reach	7700	2-yr	15.7	5395.83	5396.41	5396.36	5396.53	0.027615	2.71	5.78	16.54	0.81
B_Reach	7700	5-yr	71.4	5395.83	5396.91	5396.89	5397.25	0.031876	4.74	15.08	20.71	0.98
B_Reach	7700	10-yr	119.1	5395.83	5397.18	5397.19	5397.68	0.032793	5.69	20.93	22.18	1.03
B_Reach	7700	25-yr	199.4	5395.83	5397.44	5397.6	5398.29	0.042006	7.39	26.98	23.13	1.21
B_Reach	7700	50-yr	385.9	5395.83	5398.02	5398.34	5399.41	0.044672	9.45	40.82	25.05	1.31
B_Reach	7700	100-yr	576.9	5395.83	5398.48	5398.96	5400.34	0.045755	10.93	52.79	26.28	1.36
B_Reach	7700	500-yr	1483.8	5395.83	5400.3	5401.18	5403.23	0.048626	13.75	107.91	39.55	1.47
B_Reach	7600	2-yr	15.7	5392.27	5392.91	5392.91	5393.1	0.043604	3.43	4.57	12.72	1.01
B_Reach	7600	5-yr	71.4	5392.27	5393.56	5393.56	5393.94	0.034627	4.92	14.52	19.74	1.01
B_Reach	7600	10-yr	119.1	5392.27	5393.9	5393.91	5394.35	0.033618	5.37	22.16	25.85	1.02
B_Reach	7600	25-yr	199.4	5392.27	5394.28	5394.28	5394.84	0.030709	6.01	33.16	30.5	1.02
B_Reach	7600	50-yr	385.9	5392.27	5394.87	5394.9	5395.72	0.028539	7.4	52.17	33.08	1.04
B_Reach	7600	100-yr	576.9	5392.27	5395.3	5395.42	5396.47	0.03003	8.67	66.56	34.33	1.1
B_Reach	7600	500-yr	1483.8	5392.27	5396.81	5397.29	5399.06	0.032921	12.06	123.07	40.96	1.23
B_Reach	7500	2-yr	15.7	5387.03	5387.76	5387.79	5387.97	0.061124	3.68	4.27	13.57	1.16
B_Reach	7500	5-yr	71.4	5387.03	5388.16	5388.32	5388.71	0.088056	5.96	11.98	24.54	1.5
B_Reach	7500	10-yr	119.1	5387.03	5388.35	5388.56	5389.09	0.092428	6.86	17.36	29.89	1.59
B_Reach	7500	25-yr	199.4	5387.03	5388.56	5388.88	5389.66	0.102224	8.43	23.66	32.19	1.73
B_Reach	7500	50-yr	385.9	5387.03	5388.92	5389.46	5390.73	0.102307	10.79	35.77	33.41	1.84
B_Reach	7500	100-yr	576.9	5387.03	5389.28	5389.97	5391.53	0.090111	12.03	47.97	34.38	1.79

B_Reach	7500	500-yr	1483.8	5387.03	5390.61	5391.71	5394.26	0.07085	15.34	96.74	39.58	1.73
B_Reach	7400	2-yr	15.7	5382.85	5383.4	5383.4	5383.57	0.0431	3.35	4.68	13.55	1.01
B_Reach	7400	5-yr	71.4	5382.85	5383.97	5383.97	5384.38	0.033167	5.12	13.96	17.42	1.01
B_Reach	7400	10-yr	119.1	5382.85	5384.31	5384.31	5384.86	0.030432	5.95	20.02	18.49	1.01
B_Reach	7400	25-yr	199.4	5382.85	5384.79	5384.79	5385.5	0.028054	6.79	29.37	20.76	1.01
B_Reach	7400	50-yr	385.9	5382.85	5385.61	5385.61	5386.64	0.025413	8.15	47.35	23.22	1.01
B_Reach	7400	100-yr	576.9	5382.85	5386.27	5386.27	5387.55	0.024111	9.08	63.56	25.19	1.01
B_Reach	7400	500-yr	1483.8	5382.85	5388.57	5388.59	5390.65	0.021484	11.57	128.21	31.3	1.01
B_Reach	7300	2-yr	15.7	5378.56	5379.28	5379.23	5379.46	0.027948	3.39	4.63	9.47	0.85
B_Reach	7300	5-yr	71.4	5378.56	5379.88	5379.99	5380.49	0.045827	6.27	11.4	13.28	1.19
B_Reach	7300	10-yr	119.1	5378.56	5380.22	5380.43	5381.06	0.048354	7.38	16.14	15.25	1.26
B_Reach	7300	25-yr	199.4	5378.56	5380.66	5380.94	5381.74	0.052121	8.35	23.88	19.85	1.34
B_Reach	7300	50-yr	385.9	5378.56	5381.27	5381.72	5382.95	0.055401	10.43	37.01	22.8	1.44
B_Reach	7300	100-yr	576.9	5378.56	5381.75	5382.39	5383.96	0.055617	11.92	48.39	24.19	1.49
B_Reach	7300	500-yr	1483.8	5378.56	5383.47	5384.67	5387.29	0.053538	15.68	94.62	29.78	1.55
B_Reach	7200	2-yr	15.7	5376.2	5376.96	5376.87	5377.07	0.020406	2.64	5.96	13.93	0.71
B_Reach	7200	5-yr	71.4	5376.2	5377.55	5377.47	5377.91	0.025408	4.85	14.72	15.98	0.89
B_Reach	7200	10-yr	119.1	5376.2	5377.83	5377.84	5378.42	0.030662	6.13	19.44	17.02	1.01
B_Reach	7200	25-yr	199.4	5376.2	5378.34	5378.34	5379.1	0.027864	7.01	28.46	18.81	1
B_Reach	7200	50-yr	385.9	5376.2	5379.21	5379.21	5380.29	0.025512	8.34	46.29	21.75	1.01
B_Reach	7200	100-yr	576.9	5376.2	5379.93	5379.93	5381.25	0.024001	9.21	62.67	23.99	1
B_Reach	7200	500-yr	1483.8	5376.2	5383.06	5383.07	5383.99	0.025984	7.73	192	106.02	1.01
B_Reach	7112.015	2-yr	15.7	5374.75	5375.35	5375.25	5375.41	0.017184	1.95	8.07	26.57	0.62
B_Reach	7112.015	5-yr	71.4	5374.75	5375.79		5375.93	0.018929	3.02	23.64	43.21	0.72
B_Reach	7112.015	10-yr	119.1	5374.75	5376.03	5375.86	5376.21	0.018645	3.44	34.62	51.35	0.74
B_Reach	7112.015	25-yr	199.4	5374.75	5376.3	5376.13	5376.56	0.017364	4.08	48.86	53.09	0.75
B_Reach	7112.015	50-yr	385.9	5374.75	5376.39	5376.56	5377.2	0.048501	7.2	53.61	53.69	1.27
B_Reach	7112.015	100-yr	576.9	5374.75	5376.54	5376.93	5377.9	0.069636	9.35	61.7	54.72	1.55
B_Reach	7112.015	500-yr	1483.8	5374.75	5377.39	5378.26	5380.18	0.075517	13.4	110.76	60.58	1.75
B_Reach	6999.715	2-yr	15.7	5372.37	5372.84	5372.79	5372.91	0.029706	2.24	7	28	0.79
B_Reach	6999.715	5-yr	71.4	5372.37	5373.23	5373.18	5373.36	0.02813	2.87	24.88	66.08	0.82
B_Reach	6999.715	10-yr	119.1	5372.37	5373.37	5373.32	5373.55	0.031093	3.38	35.26	79.07	0.89
B_Reach	6999.715	25-yr	199.4	5372.37	5373.52	5373.52	5373.78	0.037967	4.05	49.2	97.55	1.01
B_Reach	6999.715	50-yr	385.9	5372.37	5373.81	5373.83	5374.17	0.035916	4.83	79.91	116.85	1.03
B_Reach	6999.715	100-yr	576.9	5372.37	5374.02	5374.02	5374.49	0.032619	5.49	104.99	117.52	1.02
B_Reach	6999.715	500-yr	1483.8	5372.37	5374.82	5374.83	5375.68	0.026055	7.43	199.76	119.68	1.01
B_Reach	6899.505	2-yr	15.7	5369.71	5370.38		5370.43	0.02081	1.83	8.57	35.61	0.66
B_Reach	6899.505	5-yr	71.4	5369.71	5370.72		5370.84	0.022462	2.74	26.1	62.96	0.75
B_Reach	6899.505	10-yr	119.1	5369.71	5370.93		5371.06	0.020116	2.85	41.73	87.06	0.73
B_Reach	6899.505	25-yr	199.4	5369.71	5371.15	5371	5371.31	0.016942	3.18	62.8	98.09	0.7
B_Reach	6899.505	50-yr	385.9	5369.71	5371.53	5371.29	5371.76	0.013912	3.81	101.22	103.49	0.68
B_Reach	6899.505	100-yr	576.9	5369.71	5371.84	5371.53	5372.13	0.012704	4.34	133.01	104.55	0.68
B_Reach	6899.505	500-yr	1483.8	5369.71	5372.81	5372.4	5373.42	0.013057	6.29	236.08	108.1	0.75
B_Reach	6800	2-yr	15.7	5367.08	5367.59	5367.57	5367.76	0.035849	3.29	4.78	12.44	0.94
B_Reach	6800	5-yr	71.4	5367.08	5368.3	5368.2	5368.51	0.024253	3.69	19.35	31.58	0.83
B_Reach	6800	10-yr	119.1	5367.08	5368.56	5368.47	5368.83	0.024643	4.19	28.41	38.69	0.86
B_Reach	6800	25-yr	199.4	5367.08	5368.87	5368.8	5369.2	0.026851	4.63	43.06	53.9	0.91
B_Reach	6800	50-yr	385.9	5367.08	5369.27	5369.26	5369.8	0.029011	5.84	66.05	61.68	0.99
B_Reach	6800	100-yr	576.9	5367.08	5369.63	5369.63	5370.26	0.029487	6.33	91.15	76.41	1.02
B_Reach	6800	500-yr	1483.8	5367.08	5370.87	5370.72	5371.83	0.018946	7.88	188.21	80.86	0.91
B_Reach	6700	2-yr	15.7	5364.01	5364.85		5364.98	0.021858	2.98	5.27	10.85	0.75
B_Reach	6700	5-yr	71.4	5364.01	5365.6	5365.53	5365.9	0.02793	4.38	16.32	22.67	0.91
B_Reach	6700	10-yr	119.1	5364.01	5365.98	5365.91	5366.26	0.026735	4.26	27.96	39.29	0.89
B_Reach	6700	25-yr	199.4	5364.01	5366.31	5366.21	5366.66	0.024112	4.73	42.15	46.68	0.88
B_Reach	6700	50-yr	385.9	5364.01	5366.82	5366.7	5367.34	0.020946	5.78	66.72	48.83	0.87
B_Reach	6700	100-yr	576.9	5364.01	5367.33	5367.09	5367.94	0.016873	6.29	91.71	49.94	0.82
B_Reach	6700	500-yr	1483.8	5364.01	5368.8	5368.51	5370.03	0.016747	8.87	167.19	52.88	0.88
B_Reach	6600	2-yr	15.7	5362.32	5362.81		5362.91	0.019537	2.51	6.27	15.53	0.69
B_Reach	6600	5-yr	71.4	5362.32	5363.46		5363.72	0.017363	4.03	17.73	19.48	0.74

B_Reach	6600	10-yr	119.1	5362.32	5363.98		5364.23	0.015963	4.02	29.61	30.66	0.72
B_Reach	6600	25-yr	199.4	5362.32	5364.4		5364.71	0.016031	4.45	44.77	39.9	0.74
B_Reach	6600	50-yr	385.9	5362.32	5364.94		5365.43	0.017505	5.63	68.57	45.83	0.81
B_Reach	6600	100-yr	576.9	5362.32	5365.23	5365.14	5366	0.022425	7.03	82.04	47.19	0.94
B_Reach	6600	500-yr	1483.8	5362.32	5366.65	5366.65	5368.09	0.022151	9.61	154.33	54.67	1.01
B_Reach	6500	2-yr	15.7	5360.02	5360.63	5360.55	5360.76	0.023558	2.83	5.55	13.21	0.77
B_Reach	6500	5-yr	71.4	5360.02	5361.24	5361.18	5361.59	0.026535	4.74	15.05	17.93	0.91
B_Reach	6500	10-yr	119.1	5360.02	5361.6	5361.59	5362.03	0.031293	5.27	22.58	25.94	1
B_Reach	6500	25-yr	199.4	5360.02	5362	5362	5362.5	0.031628	5.66	35.25	36.69	1.02
B_Reach	6500	50-yr	385.9	5360.02	5362.63	5362.62	5363.18	0.02985	5.97	64.62	59.21	1.01
B_Reach	6500	100-yr	576.9	5360.02	5363.05	5362.98	5363.68	0.023227	6.37	90.58	62.25	0.93
B_Reach	6500	500-yr	1483.8	5360.02	5364.6	5364.21	5365.54	0.014285	7.78	190.79	66.57	0.81
B_Reach	6400	2-yr	15.7	5358.28	5358.95		5359.01	0.013178	2	7.87	20.47	0.57
B_Reach	6400	5-yr	71.4	5358.28	5359.54	5359.3	5359.68	0.013569	3	23.83	34.29	0.63
B_Reach	6400	10-yr	119.1	5358.28	5359.82		5360.01	0.013239	3.5	34	37.98	0.65
B_Reach	6400	25-yr	199.4	5358.28	5360.17	5359.86	5360.44	0.013085	4.18	47.7	40.45	0.68
B_Reach	6400	50-yr	385.9	5358.28	5360.75		5361.19	0.013844	5.34	72.28	44.16	0.74
B_Reach	6400	100-yr	576.9	5358.28	5361.14		5361.78	0.015919	6.41	90.04	46.33	0.81
B_Reach	6400	500-yr	1483.8	5358.28	5362.74	5362.74	5363.7	0.024461	7.88	188.28	98.34	1
B_Reach	6300	2-yr	15.7	5356.21	5356.73	5356.72	5356.87	0.040134	3.02	5.2	16.69	0.95
B_Reach	6300	5-yr	71.4	5356.21	5357.22	5357.22	5357.59	0.035105	4.88	14.64	20.48	1.02
B_Reach	6300	10-yr	119.1	5356.21	5357.57	5357.57	5358.02	0.032102	5.36	22.24	25.18	1
B_Reach	6300	25-yr	199.4	5356.21	5357.99	5357.99	5358.5	0.030128	5.76	34.6	33.35	1
B_Reach	6300	50-yr	385.9	5356.21	5358.64	5358.64	5359.19	0.030865	5.97	64.63	60.18	1.02
B_Reach	6300	100-yr	576.9	5356.21	5359.08	5359.08	5359.64	0.029518	6	96.15	86.12	1
B_Reach	6300	500-yr	1483.8	5356.21	5360	5360.09	5360.87	0.031921	7.51	197.66	134.29	1.09
B_Reach	6200	2-yr	15.7	5354.05	5354.56		5354.6	0.014321	1.56	10.05	40.27	0.55
B_Reach	6200	5-yr	71.4	5354.05	5354.95	5354.78	5355.05	0.013881	2.48	28.74	55.88	0.61
B_Reach	6200	10-yr	119.1	5354.05	5355.18	5354.96	5355.3	0.012524	2.85	41.82	61.17	0.61
B_Reach	6200	25-yr	199.4	5354.05	5355.49	5355.18	5355.65	0.011007	3.22	61.85	67.95	0.6
B_Reach	6200	50-yr	385.9	5354.05	5356.04	5355.62	5356.24	0.009588	3.55	108.79	93.15	0.58
B_Reach	6200	100-yr	576.9	5354.05	5356.4	5355.91	5356.65	0.00921	4.02	143.63	98.86	0.59
B_Reach	6200	500-yr	1483.8	5354.05	5357.56	5356.96	5357.95	0.009925	5.02	295.53	154.3	0.64
B_Reach	6100	2-yr	15.7	5352.06	5352.68		5352.76	0.024493	2.34	6.7	21.81	0.74
B_Reach	6100	5-yr	71.4	5352.06	5353.19	5353.06	5353.38	0.020345	3.54	20.17	30.52	0.77
B_Reach	6100	10-yr	119.1	5352.06	5353.48		5353.7	0.020906	3.79	31.46	43.85	0.79
B_Reach	6100	25-yr	199.4	5352.06	5353.74	5353.64	5354.06	0.024283	4.53	44.05	52.5	0.87
B_Reach	6100	50-yr	385.9	5352.06	5354.14	5354.13	5354.65	0.029291	5.77	66.94	63.8	0.99
B_Reach	6100	100-yr	576.9	5352.06	5354.47	5354.47	5355.11	0.028941	6.42	89.93	72.4	1.01
B_Reach	6100	500-yr	1483.8	5352.06	5355.66	5355.66	5356.39	0.02677	6.83	217.23	151.17	1
B_Reach	6000	2-yr	15.7	5350.18	5350.79		5350.85	0.015219	1.9	8.25	25.75	0.59
B_Reach	6000	5-yr	71.4	5350.18	5351.26		5351.39	0.01932	2.85	25.08	51.05	0.72
B_Reach	6000	10-yr	119.1	5350.18	5351.47	5351.33	5351.63	0.020437	3.19	37.39	67.09	0.75
B_Reach	6000	25-yr	199.4	5350.18	5351.75	5351.57	5351.93	0.018334	3.35	59.44	90.96	0.73
B_Reach	6000	50-yr	385.9	5350.18	5352.13		5352.38	0.017241	3.99	96.66	108.81	0.75
B_Reach	6000	100-yr	576.9	5350.18	5352.4	5352.2	5352.72	0.01625	4.55	126.73	112.01	0.75
B_Reach	6000	500-yr	1483.8	5350.18	5353.46	5353.02	5354.01	0.012169	5.93	250.15	119.4	0.72
B_Reach	5900	2-yr	15.7	5347.69	5348.23	5348.23	5348.34	0.048885	2.65	5.92	26.81	1
B_Reach	5900	5-yr	71.4	5347.69	5348.62	5348.59	5348.84	0.034552	3.78	18.89	38.71	0.95
B_Reach	5900	10-yr	119.1	5347.69	5348.83	5348.8	5349.12	0.031216	4.3	27.73	43.38	0.95
B_Reach	5900	25-yr	199.4	5347.69	5349.07	5349.07	5349.49	0.033097	5.15	38.74	48.19	1.01
B_Reach	5900	50-yr	385.9	5347.69	5349.56	5349.56	5350.1	0.030457	5.93	65.06	61.39	1.02
B_Reach	5900	100-yr	576.9	5347.69	5349.89	5349.89	5350.59	0.027975	6.69	86.19	63.54	1.01
B_Reach	5900	500-yr	1483.8	5347.69	5351.13	5351.13	5352.32	0.023006	8.75	169.65	72.02	1
B_Reach	5815.671	2-yr	15.7	5344.75	5345.62	5345.47	5345.73	0.01634	2.72	5.77	10.94	0.66
B_Reach	5815.671	5-yr	71.4	5344.75	5346.44	5346.21	5346.68	0.019746	3.89	18.36	23.19	0.77
B_Reach	5815.671	10-yr	119.1	5344.75	5346.87	5346.68	5347.07	0.018991	3.59	33.15	46.07	0.75
B_Reach	5815.671	25-yr	199.4	5344.75	5347.22	5347	5347.46	0.015856	3.87	51.56	56.1	0.71
B_Reach	5815.671	50-yr	385.9	5344.75	5347.69	5347.44	5348.07	0.015487	4.92	78.42	58.23	0.75
B_Reach	5815.671	100-yr	576.9	5344.75	5348.02	5347.8	5348.56	0.017148	5.9	97.82	59.65	0.81

B_Reach	4100	500-yr	1508.3	5273.64	5278.42	5279.69	5282.62	0.054107	17.14	101.69	49.84	1.57
B_Reach	4000	2-yr	16	5268.47	5268.87	5268.88	5269.01	0.055211	3.01	5.32	21.97	1.08
B_Reach	4000	5-yr	72.8	5268.47	5269.16	5269.32	5269.69	0.087483	5.85	12.44	26.75	1.51
B_Reach	4000	10-yr	121.3	5268.47	5269.32	5269.57	5270.12	0.099151	7.19	16.87	29.25	1.67
B_Reach	4000	25-yr	202.9	5268.47	5269.52	5269.88	5270.71	0.109206	8.75	23.19	32.15	1.82
B_Reach	4000	50-yr	392.6	5268.47	5269.9	5270.45	5271.74	0.108277	10.89	36.06	35.6	1.91
B_Reach	4000	100-yr	586.7	5268.47	5270.23	5270.93	5272.56	0.098377	12.25	47.91	36.74	1.89
B_Reach	4000	500-yr	1508.3	5268.47	5271.32	5272.7	5275.61	0.093907	16.62	90.75	42.11	2
B_Reach	3900	2-yr	16	5263.04	5263.58	5263.51	5263.67	0.022338	2.47	6.47	18.19	0.73
B_Reach	3900	5-yr	72.8	5263.04	5264.04	5264.02	5264.4	0.029839	4.76	15.31	19.77	0.95
B_Reach	3900	10-yr	121.3	5263.04	5264.31	5264.33	5264.84	0.031906	5.84	20.79	20.61	1.02
B_Reach	3900	25-yr	202.9	5263.04	5264.77	5264.78	5265.44	0.0296	6.58	30.83	23.96	1.02
B_Reach	3900	50-yr	392.6	5263.04	5265.51	5265.57	5266.41	0.029065	7.62	51.54	31.66	1.05
B_Reach	3900	100-yr	586.7	5263.04	5266.06	5266.17	5267.1	0.03085	8.17	71.8	41.62	1.1
B_Reach	3900	500-yr	1508.3	5263.04	5267.47	5267.85	5269.19	0.037735	10.52	143.36	66.41	1.26
B_Reach	3800	2-yr	16	5259.98	5260.37	5260.37	5260.47	0.05002	2.53	6.32	31.37	0.99
B_Reach	3800	5-yr	72.8	5259.98	5260.71	5260.71	5260.95	0.039411	3.88	18.77	40.85	1.01
B_Reach	3800	10-yr	121.3	5259.98	5260.9	5260.91	5261.21	0.040289	4.49	26.99	47.76	1.05
B_Reach	3800	25-yr	202.9	5259.98	5261.06	5261.16	5261.58	0.051034	5.84	34.77	49.53	1.23
B_Reach	3800	50-yr	392.6	5259.98	5261.35	5261.59	5262.31	0.061869	7.88	49.8	52.03	1.42
B_Reach	3800	100-yr	586.7	5259.98	5261.63	5262.02	5262.91	0.059303	9.06	64.74	53	1.45
B_Reach	3800	500-yr	1508.3	5259.98	5262.6	5263.15	5264.6	0.05631	11.34	132.95	74.62	1.5
B_Reach	3700	2-yr	16	5256.52	5257.2	5257.11	5257.26	0.021536	2.09	7.64	26.71	0.69
B_Reach	3700	5-yr	72.8	5256.52	5257.66	5257.52	5257.79	0.017571	2.9	25.09	46.11	0.69
B_Reach	3700	10-yr	121.3	5256.52	5257.89	5257.72	5258.06	0.017649	3.31	36.68	55.61	0.72
B_Reach	3700	25-yr	202.9	5256.52	5258.14	5257.97	5258.38	0.018613	3.91	51.86	63.57	0.76
B_Reach	3700	50-yr	392.6	5256.52	5258.58	5258.42	5258.92	0.019869	4.66	84.21	83.36	0.82
B_Reach	3700	100-yr	586.7	5256.52	5258.9	5258.75	5259.32	0.019681	5.23	112.14	92.73	0.84
B_Reach	3700	500-yr	1508.3	5256.52	5260	5259.74	5260.72	0.016761	6.83	221	108.94	0.84
B_Reach	3600	2-yr	16	5253.83	5255.01	5254.91	5255.1	0.021902	2.41	6.65	18.64	0.71
B_Reach	3600	5-yr	72.8	5253.83	5255.46	5255.4	5255.63	0.027286	3.24	22.44	48.14	0.84
B_Reach	3600	10-yr	121.3	5253.83	5255.67	5255.58	5255.87	0.02754	3.63	33.38	60.9	0.86
B_Reach	3600	25-yr	202.9	5253.83	5255.88	5255.83	5256.17	0.026677	4.31	47.11	65.01	0.89
B_Reach	3600	50-yr	392.6	5253.83	5256.28	5256.2	5256.72	0.024249	5.35	73.32	67.88	0.91
B_Reach	3600	100-yr	586.7	5253.83	5256.61	5256.52	5257.19	0.022823	6.09	96.42	70.35	0.92
B_Reach	3600	500-yr	1508.3	5253.83	5257.78	5257.69	5258.83	0.02055	8.24	183.08	78.1	0.95
B_Reach	3500	2-yr	16	5252.37	5253.02		5253.09	0.018484	2.04	7.86	25.59	0.65
B_Reach	3500	5-yr	72.8	5252.37	5253.54	5253.35	5253.64	0.015011	2.56	28.46	56.42	0.63
B_Reach	3500	10-yr	121.3	5252.37	5253.73	5253.55	5253.87	0.014879	3.04	39.91	60.64	0.66
B_Reach	3500	25-yr	202.9	5252.37	5253.97		5254.18	0.015111	3.69	55.05	63.3	0.7
B_Reach	3500	50-yr	392.6	5252.37	5254.39		5254.74	0.016141	4.75	82.62	68.09	0.76
B_Reach	3500	100-yr	586.7	5252.37	5254.72		5255.2	0.016988	5.6	104.82	70.12	0.81
B_Reach	3500	500-yr	1508.3	5252.37	5255.8	5255.67	5256.84	0.01917	8.18	184.49	76.22	0.93
B_Reach	3400	2-yr	16	5249.45	5250.23	5250.23	5250.46	0.039873	3.86	4.15	9.07	1
B_Reach	3400	5-yr	72.8	5249.45	5251.03	5251.03	5251.36	0.0376	4.64	15.7	25.05	1.03
B_Reach	3400	10-yr	121.3	5249.45	5251.38	5251.38	5251.66	0.035916	4.25	28.52	50.35	1
B_Reach	3400	25-yr	202.9	5249.45	5251.61	5251.61	5251.98	0.034203	4.86	41.78	58.32	1.01
B_Reach	3400	50-yr	392.6	5249.45	5252.01	5252.01	5252.57	0.030383	5.98	65.65	61.27	1.02
B_Reach	3400	100-yr	586.7	5249.45	5252.38	5252.38	5253.06	0.027248	6.6	88.94	66	1
B_Reach	3400	500-yr	1508.3	5249.45	5253.55	5253.55	5254.7	0.023633	8.61	175.22	78.77	1.01
B_Reach	3300	2-yr	16	5246.93	5247.55	5247.41	5247.63	0.015127	2.24	7.14	17.33	0.62
B_Reach	3300	5-yr	72.8	5246.93	5248.17	5248.01	5248.34	0.017697	3.3	22.06	33.62	0.72
B_Reach	3300	10-yr	121.3	5246.93	5248.41	5248.25	5248.66	0.018269	3.95	30.68	36.5	0.76
B_Reach	3300	25-yr	202.9	5246.93	5248.76	5248.57	5249.08	0.018394	4.54	44.69	43.4	0.79
B_Reach	3300	50-yr	392.6	5246.93	5249.32	5249.1	5249.81	0.017895	5.61	69.92	48.25	0.82
B_Reach	3300	100-yr	586.7	5246.93	5249.8	5249.55	5250.4	0.016864	6.22	94.33	53.36	0.82
B_Reach	3300	500-yr	1508.3	5246.93	5251.05	5251.13	5252.18	0.027132	8.51	177.23	89.77	1.07
B_Reach	3200	2-yr	16	5244.47	5245.03	5245.03	5245.19	0.045611	3.19	5.02	16.41	1.02
B_Reach	3200	5-yr	72.8	5244.47	5245.55	5245.55	5245.89	0.03528	4.65	15.66	23.94	1.01

B_Reach	3200	10-yr	121.3	5244.47	5245.84	5245.84	5246.27	0.031678	5.24	23.17	27.27	1
B_Reach	3200	25-yr	202.9	5244.47	5246.2	5246.2	5246.74	0.030015	5.88	34.5	32.63	1.01
B_Reach	3200	50-yr	392.6	5244.47	5246.8	5246.8	5247.6	0.027083	7.19	54.63	35	1.01
B_Reach	3200	100-yr	586.7	5244.47	5247.3	5247.3	5248.32	0.025194	8.1	72.47	36.45	1.01
B_Reach	3200	500-yr	1508.3	5244.47	5249.03	5249.03	5249.86	0.020561	7.75	216.57	128.75	0.93
B_Reach	3100	2-yr	16	5242.5	5243.2	5242.98	5243.24	0.008837	1.69	9.45	23.11	0.47
B_Reach	3100	5-yr	72.8	5242.5	5243.76	5243.48	5243.87	0.010293	2.68	27.13	36.89	0.55
B_Reach	3100	10-yr	121.3	5242.5	5244.04	5243.71	5244.19	0.011658	3.2	37.96	43.49	0.6
B_Reach	3100	25-yr	202.9	5242.5	5244.43	5244.04	5244.61	0.013352	3.39	59.91	70.02	0.65
B_Reach	3100	50-yr	392.6	5242.5	5244.85	5244.59	5245.12	0.014965	4.18	94.26	96.02	0.71
B_Reach	3100	100-yr	586.7	5242.5	5245.16	5244.92	5245.5	0.016201	4.75	126.95	120.29	0.76
B_Reach	3100	500-yr	1508.3	5242.5	5245.48	5245.83	5246.82	0.047532	9.43	166.01	122.65	1.34
B_Reach	3000	2-yr	16	5240.71	5241.36	5241.36	5241.5	0.048543	3.02	5.3	19.69	1.02
B_Reach	3000	5-yr	72.8	5240.71	5241.83	5241.83	5242.02	0.041947	3.5	20.78	55.25	1.01
B_Reach	3000	10-yr	121.3	5240.71	5242	5242	5242.23	0.038915	3.92	30.97	65.87	1.01
B_Reach	3000	25-yr	202.9	5240.71	5242.19	5242.19	5242.52	0.036813	4.59	44.25	71.31	1.03
B_Reach	3000	50-yr	392.6	5240.71	5242.57	5242.57	5243.01	0.031691	5.3	74.03	85.74	1.01
B_Reach	3000	100-yr	586.7	5240.71	5242.91	5242.91	5243.38	0.028473	5.51	107.94	127.84	0.98
B_Reach	3000	500-yr	1508.3	5240.71	5243.71	5243.71	5244.49	0.023099	7.29	216.55	139.34	0.97
B_Reach	2900	2-yr	16	5235.31	5236.02	5236.04	5236.18	0.058599	3.21	4.98	19.39	1.12
B_Reach	2900	5-yr	72.8	5235.31	5236.36	5236.45	5236.76	0.067703	5.07	14.35	31.2	1.32
B_Reach	2900	10-yr	121.3	5235.31	5236.54	5236.67	5237.11	0.065402	6.09	19.91	31.94	1.36
B_Reach	2900	25-yr	202.9	5235.31	5236.75	5236.99	5237.64	0.06949	7.54	26.9	32.67	1.46
B_Reach	2900	50-yr	392.6	5235.31	5237.2	5237.57	5238.56	0.063352	9.37	41.92	34.09	1.49
B_Reach	2900	100-yr	586.7	5235.31	5237.6	5238.08	5239.32	0.05782	10.53	55.71	35.28	1.48
B_Reach	2900	500-yr	1508.3	5235.31	5239.47	5240.2	5241.63	0.032589	11.8	127.8	43.65	1.22
B_Reach	2799.859	2-yr	16	5233.19	5233.86	5233.69	5233.89	0.007499	1.5	10.66	27.82	0.43
B_Reach	2799.859	5-yr	72.8	5233.19	5234.45	5234.07	5234.55	0.006915	2.51	29	32.79	0.47
B_Reach	2799.859	10-yr	121.3	5233.19	5234.78	5234.31	5234.93	0.006913	3.03	40.05	33.98	0.49
B_Reach	2799.859	25-yr	202.9	5233.19	5235.24	5234.63	5235.44	0.006799	3.63	55.89	35.44	0.51
B_Reach	2799.859	50-yr	392.6	5233.19	5236.07	5235.22	5236.39	0.006643	4.55	86.35	37.94	0.53
B_Reach	2799.859	100-yr	586.7	5233.19	5236.94	5235.71	5237.27	0.00756	4.63	126.59	60.14	0.56
B_Reach	2799.859	500-yr	1508.3	5233.19	5239.23	5237.67	5239.55	0.00456	4.59	328.29	108.91	0.47
B_Reach	2700	2-yr	16	5231.67	5232.33	5232.3	5232.47	0.03613	2.99	5.35	16.08	0.91
B_Reach	2700	5-yr	72.8	5231.67	5232.84	5232.84	5233.2	0.034861	4.81	15.15	21.73	1.01
B_Reach	2700	10-yr	121.3	5231.67	5233.14	5233.14	5233.61	0.031527	5.52	21.99	23.7	1.01
B_Reach	2700	25-yr	202.9	5231.67	5233.54	5233.54	5234.17	0.028895	6.4	31.72	25.5	1.01
B_Reach	2700	50-yr	392.6	5231.67	5234.25	5234.25	5235.17	0.025935	7.66	51.26	28.76	1.01
B_Reach	2700	100-yr	586.7	5231.67	5234.88	5234.88	5235.96	0.023568	8.35	70.23	32.03	0.99
B_Reach	2700	500-yr	1508.3	5231.67	5236.8	5236.8	5238.56	0.021218	10.65	141.65	40.84	1.01
B_Reach	2600	2-yr	16	5229.48	5230.17		5230.25	0.014929	2.18	7.35	18.35	0.61
B_Reach	2600	5-yr	72.8	5229.48	5230.79	5230.56	5231	0.014172	3.63	20.04	22.15	0.67
B_Reach	2600	10-yr	121.3	5229.48	5231.15	5230.87	5231.44	0.013847	4.27	28.43	24.18	0.69
B_Reach	2600	25-yr	202.9	5229.48	5231.7	5231.28	5232.05	0.013033	4.75	42.75	29.58	0.7
B_Reach	2600	50-yr	392.6	5229.48	5232.53	5232.04	5233	0.014274	5.49	71.54	42.73	0.75
B_Reach	2600	100-yr	586.7	5229.48	5233.01	5232.65	5233.62	0.015116	6.31	92.95	46.94	0.79
B_Reach	2600	500-yr	1508.3	5229.48	5233.78	5234.55	5235.74	0.038849	11.26	133.99	57.72	1.3
B_Reach	2500	2-yr	16	5228.04	5228.57		5228.65	0.017297	2.2	7.28	20.12	0.64
B_Reach	2500	5-yr	72.8	5228.04	5229.09	5228.95	5229.33	0.019687	3.92	18.57	23.6	0.78
B_Reach	2500	10-yr	121.3	5228.04	5229.36	5229.24	5229.72	0.021827	4.81	25.22	25.42	0.85
B_Reach	2500	25-yr	202.9	5228.04	5229.77	5229.66	5230.25	0.025987	5.54	36.59	33.97	0.94
B_Reach	2500	50-yr	392.6	5228.04	5230.35	5230.35	5231.06	0.026927	6.77	58.01	41	1
B_Reach	2500	100-yr	586.7	5228.04	5230.85	5230.85	5231.66	0.025814	7.25	80.87	49.92	1
B_Reach	2500	500-yr	1508.3	5228.04	5232.53	5232.53	5233.08	0.03164	5.96	253.19	246.42	1.04
B_Reach	2402.135	2-yr	16	5225.79	5226.39	5226.35	5226.47	0.030006	2.28	7.03	27.68	0.8
B_Reach	2402.135	5-yr	72.8	5225.79	5226.79	5226.72	5226.95	0.030042	3.27	22.29	51.16	0.87
B_Reach	2402.135	10-yr	121.3	5225.79	5226.98	5226.92	5227.18	0.030048	3.65	33.22	64.56	0.9
B_Reach	2402.135	25-yr	202.9	5225.79	5227.19	5227.15	5227.46	0.030013	4.18	48.51	76.79	0.93
B_Reach	2402.135	50-yr	392.6	5225.79	5227.46	5227.49	5227.95	0.036048	5.63	69.78	81.15	1.07
B_Reach	2402.135	100-yr	586.7	5225.79	5227.63	5227.78	5228.38	0.044788	6.95	84.42	84.09	1.22

B_Reach	2402.135	500-yr	1508.3	5225.79	5228.6	5228.86	5229.72	0.036518	8.49	177.62	112.27	1.19

APPENDIX C2

HEC-RAS SEDIMENT TRANSPORT CAPACITY POTENTIAL ANALYSIS RESULTS

Golder Associates
BMSG/Blackbird Mine Site
943-1595-004.1280
Blackbird Creek HEC-RAS Sediment Transport Modeling
Revised: May 7, 2010/JMS

Objective: Develop a HEC-RAS sediment transport hydraulic model of Blackbird Creek, extending from the Water Treatment Plant (WTP) downstream to the confluence with Panther Creek, to develop hydraulic parameters for design flow scenarios and to evaluate sediment transport potential in Blackbird Creek.

Discussion:
Refer to the discussion in Appendix C1 summarizing the 1-D HEC-RAS model used for developing the base hydrodynamic model and boundary conditions. The sediment transport module was then engaged to continue with the sediment transport assessment. The sediment module requires development of design flows (quasi-unsteady flow time series), sediment grain size distributions, and boundary conditions geometry files. The Meyer-Peter-Muller (MPM) function was used in the sediment transport analyses. The boundary conditions are represented by the base 1-D model 9see Appendix C1).

A simplified quasi-unsteady flow time series representative of the 100-year flood event was used as input to a sediment transport assessment. The quasi-unsteady flow time series replicates approximately a 6-hour peak storm duration event (total duration with front and back tail of the hydrograph totals approximately 12 hours, while majority of peak event is represented within the 6-hour peak duration), with peaks matching the steady-state results and volumes and durations matching hydrologic assessments completed and summarized in Appendix B.

Sediment grain size distributions derived from the sediment sampling program were used as inputs to the sediment transport analysis. Refer to Appendix D for detailed summaries and reporting. The following summarizes the approximate range of sediment grain size distribution used in the model:

Particle Diameter	Percent Passing (mm)	
	High	Low
D100	60	60
D90	45	5
D65	25	0.4
D50	15	0.25
D35	7	0.15
D10	1.5	0.1

Results:
The HEC-RAS modeling shows a difference in sediment transport capacity between the channel reach upstream of West Fork and channel reaches downstream of West Fork. The model is accounting for the confined valley (in the upstream reaches), difference in channel geometry between the upper and lower reaches (narrow and incised in the upstream versus wider and more dynamic in lower reaches), the dramatic increase in flow contribution at the West Fork (almost double the flow potential coming from the West Fork), and the limited supply of sediment through the upstream reaches of bedrock controlled channel versus the numerous sediment sources in the downstream reaches of Blackbird Creek below West Fork. The sediment sources in the upper reaches are limited by bedrock and geometry in the bed, bank and overbank areas, while the lower reaches of the system have sediment stored in the bed and banks, representative of variable floodplain surfaces, some of which are active during floods and some that are accessed by lateral channel migration and headcut erosion.

The sediment transport potential results are summarized in the table below:

Summary of HEC-RAS Sediment Transport
Potential for the 100-year Design Event

Sediment Type/Location	Estimated Bedload (tons/day)
Upper reach above West Fork	2,000 – 3,600
Lower Reach below West Fork	5,000 – 9,000

Graphical sediment transport results for 1-hour time-steps through the defined storm event hydrograph are provided below.

APPENDIX D

SEDIMENT SAMPLING

Appendix D1 – Sediment Sampling Results

Appendix D2 – Blackbird Creek Channel Surface Sediment Calculations for In-Stream Stabilization Effectiveness

APPENDIX D1
SEDIMENT SAMPLING RESULTS

TABLES

TABLE D1
D50 (mm) for Rock and Sediment Samples

Sample ID#	Substrate Grab Samples	Armor Layer Pebble Counts
236	24	129.9
238	2.35	92.0
239	10	153.6
240	12	101.8
242	7.6	143.1
248	10	75.7
254	35	79.9
255	19	77.3
258	11.5	
259	18	117.5
260	11.5	
261		70.9
262	3.65	
264		60.3
265	0.28	
267	30	59.7
268		112.6
269	4.9	
271		67.3
272	0.19	
273	9	92.5
276	13	90.7
277		102.9
278	0.15	
279	12	102.3
282	0.37	
285	16	40.7
289	16.5	121.0
291		69.3
292	12	
294	8	58.7

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA

Sample ID #	D1	D2	D3	Geometric Mean	Sort
	(feet)			(feet)	Large - Small
1 / 236					
	1.3	0.5	0.65	0.75	0.75
	1.2	0.55	0.5	0.69	0.69
	0.65	0.75	0.4	0.58	0.58
	0.4	0.25	1.1	0.48	0.48
	0.6	0.25	0.5	0.42	0.42
	0.45	0.8	0.2	0.42	0.42
	0.55	0.25	0.5	0.41	0.41
	0.2	0.65	0.4	0.37	0.37
	0.45	0.4	0.25	0.36	0.36
	0.6	0.2	0.35	0.35	0.35
	0.3	0.7	0.2	0.35	0.35
	0.55	0.25	0.3	0.35	0.35
	0.3	0.5	0.2	0.31	0.31
	0.3	0.4	0.25	0.31	0.31
	0.4	0.15	0.5	0.31	0.31
	0.3	0.65	0.15	0.31	0.31
	0.25	0.5	0.2	0.29	0.29
	0.45	0.25	0.15	0.26	0.26
	0.45	0.25	0.15	0.26	0.26
	0.25	0.35	0.15	0.24	0.24
	0.25	0.15	0.3	0.22	0.22
	0.15	0.5	0.15	0.22	0.22
	0.2	0.65	0.075	0.21	0.21
	0.25	0.35	0.1	0.21	0.21
	0.2	0.4	0.1	0.20	0.20
	0.15	0.25	0.2	0.20	0.20
	0.15	0.25	0.2	0.20	0.20
	0.15	0.25	0.2	0.20	0.20
	0.25	0.3	0.1	0.20	0.20
	0.35	0.1	0.2	0.19	0.19
	0.35	0.1	0.2	0.19	0.19
	0.1	0.35	0.2	0.19	0.19
	0.15	0.4	0.1	0.18	0.18
	0.15	0.4	0.1	0.18	0.18
	0.15	0.25	0.1	0.16	0.16
2 / 238	0.8	1	0.35	0.65	0.65
	0.8	0.35	0.2	0.38	0.55
	0.75	0.15	0.2	0.28	0.43
	0.75	0.15	0.2	0.28	0.41
	0.75	0.15	0.2	0.28	0.40
	0.75	0.15	0.2	0.28	0.40
	0.75	0.15	0.2	0.28	0.39
	0.75	0.15	0.2	0.28	0.38
	0.75	0.15	0.2	0.28	0.34
	0.75	0.15	0.2	0.28	0.34
	0.75	0.15	0.2	0.28	0.34
	0.65	0.2	0.15	0.27	0.34
	0.65	0.35	0.1	0.28	0.34
	0.5	1.1	0.3	0.55	0.34
	0.35	0.55	0.35	0.41	0.34
	0.35	0.55	0.4	0.43	0.34
	0.35	0.45	0.075	0.23	0.34
	0.325	0.375	0.15	0.26	0.34
	0.32	0.15	0.65	0.31	0.32
	0.275	0.35	0.65	0.40	0.31
	0.275	0.35	0.65	0.40	0.30
	0.275	0.35	0.25	0.29	0.30
	0.25	0.5	0.2	0.29	0.29
	0.25	0.225	0.2	0.22	0.29
	0.25	0.35	0.075	0.19	0.29

CALCULATED GEOMETRIC MEAN
BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.72	8.6	2
0.6 to 0.4	7.2 to 4.8	0.46	5.5	5
0.4 to 0.3	4.8 to 3.6	0.33	4.0	9
0.3 to 0.2	3.6 to 2.4	0.22	2.6	13
0.2 to 0.10	2.4 to 1.2	0.18	2.2	6
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.65	7.9	1
0.6 to 0.4	7.2 to 4.8	0.43	5.2	5
0.4 to 0.3	4.8 to 3.6	0.34	4.0	16
0.3 to 0.2	3.6 to 2.4	0.26	3.1	31
0.2 to 0.10	2.4 to 1.2	0.16	1.9	19
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

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TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA

2 / 238	0.25	0.35	0.075	0.19	0.29
cont'd	0.25	0.45	0.3	0.32	0.29
	0.25	0.45	0.175	0.27	0.29
	0.25	0.2	0.1	0.17	0.28
	0.25	0.2	0.1	0.17	0.28
	0.25	0.275	0.15	0.22	0.28
	0.25	0.275	0.15	0.22	0.28
	0.225	0.15	0.4	0.24	0.28
	0.225	0.75	0.15	0.29	0.28
	0.2	0.55	0.05	0.18	0.28
	0.2	0.55	0.05	0.18	0.28
	0.2	0.5	0.25	0.29	0.28
	0.2	0.5	0.25	0.29	0.28
	0.175	0.4	0.375	0.30	0.27
	0.175	0.4	0.375	0.30	0.27
	0.175	0.5	0.05	0.16	0.26
	0.15	0.675	0.25	0.29	0.24
	0.15	1.1	0.35	0.39	0.24
	0.15	0.25	0.1	0.16	0.24
	0.15	0.25	0.1	0.16	0.24
	0.15	0.25	0.1	0.16	0.23
	0.15	0.25	0.1	0.16	0.22
	0.15	0.25	0.1	0.16	0.22
	0.15	0.25	0.1	0.16	0.22
	0.15	0.25	0.1	0.16	0.21
	0.15	0.35	0.75	0.34	0.21
	0.15	0.35	0.75	0.34	0.20
	0.15	0.35	0.75	0.34	0.20
	0.15	0.35	0.75	0.34	0.19
	0.15	0.35	0.75	0.34	0.19
	0.15	0.35	0.75	0.34	0.18
	0.15	0.35	0.75	0.34	0.18
	0.15	0.35	0.75	0.34	0.17
	0.15	0.35	0.75	0.34	0.17
	0.15	0.35	0.75	0.34	0.16
	0.15	0.3	0.075	0.15	0.16
	0.15	0.3	0.075	0.15	0.16
	0.15	0.3	0.075	0.15	0.16
	0.15	0.3	0.075	0.15	0.16
	0.15	0.3	0.075	0.15	0.16
	0.15	0.3	0.175	0.20	0.16
	0.15	0.3	0.175	0.20	0.16
	0.15	0.375	0.25	0.24	0.15
	0.15	0.375	0.25	0.24	0.15
	0.15	0.375	0.25	0.24	0.15
	0.125	0.2	0.35	0.21	0.15
	0.125	0.2	0.35	0.21	0.15
	0.25	1	0.675	0.55	1.00
3 / 239	0.55	0.95	0.2	0.47	0.69
	0.25	0.7	0.4	0.41	0.69
	0.35	0.55	0.225	0.35	0.62
	0.55	0.65	0.6	0.60	0.60
	0.35	0.4	0.125	0.26	0.55
	0.45	0.55	0.475	0.49	0.53
	0.4	1.25	0.475	0.62	0.50
	0.55	1.35	0.45	0.69	0.50
	0.25	0.575	0.175	0.29	0.49
	0.3	0.75	0.55	0.50	0.47
	0.4	0.475	0.25	0.36	0.47
	0.25	0.5	0.175	0.28	0.44
	0.3	0.75	0.55	0.50	0.43

CALCULATED GEOMETRIC MEAN
BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	1.00	0.0	1
0.8 to 0.6	9.6 to 7.2	0.65	7.8	4
0.6 to 0.4	7.2 to 4.8	0.48	5.7	10
0.4 to 0.3	4.8 to 3.6	0.33	3.9	9
0.3 to 0.2	3.6 to 2.4	0.24	2.9	19
0.2 to 0.10	2.4 to 1.2	0.15	1.8	28
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210arv1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

FIELD MEASURED DATA					
3 / 239 cont'd	0.4	0.475	0.25	0.36	0.41
	0.25	0.5	0.175	0.28	0.36
	0.175	0.6	0.3	0.32	0.36
	0.425	0.55	0.45	0.47	0.35
	0.3	0.475	0.2	0.31	0.33
	0.3	0.475	0.2	0.31	0.32
	0.425	0.475	0.425	0.44	0.32
	0.35	0.4	0.225	0.32	0.31
	0.175	0.45	0.25	0.27	0.31
	0.225	0.325	0.15	0.22	0.30
	0.125	0.4	0.15	0.20	0.29
	0.125	0.4	0.15	0.20	0.29
	0.225	0.075	0.3	0.17	0.28
	0.225	0.075	0.3	0.17	0.28
	0.25	0.425	0.05	0.17	0.28
	0.125	0.35	0.075	0.15	0.27
	0.125	0.35	0.075	0.15	0.26
	0.125	0.35	0.075	0.15	0.26
	0.2	0.325	0.125	0.20	0.25
	0.275	0.35	0.175	0.26	0.25
	0.275	0.4	0.2	0.28	0.24
	0.2	0.4	0.125	0.22	0.23
	0.175	0.275	0.075	0.15	0.22
	0.175	0.275	0.075	0.15	0.22
	0.175	0.275	0.075	0.15	0.21
	0.45	1.65	0.45	0.69	0.21
	0.15	0.2	0.125	0.16	0.20
	0.15	0.2	0.125	0.16	0.20
	0.15	0.2	0.125	0.16	0.20
	0.15	0.2	0.125	0.16	0.19
	0.15	0.2	0.125	0.16	0.17
	0.15	0.2	0.125	0.16	0.17
	0.15	0.2	0.125	0.16	0.17
	0.15	0.2	0.125	0.16	0.16
	0.15	0.2	0.125	0.16	0.16
	0.15	0.2	0.125	0.16	0.16
	0.15	0.2	0.125	0.16	0.16
	0.15	0.2	0.125	0.16	0.16
	0.575	0.3	0.85	0.53	0.16
	0.25	0.5	0.275	0.33	0.16
	0.3	0.95	0.275	0.43	0.16
	0.25	0.35	0.175	0.25	0.16
	0.25	0.35	0.175	0.25	0.16
	0.4	0.4	0.15	0.29	0.16
	0.275	0.275	0.05	0.16	0.16
	0.1	0.3	0.1	0.14	0.16
	0.1	0.3	0.1	0.14	0.15
	0.275	0.575	0.175	0.30	0.15
	0.2	0.475	0.075	0.19	0.15
	0.225	0.325	0.125	0.21	0.15
	0.225	0.325	0.125	0.21	0.15
	0.1	0.3	0.075	0.13	0.15
	0.1	0.3	0.075	0.13	0.14
	0.15	0.375	0.25	0.24	0.14
	0.2	0.25	0.05	0.14	0.14
	0.25	0.325	0.15	0.23	0.13
	1.6	0.9	0.7	1.00	0.13
	0.75	0.45	0.2	0.41	0.62
	0.35	0.3	0.125	0.24	0.59

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
4 / 240	0.525	0.325	0.15	0.29	0.43
	0.475	0.95	0.45	0.59	0.41
	0.35	0.55	0.4	0.43	0.41
	1	0.35	0.2	0.41	0.40
	0.2	0.825	0.3	0.37	0.40
	0.325	0.525	0.175	0.31	0.37
	0.175	0.55	0.25	0.29	0.31
	0.25	0.425	0.225	0.29	0.31
	0.35	0.45	0.075	0.23	0.29
	0.275	0.5	0.05	0.19	0.29
	0.55	0.375	0.15	0.31	0.29
	0.15	0.4	0.175	0.22	0.29
	0.15	0.375	0.15	0.20	0.29
	0.3	0.4	0.15	0.26	0.26
	0.2	0.3	0.125	0.20	0.25
	0.15	0.3	0.15	0.19	0.25
	0.15	0.3	0.15	0.19	0.24
	0.15	0.3	0.15	0.19	0.24
	0.275	0.3	0.15	0.23	0.24
	0.275	0.3	0.15	0.23	0.24
	0.275	0.3	0.15	0.23	0.24
	0.3	0.25	0.175	0.24	0.23
	0.2	0.35	0.125	0.21	0.23
	0.2	0.35	0.125	0.21	0.23
	0.2	0.35	0.125	0.21	0.23
	0.175	0.2	0.075	0.14	0.23
	0.175	0.2	0.075	0.14	0.23
	0.175	0.2	0.075	0.14	0.22
	0.175	0.2	0.075	0.14	0.21
	0.175	0.2	0.075	0.14	0.21
	0.175	0.2	0.075	0.14	0.21
	0.175	0.2	0.075	0.14	0.20
	0.175	0.2	0.075	0.14	0.20
	0.175	0.2	0.075	0.14	0.19
	0.175	0.2	0.075	0.14	0.19
	0.175	0.2	0.075	0.14	0.19
	0.175	0.2	0.075	0.14	0.19
	0.175	0.2	0.075	0.14	0.18
	0.175	0.2	0.075	0.14	0.18
	0.175	0.2	0.075	0.14	0.18
	0.175	0.2	0.075	0.14	0.17
	0.175	0.2	0.075	0.14	0.17
	0.175	0.2	0.075	0.14	0.17
	0.15	0.25	0.075	0.14	0.17
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.62	7.5	1
0.6 to 0.4	7.2 to 4.8	0.43	5.2	6
0.4 to 0.3	4.8 to 3.6	0.33	4.0	3
0.3 to 0.2	3.6 to 2.4	0.24	2.9	25
0.2 to 0.10	2.4 to 1.2	0.15	1.8	75
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
4 / 240 cont'd	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.15
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.125	0.2	0.125	0.15	0.14
	0.175	0.775	0.475	0.40	0.14
	0.175	0.775	0.475	0.40	0.14
	0.25	0.5	0.2	0.29	0.14
	0.25	0.5	0.2	0.29	0.14
	0.15	0.45	0.225	0.25	0.14
	0.15	0.45	0.225	0.25	0.14
	0.175	0.45	0.15	0.23	0.14
	0.175	0.45	0.15	0.23	0.14
	0.175	0.35	0.1	0.18	0.14
	0.175	0.35	0.1	0.18	0.14
	0.175	0.35	0.1	0.18	0.14
	0.15	0.375	0.25	0.24	0.14
	0.15	0.375	0.25	0.24	0.14
	0.15	0.375	0.25	0.24	0.14
	0.2	0.3	0.05	0.14	0.14
	0.2	0.3	0.05	0.14	0.14
	0.2	0.3	0.05	0.14	0.14
	0.15	0.35	0.1	0.17	0.14
	0.15	0.35	0.1	0.17	0.14
	0.15	0.35	0.1	0.17	0.14
	0.15	0.35	0.1	0.17	0.14
	0.6	1	0.4	0.62	0.14
	0.3	0.45	0.175	0.29	0.64
	0.2	0.4	0.2	0.25	0.58
	0.2	0.4	0.175	0.24	0.40
5B / 254	0.175	0.3	0.075	0.16	0.36
	0.3	0.3	0.15	0.24	0.35
	0.275	0.325	0.175	0.25	0.34
	0.175	0.275	0.2	0.21	0.30
	0.35	0.6	0.3	0.40	0.29
	0.275	0.325	0.2	0.26	0.29
	0.25	0.4	0.275	0.30	0.28
	0.275	0.3	0.1	0.20	0.28
	0.225	0.375	0.25	0.28	0.26
	0.125	0.375	0.175	0.20	0.25
	0.3	0.4	0.2	0.29	0.25
	0.325	0.425	0.3	0.35	0.25

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.64	7.7	1
0.6 to 0.4	7.2 to 4.8	0.48	5.7	2
0.4 to 0.3	4.8 to 3.6	0.34	4.1	4
0.3 to 0.2	3.6 to 2.4	0.22	2.7	31
0.2 to 0.10	2.4 to 1.2	0.14	1.7	68
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA						CALCULATED GEOMETRIC MEAN BY SAMPLE ID #
5B / 254 cont'd	0.225	0.3	0.225	0.25	0.25	
	0.225	0.3	0.1	0.19	0.24	
	0.125	0.375	0.175	0.20	0.24	
	0.15	0.25	0.225	0.20	0.24	
	0.15	0.25	0.225	0.20	0.24	
	0.15	0.25	0.225	0.20	0.21	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.15	0.25	0.225	0.20	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.20	
	0.175	0.175	0.1	0.15	0.19	
	0.175	0.175	0.1	0.15	0.17	
	0.175	0.175	0.1	0.15	0.17	
	0.175	0.175	0.1	0.15	0.17	
	0.175	0.175	0.1	0.15	0.17	
	0.175	0.175	0.1	0.15	0.16	
	0.175	0.175	0.1	0.15	0.16	
	0.175	0.175	0.1	0.15	0.16	
	0.175	0.175	0.1	0.15	0.15	
	0.175	0.175	0.1	0.15	0.15	
	0.275	0.275	0.175	0.24	0.15	
	0.275	0.275	0.175	0.24	0.15	
	0.3	0.575	0.275	0.36	0.15	
	0.225	0.35	0.05	0.16	0.15	
	0.2	0.325	0.075	0.17	0.15	
	0.2	0.325	0.075	0.17	0.15	
	0.2	0.325	0.075	0.17	0.15	
	0.075	0.25	0.05	0.10	0.15	
	0.075	0.25	0.05	0.10	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.15	0.1	0.1	0.11	0.15	
	0.125	0.2	0.125	0.15	0.15	
	0.5	1.3	0.4	0.64	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.15	
	0.2	0.15	0.075	0.13	0.13	
	0.2	0.15	0.075	0.13	0.13	

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
5B / 254 cont'd	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.15	0.075	0.13	0.13
	0.2	0.4	0.1	0.20	0.13
	0.2	0.4	0.1	0.20	0.13
	0.225	0.35	0.05	0.16	0.13
	0.3	0.35	0.05	0.17	0.13
	0.3	0.35	0.2	0.28	0.13
	0.225	0.35	0.2	0.25	0.13
	0.2	0.175	0.1	0.15	0.13
	0.2	0.175	0.1	0.15	0.13
	0.2	0.175	0.1	0.15	0.13
	0.2	0.175	0.1	0.15	0.11
	0.2	0.175	0.1	0.15	0.11
	0.2	0.175	0.1	0.15	0.11
	0.2	0.175	0.1	0.15	0.11
	0.2	0.175	0.1	0.15	0.11
	0.2	0.175	0.1	0.15	0.11
	0.2	0.175	0.1	0.15	0.11
	0.3	0.45	0.3	0.34	0.10
	0.45	0.85	0.5	0.58	0.10
	0.3	0.3	0.2	0.26	0.81
	0.225	0.225	0.175	0.21	0.52
	0.175	0.25	0.3	0.24	0.42
	0.4	0.7	0.5	0.52	0.33
6 / 242	0.35	0.675	0.15	0.33	0.30
	0.3	0.6	0.15	0.30	0.29
	0.425	0.575	0.3	0.42	0.26
	1.2	1.1	0.4	0.81	0.25
	0.175	0.475	0.175	0.24	0.25
	0.225	0.35	0.2	0.25	0.25
	0.225	0.35	0.2	0.25	0.24
	0.225	0.35	0.2	0.25	0.24
	0.175	0.2	0.1	0.15	0.23
	0.175	0.2	0.1	0.15	0.21
	0.175	0.2	0.1	0.15	0.21
	0.175	0.2	0.1	0.15	0.20
	0.175	0.2	0.1	0.15	0.20
	0.325	0.5	0.05	0.20	0.20
	0.225	0.325	0.125	0.21	0.20
	0.3	0.4	0.2	0.29	0.20
	0.175	0.3	0.225	0.23	0.19
	0.225	0.275	0.125	0.20	0.18
	0.225	0.275	0.125	0.20	0.15
	0.225	0.275	0.125	0.20	0.15
	0.225	0.275	0.125	0.20	0.15
	0.225	0.375	0.075	0.18	0.15
	0.225	0.1	0.325	0.19	0.15
	0.2	0.325	0.025	0.12	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.81	0.0	1
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.47	5.6	2
0.4 to 0.3	4.8 to 3.6	0.31	3.8	2
0.3 to 0.2	3.6 to 2.4	0.23	2.7	15
0.2 to 0.10	2.4 to 1.2	0.14	1.6	32
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
6 / 242 cont'd	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.125	0.1	0.15	0.12	0.12
	0.225	0.9	0.5	0.47	0.47
	0.225	0.375	0.225	0.27	0.37
	0.3	0.35	0.175	0.26	0.36
	0.275	0.275	0.25	0.27	0.30
	0.325	0.35	0.125	0.24	0.28
7C / 255	0.2	0.9	0.25	0.36	0.28
	0.25	0.9	0.125	0.30	0.27
	0.3	0.7	0.25	0.37	0.27
	0.25	0.35	0.125	0.22	0.26
	0.275	0.45	0.1	0.23	0.26
	0.2	0.475	0.125	0.23	0.24
	0.175	0.6	0.2	0.28	0.24
	0.275	0.4	0.2	0.28	0.23
	0.175	0.475	0.2	0.26	0.23
	0.225	0.375	0.1	0.20	0.22
	0.125	0.45	0.1	0.18	0.21
	0.175	0.4	0.2	0.24	0.20
	0.175	0.2	0.15	0.17	0.18
	0.2	0.35	0.125	0.21	0.17
	0.35	0.55	0.15	0.31	0.69
	0.3	0.5	0.6	0.45	0.66
	0.225	0.325	0.075	0.18	0.47
	0.2	0.6	0.075	0.21	0.45
	0.425	0.425	0.15	0.30	0.45
	0.2	0.6	0.6	0.42	0.44
8A / 259	0.35	1.35	0.225	0.47	0.42
	0.175	0.7	0.325	0.34	0.42
	0.15	0.55	0.2	0.25	0.41
	0.25	0.625	0.45	0.41	0.35
	1.1	0.55	0.55	0.69	0.34
	0.35	0.675	0.175	0.35	0.33
	0.45	0.65	0.25	0.42	0.31
	0.475	0.25	0.15	0.26	0.31
	1.5	0.45	0.425	0.66	0.30
	0.425	1	0.2	0.44	0.26
	0.25	0.675	0.55	0.45	0.25
	0.125	0.225	0.55	0.25	0.25
	0.25	0.65	0.175	0.31	0.24
	0.1	0.175	0.35	0.18	0.24
	0.1	0.175	0.35	0.18	0.24
	0.15	0.075	0.35	0.16	0.24

CALCULATED GEOMETRIC MEAN BY SAMPLE ID

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.47	5.6	1
0.4 to 0.3	4.8 to 3.6	0.34	4.1	3
0.3 to 0.2	3.6 to 2.4	0.24	2.9	13
0.2 to 0.10	2.4 to 1.2	0.18	2.1	2
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.68	8.1	2
0.6 to 0.4	7.2 to 4.8	0.44	5.2	7
0.4 to 0.3	4.8 to 3.6	0.32	3.9	6
0.3 to 0.2	3.6 to 2.4	0.23	2.8	22
0.2 to 0.10	2.4 to 1.2	0.16	1.9	18
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID #

FIELD MEASURED DATA					
8A / 259 cont'd	0.15	0.075	0.35	0.16	0.24
	0.2	0.325	0.225	0.24	0.24
	0.2	0.325	0.225	0.24	0.24
	0.2	0.325	0.225	0.24	0.24
	0.2	0.325	0.225	0.24	0.24
	0.2	0.325	0.225	0.24	0.24
	0.2	0.325	0.225	0.24	0.24
	0.2	0.4	0.125	0.22	0.22
	0.2	0.4	0.125	0.22	0.22
	0.2	0.4	0.125	0.22	0.22
	0.2	0.4	0.125	0.22	0.22
	0.2	0.4	0.125	0.22	0.22
	0.2	0.4	0.125	0.22	0.22
	0.2	0.4	0.125	0.22	0.22
	0.325	0.375	0.05	0.18	0.21
	0.325	0.375	0.05	0.18	0.18
	0.225	0.475	0.125	0.24	0.18
	0.2	0.375	0.5	0.33	0.18
	0.2	0.325	0.225	0.24	0.18
	0.2	0.325	0.225	0.24	0.18
	0.2	0.325	0.225	0.24	0.16
	0.2	0.325	0.225	0.24	0.16
	0.175	0.2	0.125	0.16	0.16
	0.2	0.275	0.075	0.16	0.16
	0.2	0.275	0.075	0.16	0.16
	0.2	0.275	0.075	0.16	0.16
	0.2	0.275	0.075	0.16	0.16
	0.2	0.275	0.075	0.16	0.16
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.275	0.375	0.55	0.38	0.49
	0.3	0.375	0.175	0.27	0.45
	0.25	0.525	0.1	0.24	0.45
	0.25	0.6	0.275	0.35	0.40
	0.175	0.6	0.275	0.31	0.38
	0.4	0.8	0.375	0.49	0.37
	0.45	0.35	0.4	0.40	0.37
9A / 261	0.3	0.6	0.5	0.45	0.35
	0.3	1.1	0.275	0.45	0.33
	0.2	0.15	0.7	0.28	0.31
	0.3	0.65	0.15	0.31	0.31
	0.25	0.5	0.15	0.27	0.29
	0.25	0.5	0.15	0.27	0.28
	0.3	0.325	0.375	0.33	0.28
	0.325	0.625	0.25	0.37	0.28
	0.325	0.625	0.25	0.37	0.28
	0.25	0.8	0.125	0.29	0.28
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.375	0.275	0.2	0.27	0.27
	0.25	0.5	0.175	0.28	0.27

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.45	5.4	4
0.4 to 0.3	4.8 to 3.6	0.34	4.1	7
0.3 to 0.2	3.6 to 2.4	0.24	2.9	40
0.2 to 0.10	2.4 to 1.2	0.16	1.9	46
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA						CALCULATED GEOMETRIC MEAN BY SAMPLE ID #
9A / 261 cont'd	0.25	0.5	0.175	0.28	0.27	
	0.25	0.5	0.175	0.28	0.27	
	0.25	0.5	0.175	0.28	0.24	
	0.35	0.175	0.125	0.20	0.22	
	0.35	0.175	0.125	0.20	0.22	
	0.35	0.175	0.125	0.20	0.22	
	0.35	0.175	0.125	0.20	0.22	
	0.35	0.175	0.125	0.20	0.22	
	0.35	0.175	0.125	0.20	0.22	
	0.35	0.175	0.125	0.20	0.22	
	0.225	0.375	0.125	0.22	0.22	
	0.25	0.3	0.15	0.22	0.22	
	0.25	0.3	0.15	0.22	0.22	
	0.25	0.3	0.15	0.22	0.22	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.3	0.15	0.22	0.20	
	0.25	0.25	0.05	0.15	0.20	
	0.25	0.3	0.1	0.20	0.20	
	0.175	0.225	0.125	0.17	0.19	
	0.175	0.225	0.125	0.17	0.19	
	0.175	0.225	0.125	0.17	0.19	
	0.175	0.225	0.125	0.17	0.19	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.175	0.225	0.125	0.17	0.17	
	0.2	0.2	0.175	0.19	0.17	
	0.2	0.2	0.175	0.19	0.17	
	0.2	0.2	0.175	0.19	0.17	
	0.2	0.2	0.175	0.19	0.17	
	0.15	0.15	0.05	0.10	0.17	
	0.15	0.15	0.05	0.10	0.17	
	0.15	0.15	0.05	0.10	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	
	0.15	0.25	0.125	0.17	0.17	

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID #

FIELD MEASURED DATA					
9A / 261	0.15	0.25	0.125	0.17	0.15
cont'd	0.15	0.25	0.125	0.17	0.12
	0.15	0.25	0.125	0.17	0.12
	0.1	0.25	0.075	0.12	0.12
	0.1	0.25	0.075	0.12	0.10
	0.1	0.25	0.075	0.12	0.10
	0.15	0.3	0.175	0.20	0.10
	0.375	0.85	0.35	0.48	0.48
	0.5	1	0.125	0.40	0.40
	0.2	0.45	0.2	0.26	0.40
	0.2	0.45	0.2	0.26	0.38
	0.475	0.325	0.3	0.36	0.36
	0.25	0.45	0.15	0.26	0.36
	0.3	0.75	0.25	0.38	0.33
	0.1	0.1	0.4	0.16	0.32
10 / 248	0.1	0.1	0.4	0.16	0.32
	0.1	0.1	0.4	0.16	0.28
	0.1	0.1	0.4	0.16	0.27
	0.125	0.15	0.375	0.19	0.26
	0.75	0.35	0.175	0.36	0.26
	0.325	0.35	0.2	0.28	0.26
	0.2	0.6	0.125	0.25	0.25
	0.2	0.6	0.125	0.25	0.25
	0.2	0.6	0.125	0.25	0.25
	0.2	0.6	0.125	0.25	0.25
	0.25	0.7	0.375	0.40	0.25
	0.3	0.55	0.2	0.32	0.24
	0.45	1.1	0.075	0.33	0.24
	0.45	0.7	0.1	0.32	0.24
	0.175	0.5	0.15	0.24	0.24
	0.15	0.375	0.1	0.18	0.24
	0.15	0.375	0.1	0.18	0.24
	0.15	0.375	0.1	0.18	0.22
	0.15	0.375	0.1	0.18	0.22
	0.15	0.375	0.1	0.18	0.22
	0.25	0.35	0.15	0.24	0.22
	0.25	0.35	0.15	0.24	0.22
	0.175	0.35	0.325	0.27	0.22
	0.25	0.3	0.175	0.24	0.22
	0.25	0.3	0.175	0.24	0.22
	0.25	0.3	0.175	0.24	0.22
	0.35	0.2	0.15	0.22	0.19
	0.35	0.2	0.15	0.22	0.18
	0.35	0.2	0.15	0.22	0.18
	0.35	0.2	0.15	0.22	0.18
	0.35	0.2	0.15	0.22	0.18
	0.35	0.2	0.15	0.22	0.18
	0.35	0.2	0.15	0.22	0.17
	0.35	0.2	0.15	0.22	0.17
	0.35	0.2	0.15	0.22	0.17
	0.2	0.325	0.05	0.15	0.17
	0.2	0.325	0.05	0.15	0.17
	0.2	0.325	0.05	0.15	0.17
	0.2	0.325	0.05	0.15	0.16
	0.225	0.45	0.15	0.25	0.16
	0.25	0.1	0.2	0.17	0.16
	0.25	0.1	0.2	0.17	0.16
	0.25	0.1	0.2	0.17	0.15
	0.25	0.1	0.2	0.17	0.15
	0.25	0.1	0.2	0.17	0.15
	0.25	0.1	0.2	0.17	0.15

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.43	5.1	3
0.4 to 0.3	4.8 to 3.6	0.34	4.1	6
0.3 to 0.2	3.6 to 2.4	0.24	2.9	25
0.2 to 0.10	2.4 to 1.2	0.17	2.0	20
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
10 / 248 cont'd	0.25	0.55	0.15	0.27	0.48
	0.275	0.55	0.3	0.36	0.36
	0.425	0.5	0.175	0.33	0.36
	0.4	0.425	0.1	0.26	0.35
	0.2	0.375	0.1	0.20	0.33
	0.225	0.375	0.2	0.26	0.30
	0.225	0.25	0.225	0.23	0.27
	0.3	0.125	0.425	0.25	0.27
	0.225	0.45	0.125	0.23	0.26
11A / 264	0.2	0.425	0.15	0.23	0.26
	0.275	0.8	0.5	0.48	0.25
	0.4	0.6	0.175	0.35	0.25
	0.225	0.4	0.525	0.36	0.24
	0.125	0.35	0.1	0.16	0.24
	0.125	0.35	0.1	0.16	0.23
	0.125	0.35	0.1	0.16	0.23
	0.125	0.35	0.1	0.16	0.23
	0.125	0.35	0.1	0.16	0.21
	0.125	0.35	0.1	0.16	0.21
	0.125	0.35	0.1	0.16	0.21
	0.125	0.35	0.1	0.16	0.21
	0.125	0.35	0.1	0.16	0.20
	0.125	0.35	0.1	0.16	0.20
	0.075	0.45	0.175	0.18	0.20
	0.15	0.475	0.2	0.24	0.20
	0.15	0.425	0.125	0.20	0.20
	0.3	0.2	0.45	0.30	0.20
	0.275	0.4	0.175	0.27	0.20
	0.25	0.45	0.125	0.24	0.20
	0.35	0.35	0.125	0.25	0.20
	0.1	0.3	0.175	0.17	0.20
	0.1	0.3	0.175	0.17	0.19
	0.1	0.3	0.175	0.17	0.19
	0.1	0.3	0.175	0.17	0.18
	0.1	0.3	0.175	0.17	0.18
	0.2	0.35	0.125	0.21	0.18
	0.2	0.35	0.125	0.21	0.18
	0.2	0.35	0.125	0.21	0.18
	0.2	0.35	0.125	0.21	0.17
	0.175	0.25	0.15	0.19	0.17
	0.175	0.25	0.15	0.19	0.17
	0.2	0.25	0.125	0.18	0.17
	0.2	0.25	0.125	0.18	0.17
	0.2	0.25	0.125	0.18	0.17
	0.2	0.25	0.125	0.18	0.17
	0.125	0.25	0.15	0.17	0.17
	0.125	0.25	0.15	0.17	0.17
	0.125	0.25	0.15	0.17	0.17
	0.125	0.25	0.15	0.17	0.17
	0.125	0.25	0.15	0.17	0.17
	0.225	0.2	0.075	0.15	0.17
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.2	0.075	0.15	0.16
	0.225	0.35	0.05	0.16	0.16

CALCULATED GEOMETRIC MEAN
BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.48	5.7	1
0.4 to 0.3	4.8 to 3.6	0.34	4.1	5
0.3 to 0.2	3.6 to 2.4	0.22	2.7	25
0.2 to 0.10	2.4 to 1.2	0.13	1.6	76
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID #

FIELD MEASURED DATA					
11A / 264 cont'd	0.225	0.35	0.05	0.16	0.16
	0.15	0.3	0.1	0.17	0.16
	0.15	0.3	0.1	0.17	0.15
	0.15	0.3	0.1	0.17	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.15	0.225	0.25	0.20	0.15
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.2	0.325	0.15	0.21	0.43
	0.15	0.15	0.55	0.23	0.39
	0.125	0.4	0.15	0.20	0.36
	0.125	0.4	0.15	0.20	0.35
	0.125	0.4	0.15	0.20	0.27
	0.125	0.4	0.15	0.20	0.27
	0.125	0.4	0.15	0.20	0.27
	0.175	0.3	0.1	0.17	0.25
	0.175	0.3	0.1	0.17	0.25
	0.175	0.3	0.1	0.17	0.25

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA

12B / 267	0.325	0.625	0.4	0.43	0.25
	0.3	0.55	0.35	0.39	0.25
	0.25	0.55	0.15	0.27	0.25
	0.25	0.55	0.15	0.27	0.25
	0.25	0.55	0.15	0.27	0.25
	0.375	0.45	0.25	0.35	0.25
	0.225	0.45	0.15	0.25	0.25
	0.225	0.45	0.15	0.25	0.25
	0.225	0.45	0.15	0.25	0.25
	0.2	0.35	0.15	0.22	0.25
	0.175	0.225	0.15	0.18	0.25
	0.175	0.225	0.15	0.18	0.25
	0.175	0.225	0.15	0.18	0.25
	0.175	0.225	0.15	0.18	0.25
	0.175	0.225	0.15	0.18	0.25
	0.175	0.225	0.15	0.18	0.24
	0.175	0.225	0.15	0.18	0.23
	0.25	0.5	0.125	0.25	0.22
	0.25	0.5	0.125	0.25	0.22
	0.25	0.5	0.125	0.25	0.22
	0.25	0.5	0.125	0.25	0.22
	0.25	0.5	0.125	0.25	0.22
	0.125	0.25	0.075	0.13	0.22
	0.125	0.25	0.075	0.13	0.22
	0.125	0.25	0.075	0.13	0.21
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.20
	0.125	0.25	0.075	0.13	0.18
	0.3	0.6	0.25	0.36	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.18
	0.1	0.275	0.1	0.14	0.17
	0.1	0.275	0.1	0.14	0.17
	0.1	0.275	0.1	0.14	0.17
	0.1	0.275	0.1	0.14	0.16
	0.1	0.275	0.1	0.14	0.16
	0.2	0.4	0.075	0.18	0.16
	0.2	0.4	0.075	0.18	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.16
	0.175	0.3	0.075	0.16	0.14
	0.175	0.3	0.075	0.16	0.14

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.43	5.2	1
0.4 to 0.3	4.8 to 3.6	0.36	4.4	3
0.3 to 0.2	3.6 to 2.4	0.23	2.8	39
0.2 to 0.10	2.4 to 1.2	0.15	1.8	53
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
12B / 267 cont'd	0.175	0.3	0.075	0.16	0.14
	0.175	0.3	0.075	0.16	0.14
	0.225	0.35	0.1	0.20	0.14
	0.225	0.35	0.1	0.20	0.14
	0.225	0.35	0.1	0.20	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.14
	0.275	0.3	0.2	0.25	0.13
	0.275	0.3	0.2	0.25	0.13
	0.275	0.3	0.2	0.25	0.13
	0.15	0.2	0.1	0.14	0.13
	0.15	0.2	0.1	0.14	0.13
	0.175	0.4	0.15	0.22	0.13
	0.175	0.4	0.15	0.22	0.13
	0.175	0.4	0.15	0.22	0.13
	0.2	0.35	0.15	0.22	0.13
	0.2	0.35	0.15	0.22	0.13
	0.2	0.35	0.15	0.22	0.13
	0.25	0.45	0.125	0.24	0.13
	0.4	0.85	0.35	0.49	0.50
	0.225	0.8	0.125	0.28	0.49
	0.2	0.5	0.2	0.27	0.46
	0.6	0.6	0.35	0.50	0.43
	0.45	0.65	0.275	0.43	0.36
	0.45	0.85	0.25	0.46	0.29
	0.375	0.55	0.225	0.36	0.29
	0.4	0.35	0.175	0.29	0.28
	0.3	0.35	0.15	0.25	0.27
	0.3	0.35	0.15	0.25	0.25
	0.25	0.35	0.125	0.22	0.25
13A / 268	0.15	0.5	0.125	0.21	0.25
	0.225	0.325	0.125	0.21	0.22
	0.2	0.3	0.125	0.20	0.21
	0.225	0.375	0.175	0.25	0.21
	0.225	0.3	0.125	0.20	0.20
	0.2	0.3	0.1	0.18	0.20
	0.15	0.3	0.125	0.18	0.19
	0.15	0.3	0.125	0.18	0.19
	0.15	0.3	0.125	0.18	0.19
	0.15	0.3	0.125	0.18	0.19
	0.125	0.3	0.175	0.19	0.19
	0.125	0.3	0.175	0.19	0.19
	0.125	0.3	0.175	0.19	0.19
	0.125	0.3	0.175	0.19	0.18
	0.125	0.3	0.175	0.19	0.18
	0.125	0.3	0.175	0.19	0.18
	0.125	0.3	0.175	0.19	0.18
	0.3	0.375	0.225	0.29	0.18
	0.15	0.2	0.075	0.13	0.14
	0.15	0.2	0.075	0.13	0.14
	0.15	0.2	0.075	0.13	0.14
	0.15	0.2	0.075	0.13	0.14
	0.15	0.2	0.075	0.13	0.14
	0.15	0.2	0.075	0.13	0.13
	0.15	0.2	0.075	0.13	0.13
	0.15	0.2	0.075	0.13	0.13

CALCULATED GEOMETRIC MEAN BY SAMPLE ID

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.47	5.6	4
0.4 to 0.3	4.8 to 3.6	0.36	4.3	1
0.3 to 0.2	3.6 to 2.4	0.24	2.9	12
0.2 to 0.10	2.4 to 1.2	0.14	1.7	41
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
13A / 268	0.15	0.2	0.075	0.13	0.13
cont'd	0.15	0.2	0.075	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.175	0.225	0.05	0.13	0.13
	0.125	0.225	0.1	0.14	0.13
	0.125	0.225	0.1	0.14	0.13
	0.125	0.225	0.1	0.14	0.13
	0.125	0.225	0.1	0.14	0.13
	0.125	0.225	0.1	0.14	0.13
	0.1	0.225	0.1	0.13	0.13
	0.1	0.225	0.1	0.13	0.13
	0.1	0.225	0.1	0.13	0.13
	0.1	0.225	0.1	0.13	0.13
	0.15	0.15	0.1	0.13	0.13
	0.15	0.15	0.1	0.13	0.13
	0.25	0.7	0.225	0.34	0.37
	0.2	0.8	0.125	0.27	0.37
	0.15	0.35	0.125	0.19	0.36
	0.45	0.575	0.175	0.36	0.35
	0.5	0.35	0.3	0.37	0.34
	0.3	0.7	0.2	0.35	0.33
	0.35	0.45	0.225	0.33	0.32
	0.35	0.35	0.15	0.26	0.28
	0.35	0.425	0.1	0.25	0.28
	0.35	0.55	0.175	0.32	0.28
	0.4	0.325	0.175	0.28	0.28
	0.25	0.275	0.2	0.24	0.28
14A / 271	0.25	0.275	0.2	0.24	0.27
	0.175	0.2	0.075	0.14	0.27
	0.175	0.2	0.075	0.14	0.26
	0.175	0.2	0.075	0.14	0.26
	0.175	0.2	0.075	0.14	0.25
	0.15	0.2	0.075	0.13	0.25
	0.15	0.2	0.075	0.13	0.24
	0.15	0.2	0.075	0.13	0.24
	0.175	0.3	0.1	0.17	0.24
	0.175	0.3	0.1	0.17	0.22
	0.175	0.3	0.1	0.17	0.22
	0.125	0.25	0.025	0.09	0.22
	0.125	0.25	0.025	0.09	0.22
	0.25	0.325	0.125	0.22	0.22
	0.25	0.325	0.125	0.22	0.22
	0.25	0.325	0.125	0.22	0.22
	0.25	0.325	0.125	0.22	0.22
	0.25	0.475	0.125	0.25	0.20
	0.175	0.5	0.25	0.28	0.19
	0.175	0.5	0.25	0.28	0.17
	0.175	0.5	0.25	0.28	0.17
	0.175	0.5	0.25	0.28	0.17
	0.125	0.425	0.05	0.14	0.17
	0.125	0.425	0.05	0.14	0.17
	0.125	0.425	0.05	0.14	0.17
	0.125	0.425	0.05	0.14	0.17
	0.2	0.5	0.05	0.17	0.17
	0.125	0.3	0.075	0.14	0.16

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.00	0.0	0
0.4 to 0.3	4.8 to 3.6	0.35	4.2	7
0.3 to 0.2	3.6 to 2.4	0.24	2.9	23
0.2 to 0.10	2.4 to 1.2	0.14	1.6	40
0.10 to 0.0	1.2 to 0	0.09	1.1	2

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID #

FIELD MEASURED DATA					
14A / 271 cont'd	0.125	0.3	0.075	0.14	0.16
	0.125	0.3	0.075	0.14	0.16
	0.125	0.3	0.05	0.12	0.16
	0.35	0.7	0.2	0.37	0.16
	0.1	0.6	0.175	0.22	0.14
	0.1	0.6	0.175	0.22	0.14
	0.2	0.4	0.25	0.27	0.14
	0.25	0.15	0.3	0.22	0.14
	0.25	0.15	0.3	0.22	0.14
	0.25	0.45	0.125	0.24	0.14
	0.15	0.3	0.375	0.26	0.14
	0.075	0.2	0.1	0.11	0.14
	0.075	0.2	0.1	0.11	0.14
	0.075	0.2	0.1	0.11	0.14
	0.225	0.125	0.3	0.20	0.14
	0.175	0.225	0.125	0.17	0.13
	0.175	0.225	0.125	0.17	0.13
	0.175	0.225	0.125	0.17	0.13
	0.125	0.3	0.1	0.16	0.12
	0.125	0.3	0.1	0.16	0.11
	0.125	0.3	0.1	0.16	0.11
	0.125	0.3	0.1	0.16	0.11
	0.125	0.3	0.1	0.16	0.11
	0.125	0.3	0.125	0.17	0.11
	0.1	0.175	0.05	0.10	0.11
	0.1	0.175	0.05	0.10	0.10
	0.1	0.175	0.05	0.10	0.10
	0.1	0.175	0.05	0.10	0.10
	0.1	0.175	0.05	0.10	0.10
	0.1	0.1	0.15	0.11	0.10
	0.1	0.1	0.15	0.11	0.09
	0.1	0.1	0.15	0.11	0.09
	0.325	0.85	0.275	0.42	0.75
	0.125	0.925	0.1	0.23	0.42
	0.15	0.6	0.125	0.22	0.36
	0.15	0.6	0.125	0.22	0.34
	0.175	0.525	0.075	0.19	0.33
	0.325	0.8	0.125	0.32	0.32
	0.2	0.75	0.3	0.36	0.30
	0.35	0.625	0.1	0.28	0.29
	0.225	0.475	0.1	0.22	0.28
	0.225	0.475	0.1	0.22	0.28
	0.225	0.475	0.1	0.22	0.28
	0.225	0.475	0.1	0.22	0.23
	0.225	0.45	0.4	0.34	0.23
15 / 273	0.375	0.2	0.475	0.33	0.23
	0.35	0.4	0.175	0.29	0.23
	0.125	0.375	0.125	0.18	0.22
	0.125	0.375	0.125	0.18	0.22
	0.125	0.375	0.125	0.18	0.22
	0.225	0.375	0.075	0.18	0.22
	0.225	0.375	0.075	0.18	0.22
	0.225	0.375	0.075	0.18	0.22
	0.225	0.375	0.075	0.18	0.22
	0.225	0.375	0.075	0.18	0.22
	0.2	0.375	0.125	0.21	0.21
	0.125	0.325	0.2	0.20	0.21
	0.125	0.325	0.2	0.20	0.20
	0.125	0.325	0.2	0.20	0.20
	0.125	0.325	0.2	0.20	0.20
	0.2	0.3	0.2	0.23	0.20

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.75	9.1	1
0.6 to 0.4	7.2 to 4.8	0.42	5.1	1
0.4 to 0.3	4.8 to 3.6	0.33	4.0	5
0.3 to 0.2	3.6 to 2.4	0.23	2.7	22
0.2 to 0.10	2.4 to 1.2	0.14	1.6	63
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID #

FIELD MEASURED DATA					
15 / 273 cont'd	0.2	0.3	0.2	0.23	0.19
	0.2	0.3	0.2	0.23	0.19
	0.15	0.35	0.125	0.19	0.19
	0.15	0.35	0.125	0.19	0.18
	0.15	0.35	0.175	0.21	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.18
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.15	0.25	0.075	0.14	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.125	0.15	0.075	0.11	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.14
	0.175	0.2	0.075	0.14	0.12
	0.175	0.2	0.075	0.14	0.12
	0.175	0.2	0.075	0.14	0.12
	0.225	0.475	0.1	0.22	0.12
	0.125	0.475	0.175	0.22	0.12
	0.2	0.4	0.275	0.28	0.12
	0.2	0.4	0.275	0.28	0.12
	0.125	0.3	0.075	0.14	0.12
	0.125	0.3	0.075	0.14	0.12
	0.125	0.3	0.075	0.14	0.11
	0.2	0.225	0.125	0.18	0.11
	0.15	0.25	0.075	0.14	0.11
	0.15	0.25	0.075	0.14	0.11
	0.15	0.25	0.075	0.14	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	0.175	0.125	0.075	0.12	0.11
	1.2	0.65	0.55	0.75	0.11

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
15 / 273 cont'd	0.2	0.8	0.175	0.30	0.11
	0.325	0.5	0.6	0.46	0.48
	0.4	0.7	0.35	0.46	0.46
	0.35	0.475	0.15	0.29	0.46
	0.3	0.65	0.1	0.27	0.46
	0.35	0.9	0.3	0.46	0.45
	0.35	0.375	0.15	0.27	0.41
	0.225	0.3	0.1	0.19	0.39
	0.175	0.375	0.25	0.25	0.33
	0.45	0.75	0.175	0.39	0.30
	0.55	0.75	0.275	0.48	0.30
	0.75	0.175	0.1	0.24	0.29
	0.75	0.175	0.1	0.24	0.29
	0.75	0.175	0.1	0.24	0.29
	0.75	0.175	0.1	0.24	0.27
16A / 277	0.225	0.8	0.5	0.45	0.27
	0.225	0.7	0.45	0.41	0.25
	0.275	0.875	0.1	0.29	0.25
	0.225	0.7	0.15	0.29	0.25
	0.225	0.45	0.35	0.33	0.24
	0.3	0.45	0.2	0.30	0.24
	0.25	0.45	0.25	0.30	0.24
	0.25	0.525	0.1	0.24	0.24
	0.25	0.525	0.1	0.24	0.24
	0.25	0.525	0.1	0.24	0.24
	0.175	0.4	0.05	0.15	0.24
	0.175	0.4	0.05	0.15	0.21
	0.2	0.425	0.175	0.25	0.21
	0.2	0.425	0.175	0.25	0.20
	0.225	0.325	0.125	0.21	0.20
	0.1	0.275	0.05	0.11	0.20
	0.1	0.275	0.05	0.11	0.19
	0.1	0.275	0.05	0.11	0.17
	0.15	0.4	0.15	0.21	0.17
	0.125	0.4	0.075	0.16	0.16
	0.125	0.4	0.075	0.16	0.16
	0.125	0.4	0.075	0.16	0.16
	0.125	0.4	0.075	0.16	0.16
	0.125	0.4	0.075	0.16	0.16
	0.125	0.3	0.2	0.20	0.15
	0.125	0.3	0.2	0.20	0.15
	0.125	0.3	0.2	0.20	0.15
	0.2	0.225	0.1	0.17	0.15
	0.2	0.225	0.1	0.17	0.14
	0.175	0.275	0.075	0.15	0.14
	0.175	0.275	0.075	0.15	0.14
	0.2	0.225	0.05	0.13	0.14
	0.2	0.225	0.05	0.13	0.13
	0.15	0.175	0.1	0.14	0.13
	0.15	0.175	0.1	0.14	0.11
	0.15	0.175	0.1	0.14	0.11
	0.15	0.175	0.1	0.14	0.11
	0.1	0.25	0.025	0.09	0.09
	0.1	0.25	0.025	0.09	0.09
	0.1	0.25	0.025	0.09	0.09
	0.1	0.25	0.025	0.09	0.09
	0.275	0.575	0.15	0.29	0.60
	0.275	0.7	0.175	0.32	0.33
	0.5	1.1	0.4	0.60	0.32
	0.325	0.65	0.1	0.28	0.29

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.45	5.4	6
0.4 to 0.3	4.8 to 3.6	0.33	3.9	4
0.3 to 0.2	3.6 to 2.4	0.24	2.9	20
0.2 to 0.10	2.4 to 1.2	0.14	1.7	21
0.10 to 0.0	1.2 to 0	0.09	1.0	4

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
16A / 277 cont'd	0.225	0.625	0.25	0.33	0.28
	0.4	0.4	0.1	0.25	0.25
	0.3	0.275	0.075	0.18	0.24
	0.225	0.3	0.2	0.24	0.21
	0.175	0.25	0.2	0.21	0.19
	0.125	0.3	0.15	0.18	0.19
	0.15	0.375	0.125	0.19	0.19
	0.15	0.375	0.125	0.19	0.18
	0.15	0.375	0.125	0.19	0.18
	0.1	0.225	0.075	0.12	0.15
	0.1	0.225	0.075	0.12	0.14
17A / 279	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.15	0.3	0.075	0.15	0.12
	0.075	0.225	0.175	0.14	0.12
	0.125	0.15	0.1	0.12	0.12
	0.125	0.15	0.1	0.12	0.12
	0.125	0.15	0.1	0.12	0.12
	0.125	0.15	0.1	0.12	0.12
	0.125	0.15	0.1	0.12	0.12
	0.125	0.15	0.1	0.12	0.12
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.25	0.45	0.275	0.31	0.58
	0.2	0.675	0.275	0.33	0.49
	0.15	0.5	0.2	0.25	0.46
	0.425	0.575	0.075	0.26	0.39
	0.125	0.425	0.125	0.19	0.35
	0.125	0.2	0.125	0.15	0.33
	0.125	0.5	0.125	0.20	0.33
	0.225	0.375	0.1	0.20	0.31
	0.325	0.525	0.25	0.35	0.30
	0.15	0.45	0.075	0.17	0.26
	0.15	0.45	0.075	0.17	0.25
	0.15	0.3	0.175	0.20	0.25
	0.25	0.375	0.075	0.19	0.25
	0.35	0.25	0.15	0.24	0.25
	0.125	0.225	0.1	0.14	0.25
	0.125	0.225	0.1	0.14	0.25
18 / 276	0.125	0.225	0.1	0.14	0.25
	0.125	0.225	0.1	0.14	0.24
	0.125	0.225	0.1	0.14	0.22
	0.125	0.225	0.1	0.14	0.21
	0.125	0.225	0.1	0.14	0.21
	0.3	0.8	0.25	0.39	0.21
	0.3	0.925	0.125	0.33	0.21
	0.45	1.075	0.25	0.49	0.20
	0.45	0.8	0.55	0.58	0.20
	0.3	0.5	0.1	0.25	0.20
	0.3	0.5	0.1	0.25	0.20
	0.3	0.325	0.1	0.21	0.19
	0.125	0.25	0.075	0.13	0.19
	0.15	0.5	0.125	0.21	0.19
	0.15	0.5	0.125	0.21	0.18
	0.15	0.45	0.05	0.15	0.18
	0.15	0.45	0.05	0.15	0.17
	0.15	0.3	0.125	0.18	0.17

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.60	7.2	1
0.6 to 0.4	7.2 to 4.8	0.00	0.0	0
0.4 to 0.3	4.8 to 3.6	0.33	3.9	2
0.3 to 0.2	3.6 to 2.4	0.25	3.0	5
0.2 to 0.10	2.4 to 1.2	0.13	1.6	23
0.10 to 0.0	1.2 to 0	0.00	0.0	0

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.51	6.1	3
0.4 to 0.3	4.8 to 3.6	0.34	4.0	6
0.3 to 0.2	3.6 to 2.4	0.23	2.7	18
0.2 to 0.10	2.4 to 1.2	0.14	1.7	44
0.10 to 0.0	1.2 to 0	0.00	0.0	0

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
18 / 276	0.15	0.225	0.2	0.19	0.17
cont'd	0.2	0.425	0.125	0.22	0.16
	0.125	0.2	0.075	0.12	0.16
	0.125	0.2	0.075	0.12	0.16
	0.125	0.2	0.075	0.12	0.15
	0.125	0.2	0.075	0.12	0.15
	0.125	0.2	0.075	0.12	0.15
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.4	0.025	0.11	0.14
	0.125	0.4	0.025	0.11	0.14
	0.2	0.475	0.1	0.21	0.14
	0.2	0.425	0.1	0.20	0.14
	0.35	0.2	1.425	0.46	0.14
	0.225	0.4	0.175	0.25	0.14
	0.175	0.15	0.6	0.25	0.13
	0.15	0.1	0.325	0.17	0.13
	0.1	0.075	0.35	0.14	0.13
	0.1	0.075	0.35	0.14	0.12
	0.1	0.075	0.35	0.14	0.12
	0.1	0.075	0.35	0.14	0.12
	0.1	0.075	0.35	0.14	0.12
	0.1	0.075	0.35	0.14	0.12
	0.225	0.625	0.2	0.30	0.12
	0.2	0.25	0.075	0.16	0.12
	0.2	0.25	0.075	0.16	0.12
	0.2	0.25	0.075	0.16	0.12
	0.125	0.325	0.05	0.13	0.12
	0.125	0.325	0.05	0.13	0.12
	0.3	0.25	0.2	0.25	0.12
	0.3	0.25	0.2	0.25	0.11
	0.2	0.3	0.1	0.18	0.11
	1	0.6	0.45	0.65	0.65
	0.375	0.8	0.2	0.39	0.46
	0.2	0.625	0.2	0.29	0.39
	0.6	0.7	0.225	0.46	0.29
	0.3	0.4	0.2	0.29	0.29
	0.325	0.375	0.2	0.29	0.29
	0.225	0.475	0.175	0.27	0.27
	0.125	0.5	0.15	0.21	0.21
	0.275	0.35	0.075	0.19	0.21
	0.225	0.225	0.075	0.16	0.21
	0.225	0.225	0.075	0.16	0.19
	0.2	0.275	0.05	0.14	0.19
	0.175	0.35	0.1	0.18	0.19
	0.175	0.35	0.1	0.18	0.19
	0.175	0.4	0.125	0.21	0.19
	0.175	0.4	0.125	0.21	0.19
	0.15	0.35	0.125	0.19	0.19
19A / 289	0.15	0.35	0.125	0.19	0.19
	0.15	0.35	0.125	0.19	0.19
	0.15	0.325	0.075	0.15	0.19
	0.175	0.35	0.075	0.17	0.19
	0.125	0.4	0.05	0.14	0.19
	0.125	0.4	0.05	0.14	0.19
	0.175	0.225	0.1	0.16	0.19
	0.175	0.225	0.05	0.13	0.19
	0.175	0.225	0.05	0.13	0.19
	0.175	0.225	0.1	0.16	0.18
	0.175	0.225	0.175	0.19	0.18

CALCULATED GEOMETRIC MEAN
BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.65	7.8	1
0.6 to 0.4	7.2 to 4.8	0.46	5.5	1
0.4 to 0.3	4.8 to 3.6	0.39	4.7	1
0.3 to 0.2	3.6 to 2.4	0.25	3.0	7
0.2 to 0.10	2.4 to 1.2	0.15	1.9	48
0.10 to 0.0	1.2 to 0	0.09	1.1	5

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
19A / 289 cont'd	0.175	0.225	0.175	0.19	0.18
	0.175	0.225	0.175	0.19	0.17
	0.175	0.225	0.175	0.19	0.17
	0.175	0.225	0.175	0.19	0.17
	0.175	0.225	0.175	0.19	0.17
	0.175	0.225	0.175	0.19	0.16
	0.175	0.225	0.175	0.19	0.16
	0.175	0.225	0.175	0.19	0.16
	0.175	0.225	0.175	0.19	0.16
	0.175	0.225	0.175	0.19	0.15
	0.175	0.225	0.175	0.19	0.14
	0.15	0.225	0.175	0.18	0.14
	0.125	0.225	0.175	0.17	0.14
	0.125	0.225	0.175	0.17	0.14
	0.125	0.225	0.175	0.17	0.14
	0.125	0.2	0.075	0.12	0.14
	0.125	0.2	0.075	0.12	0.13
	0.125	0.2	0.075	0.12	0.13
	0.125	0.2	0.075	0.12	0.13
	0.125	0.2	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.1	0.225	0.075	0.12	0.12
	0.075	0.225	0.075	0.11	0.12
	0.075	0.225	0.075	0.11	0.12
	0.175	0.3	0.05	0.14	0.12
	0.175	0.3	0.05	0.14	0.12
	0.175	0.3	0.05	0.14	0.11
	0.075	0.375	0.075	0.13	0.11
	0.075	0.2	0.05	0.09	0.09
	0.075	0.2	0.05	0.09	0.09
	0.075	0.2	0.05	0.09	0.09
	0.075	0.2	0.05	0.09	0.09
	0.075	0.2	0.05	0.09	0.09
	0.45	0.65	0.175	0.37	0.42
	0.25	0.35	0.7	0.39	0.39
	0.425	0.8	0.15	0.37	0.37
	0.35	0.35	0.2	0.29	0.37
	0.275	0.45	0.2	0.29	0.29
	0.25	0.275	0.325	0.28	0.29
	0.15	0.325	0.35	0.26	0.28
	0.15	0.35	0.05	0.14	0.28
	0.25	0.3	0.125	0.21	0.26
	0.225	0.05	0.4	0.17	0.25
	0.225	0.05	0.4	0.17	0.25
	0.1	0.35	0.05	0.12	0.22
	0.1	0.35	0.05	0.12	0.22
	0.25	0.35	0.175	0.25	0.22
	0.2	0.4	0.125	0.22	0.21
	0.175	0.35	0.175	0.22	0.21
	0.175	0.35	0.175	0.22	0.18
	0.15	0.35	0.1	0.17	0.17
20A / 291	0.15	0.35	0.1	0.17	0.17
	0.15	0.35	0.1	0.17	0.17
	0.25	0.5	0.125	0.25	0.17
	0.15	0.575	0.1	0.21	0.17
	0.2	0.5	0.05	0.17	0.17
	0.2	0.25	0.05	0.14	0.17
	0.2	0.25	0.05	0.14	0.17
	0.15	0.3	0.025	0.10	0.17
	0.15	0.3	0.025	0.10	0.16
	0.15	0.3	0.025	0.10	0.15
	0.15	0.25	0.075	0.14	0.15
	0.15	0.25	0.075	0.14	0.14

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.42	5.0	1
0.4 to 0.3	4.8 to 3.6	0.38	4.5	3
0.3 to 0.2	3.6 to 2.4	0.25	2.9	12
0.2 to 0.10	2.4 to 1.2	0.13	1.5	48
0.10 to 0.0	1.2 to 0	0.08	1.0	24

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
20A / 291 cont'd	0.15	0.3	0.075	0.15	0.14
	0.2	0.3	0.1	0.18	0.14
	0.15	0.3	0.1	0.17	0.14
	0.15	0.3	0.1	0.17	0.14
	0.15	0.25	0.1	0.16	0.14
	0.15	0.2	0.075	0.13	0.13
	0.15	0.2	0.075	0.13	0.13
	0.15	0.2	0.075	0.13	0.13
	0.175	0.175	0.1	0.15	0.12
	0.1	0.25	0.075	0.12	0.12
	0.1	0.25	0.075	0.12	0.12
	0.1	0.25	0.075	0.12	0.12
	0.1	0.25	0.075	0.12	0.12
	0.175	0.2	0.075	0.14	0.12
	0.1	0.225	0.05	0.10	0.11
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.225	0.05	0.10	0.10
	0.1	0.15	0.1	0.11	0.10
	0.3	0.4	0.175	0.28	0.10
	0.55	0.65	0.2	0.42	0.10
	0.175	0.2	0.15	0.17	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.125	0.175	0.05	0.10	0.10
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.075	0.075	0.1	0.08	0.08
	0.225	0.35	0.175	0.24	0.29
	0.225	0.35	0.175	0.24	0.26
	0.275	0.325	0.275	0.29	0.24
	0.25	0.3	0.15	0.22	0.24
	0.125	0.525	0.125	0.20	0.23
	0.2	0.275	0.2	0.22	0.23
	0.2	0.275	0.2	0.22	0.23

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
20A / 291 cont'd	0.275	0.3	0.125	0.22	0.22
	0.25	0.35	0.2	0.26	0.22
	0.2	0.25	0.125	0.18	0.22
	0.2	0.25	0.125	0.18	0.22
	0.175	0.125	0.225	0.17	0.20
	0.175	0.125	0.225	0.17	0.20
	0.175	0.125	0.225	0.17	0.20
	0.225	0.25	0.075	0.16	0.20
	0.225	0.25	0.075	0.16	0.19
	0.125	0.2	0.2	0.17	0.19
	0.125	0.2	0.2	0.17	0.19
	0.125	0.2	0.2	0.17	0.19
21 / 285	0.125	0.2	0.2	0.17	0.19
	0.125	0.2	0.2	0.17	0.19
	0.125	0.2	0.2	0.17	0.18
	0.125	0.2	0.2	0.17	0.18
	0.15	0.25	0.1	0.16	0.17
	0.1	0.3	0.05	0.11	0.17
	0.1	0.3	0.05	0.11	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.17
	0.2	0.125	0.125	0.15	0.16
	0.2	0.125	0.125	0.15	0.16
	0.075	0.25	0.05	0.10	0.16
	0.075	0.25	0.05	0.10	0.16
	0.075	0.25	0.05	0.10	0.16
	0.075	0.25	0.05	0.10	0.16
	0.075	0.25	0.05	0.10	0.16
	0.075	0.25	0.05	0.10	0.16
	0.225	0.5	0.075	0.20	0.16
	0.225	0.5	0.075	0.20	0.15
	0.15	0.35	0.075	0.16	0.15
	0.15	0.35	0.075	0.16	0.15
	0.15	0.35	0.075	0.16	0.15
	0.15	0.35	0.075	0.16	0.15
	0.225	0.3	0.1	0.19	0.15
	0.225	0.3	0.1	0.19	0.15
	0.175	0.35	0.2	0.23	0.15
	0.175	0.35	0.2	0.23	0.15
	0.175	0.4	0.175	0.23	0.14
	0.175	0.4	0.1	0.19	0.14
	0.175	0.4	0.1	0.19	0.14
	0.2	0.35	0.1	0.19	0.13
	0.1	0.525	0.125	0.19	0.13
	0.175	0.45	0.1	0.20	0.13
	0.175	0.325	0.05	0.14	0.13
	0.15	0.15	0.075	0.12	0.13
	0.175	0.225	0.075	0.14	0.12
	0.175	0.225	0.05	0.13	0.12
	0.175	0.225	0.05	0.13	0.12
	0.175	0.225	0.05	0.13	0.12
	0.175	0.225	0.05	0.13	0.11
	0.175	0.225	0.05	0.13	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.11
	0.125	0.175	0.025	0.08	0.10

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.00	0.0	0
0.4 to 0.3	4.8 to 3.6	0.00	0.0	0
0.3 to 0.2	3.6 to 2.4	0.23	2.7	15
0.2 to 0.10	2.4 to 1.2	0.14	1.7	63
0.10 to 0.0	1.2 to 0	0.09	1.1	68

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

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TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
21 / 285 cont'd	0.125	0.125	0.05	0.09	0.10
	0.125	0.125	0.05	0.09	0.10
	0.125	0.125	0.05	0.09	0.10
	0.125	0.125	0.05	0.09	0.10
	0.125	0.125	0.05	0.09	0.10
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.125	0.125	0.05	0.09	0.09
	0.1	0.25	0.175	0.16	0.09
	0.1	0.25	0.175	0.16	0.09
	0.175	0.175	0.05	0.12	0.09
	0.175	0.175	0.05	0.12	0.09
	0.175	0.175	0.05	0.12	0.09
	0.175	0.3	0.05	0.14	0.08

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

TABLE D2
Armor Layer Pebble Count Summary by Sample ID

FIELD MEASURED DATA					
21 / 285	0.125	0.225	0.05	0.11	0.08
cont'd	0.125	0.225	0.05	0.11	0.08
	0.075	0.075	0.225	0.11	0.08
	0.075	0.075	0.225	0.11	0.08
	0.075	0.075	0.225	0.11	0.08
	0.1	0.3	0.05	0.11	0.08
	0.1	0.3	0.05	0.11	0.08
	0.35	0.6	0.175	0.33	0.35
	0.3	0.35	0.25	0.30	0.33
	0.25	0.35	0.15	0.24	0.31
	0.35	0.55	0.15	0.31	0.30
	0.3	0.35	0.225	0.29	0.29
	0.45	0.55	0.175	0.35	0.29
	0.225	0.5	0.225	0.29	0.24
	0.2	0.525	0.1	0.22	0.24
	0.15	0.475	0.175	0.23	0.23
	0.225	0.45	0.1	0.22	0.22
	0.3	0.325	0.1	0.21	0.22
	0.175	0.275	0.05	0.13	0.21
	0.35	0.125	0.3	0.24	0.18
	0.2	0.325	0.075	0.17	0.17
	0.2	0.325	0.075	0.17	0.17
	0.2	0.225	0.05	0.13	0.16
	0.15	0.25	0.05	0.12	0.16
	0.15	0.25	0.05	0.12	0.16
	0.15	0.25	0.05	0.12	0.16
	0.15	0.25	0.05	0.12	0.16
22A / 294	0.15	0.25	0.05	0.12	0.14
	0.1	0.325	0.125	0.16	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.175	0.1	0.14	0.14
	0.15	0.125	0.225	0.16	0.14
	0.15	0.125	0.225	0.16	0.14
	0.15	0.125	0.225	0.16	0.14
	0.2	0.1	0.125	0.14	0.14
	0.2	0.1	0.125	0.14	0.14
	0.2	0.1	0.125	0.14	0.14
	0.2	0.1	0.125	0.14	0.14
	0.2	0.1	0.125	0.14	0.13
	0.15	0.5	0.075	0.18	0.13
	0.125	0.3	0.035	0.11	0.12
	0.125	0.175	0.075	0.12	0.12
	0.125	0.175	0.075	0.12	0.12
	0.125	0.175	0.075	0.12	0.12
	0.125	0.175	0.075	0.12	0.12
	0.175	0.1	0.225	0.16	0.12
	0.2	0.3	0.05	0.14	0.12
	0.125	0.325	0.075	0.14	0.12
	0.125	0.325	0.075	0.14	0.12
	0.125	0.325	0.075	0.14	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

Size Ranges		Geometric Mean of Group		Count in Size Range
(feet)	(inches)	(feet)	(inches)	
1.0 to 0.8	12 to 9.6	0.00	0.0	0
0.8 to 0.6	9.6 to 7.2	0.00	0.0	0
0.6 to 0.4	7.2 to 4.8	0.00	0.0	0
0.4 to 0.3	4.8 to 3.6	0.32	3.9	4
0.3 to 0.2	3.6 to 2.4	0.24	2.9	8
0.2 to 0.10	2.4 to 1.2	0.13	1.6	51
0.10 to 0.0	1.2 to 0	0.08	1.0	2

Data Collected:November 11 - 21, 2008 By: AMR
Checked: AY
Reviewed :AQK
022210amr1_Table D2 & Figure D2.xlsx

Golder Associates

TABLE D2
Armor Layer Pebble Count Summary by Sample ID #

FIELD MEASURED DATA					
22A / 294 cont'd	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.12
	0.075	0.125	0.2	0.12	0.11
	0.1	0.225	0.025	0.08	0.10
	0.1	0.225	0.025	0.08	0.10
	0.1	0.175	0.05	0.10	0.08
	0.1	0.175	0.05	0.10	0.08

CALCULATED GEOMETRIC MEAN BY SAMPLE ID #

FIGURES

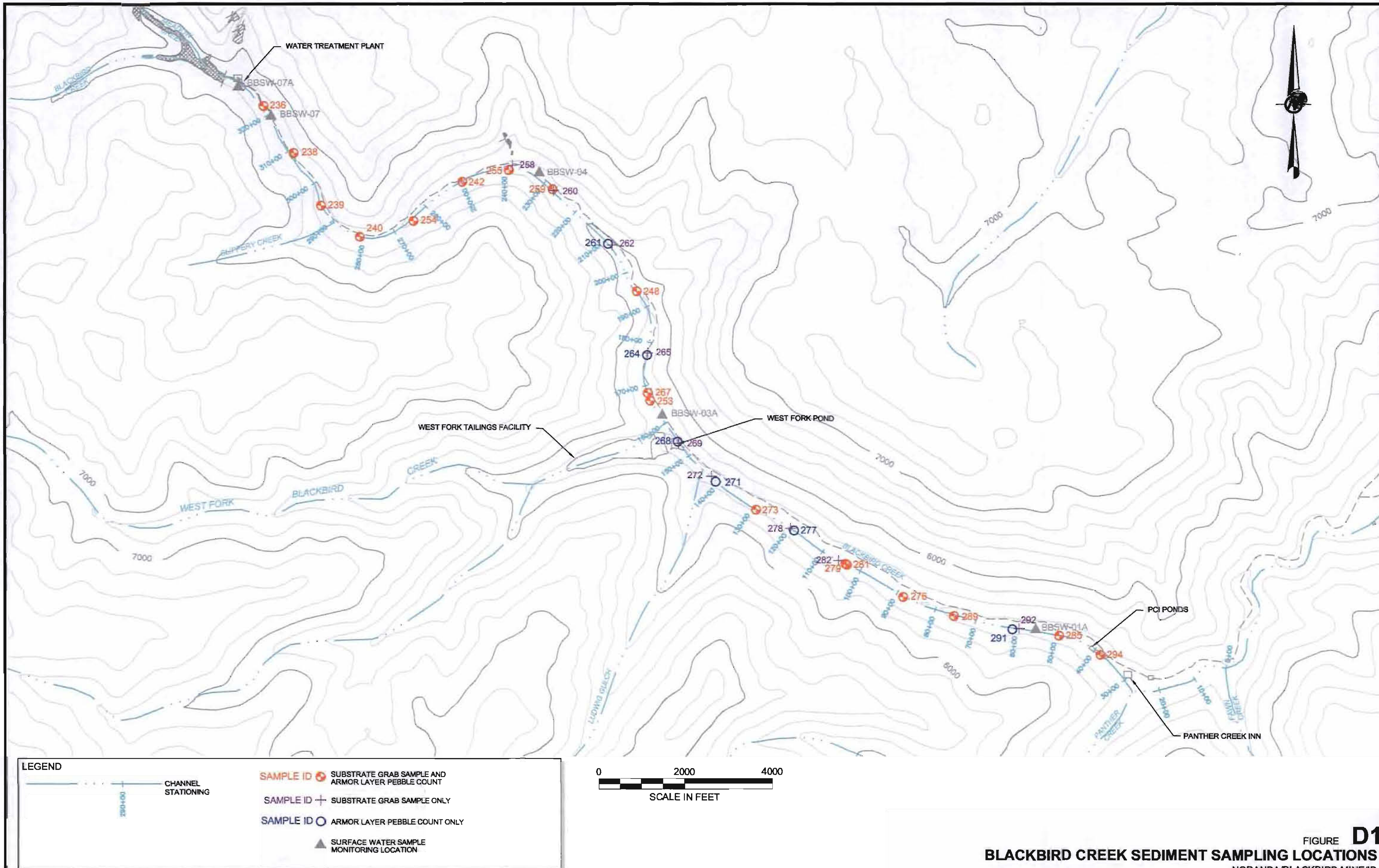

FIGURE **D1**

BLACKBIRD CREEK SEDIMENT SAMPLING LOCATIONS

NORANDA/BLACKBIRD MINE/ID

K:\CAD\Projects\1994\9431595\x004\1280\943-1595-004_1280_FD-1r1.dwg | D-1 | Mod: 02/18/2010, 15:59 | Plotted: 02/18/2010, 15:59 | SSimmons

Golder Associates

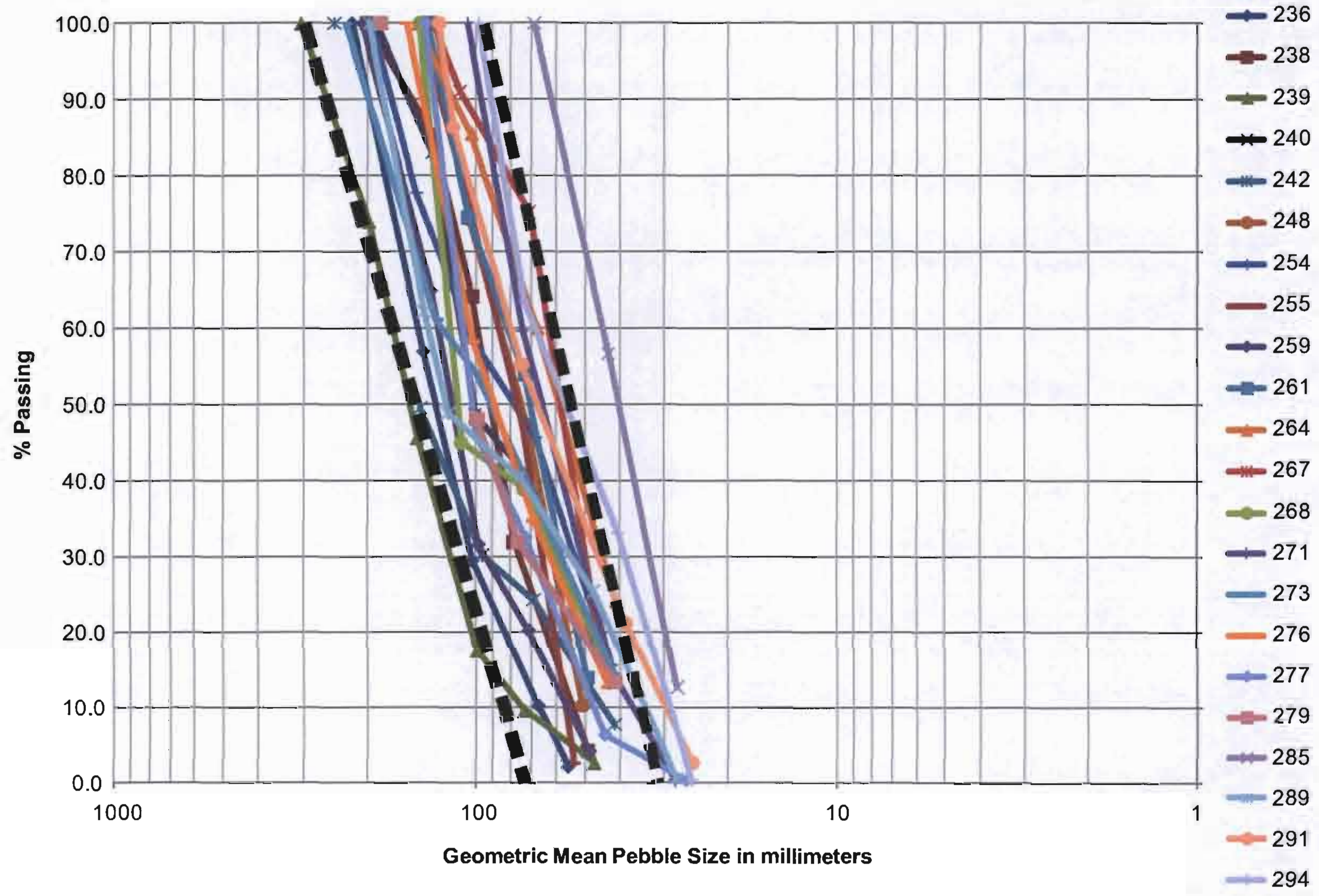

FIGURE **D2**

ARMOR LAYER PEBBLE COUNT RESULTS
RESULTS BY SAMPLE ID #
BMSG/BLACKBIRD MINE/ID

Note: Samples were taken Nov 11 - Nov 21, 2008

943159500912809figD2.ai | Mod: 07/21/10 | AMP

Golder Associates

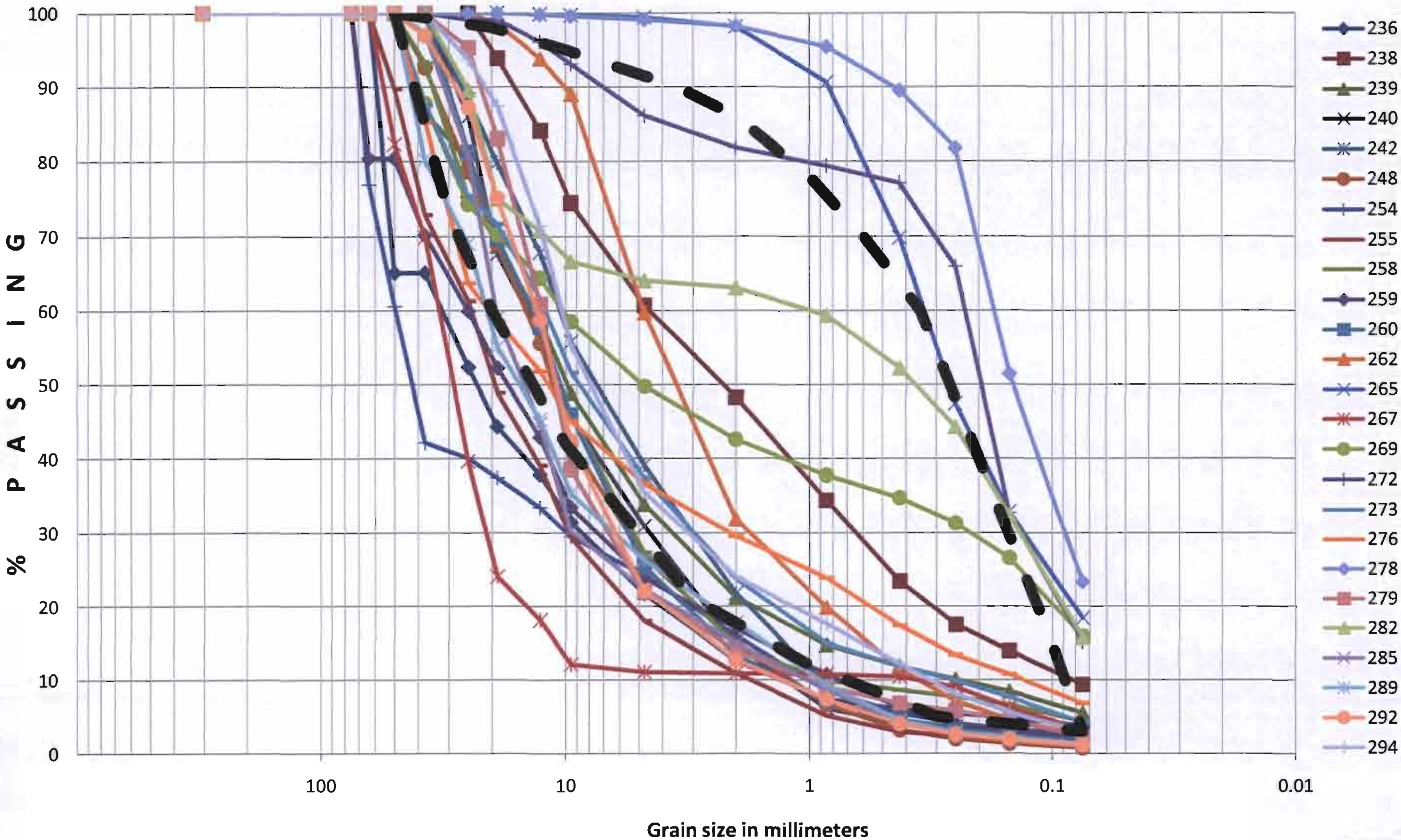

FIGURE **D3**

SUBSTRATE SEDIMENT GRAB SAMPLE RESULTS

BY SAMPLE ID #

BMSG/Blackbird Mine/ID

Note: Samples were taken Nov 11 - Nov 21, 2008

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P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Report\6-Third Draft for EPA Review\Formatted Docs for 24 Feb delivery\Appendix D\Appendix D1\Figure D3 & Figure D4_amr.xlsx

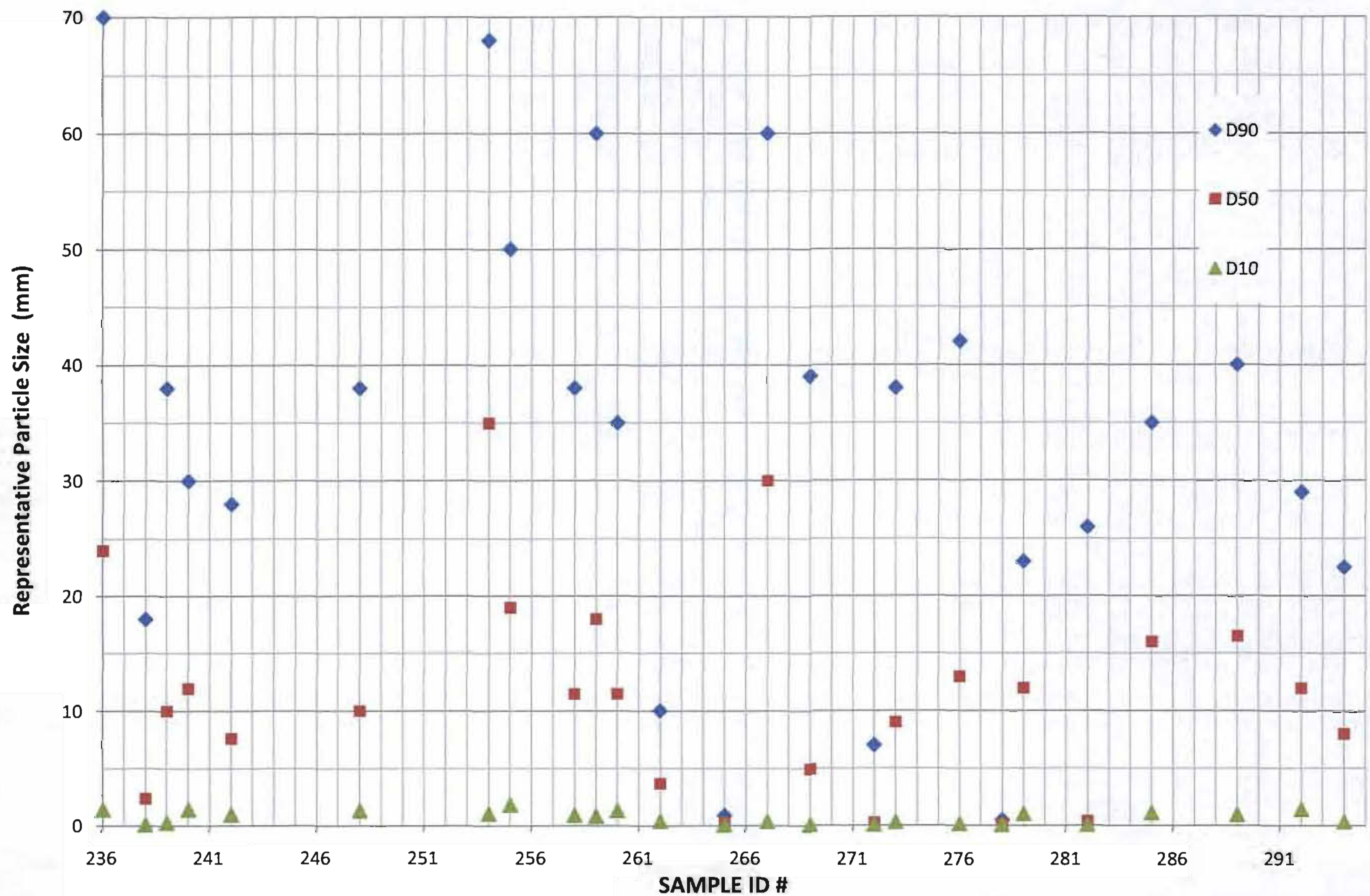

FIGURE **D4**

SUBSTRATE SEDIMENT GRAB SAMPLE - D-90, D-50, and D-10 RESULTS

RESULTLS BY SAMPLE ID #

BMSG/Blackbird Mine/ID

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LABORATORY DATA SHEETS

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	236
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2147.90
Wt Dry Soil & Tare (gm)	(w2)	2071.40
Weight of Tare (gm)	(w3)	326.60
Weight of Water (gm)	(w4=w1-w2)	76.50
Weight of Dry Soil (gm)	(w5=w2-w3)	1744.80
Moisture Content (%)	(w4/w5)*100	4.38

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2071.40
Tare Weight (gm)	326.60
(W6) Total Dry Weight (gm)	1744.80

SIEVE ANALYSIS

Tare Weight: 326.60

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	326.60	0.00	0.00	100.00	12.0"	cobbles
3.0"	326.60	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	326.60	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	936.50	609.90	34.96	65.04	2.0"	coarse gravel
1.5"	936.50	609.90	34.96	65.04	1.5"	coarse gravel
1.0"	1158.90	832.30	47.70	52.30	1.0"	coarse gravel
0.75"	1299.50	972.90	55.76	44.24	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1522.10	1195.50	68.52	31.48	0.375"	fine gravel
#4	1693.40	1366.80	78.34	21.66	#4	coarse sand
#10	1852.30	1525.70	87.44	12.56	#10	medium sand
#20	1943.60	1617.00	92.68	7.32	#20	medium sand
#40	1967.40	1640.80	94.04	5.96	#40	fine sand
#60	1977.40	1650.80	94.61	5.39	#60	fine sand
#100	1986.00	1659.40	95.11	4.89	#100	fine sand
#200	2006.20	1679.60	96.26	3.74	#200	fines
PAN	17512.80	17186.20			PAN	

% COBBLES	0.00
% C GRAVEL	55.76
% F GRAVEL	22.58
% C SAND	9.11
% M SAND	6.60
% F SAND	2.22
% FINES	3.74
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

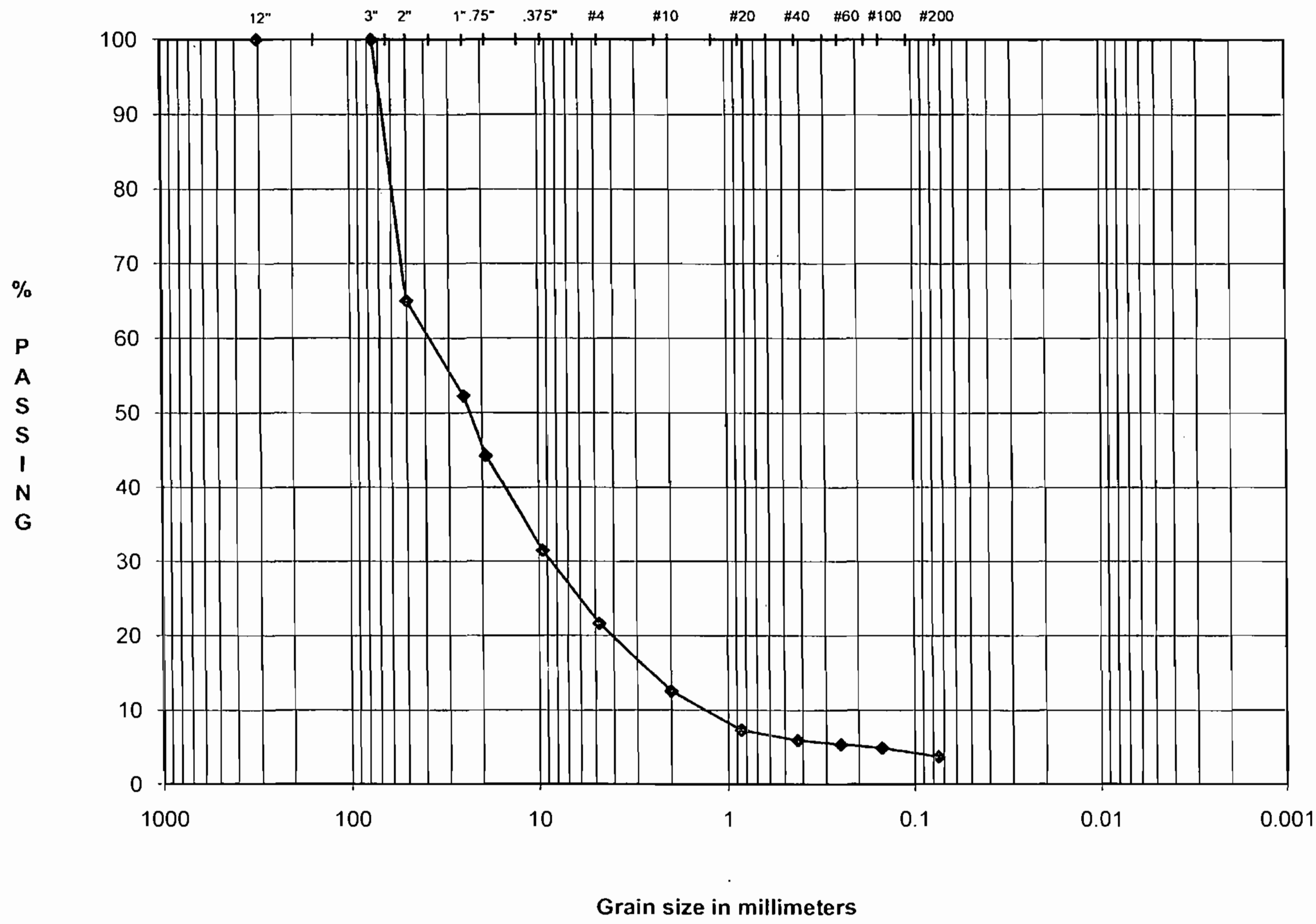
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.40
D30 (mm)	8.80
D60 (mm)	38.00
Cu	27.1
Cc	1.5

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	236	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	238
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2002.90
Wt Dry Soil & Tare (gm)	(w2)	1818.20
Weight of Tare (gm)	(w3)	307.00
Weight of Water (gm)	(w4=w1-w2)	184.70
Weight of Dry Soil (gm)	(w5=w2-w3)	1511.20
Moisture Content (%)	(w4/w5)*100	12.22

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	1818.20
Tare Weight (gm)	307.00
(W6) Total Dry Weight (gm)	1511.20

SIEVE ANALYSIS

Tare Weight: 307.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	307.00	0.00	0.00	100.00	12.0"	cobbles
3.0"	307.00	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	307.00	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	307.00	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	307.00	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	307.00	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	399.80	92.80	6.14	93.86	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	692.80	385.80	25.53	74.47	0.375"	fine gravel
#4	901.00	594.00	39.31	60.69	#4	coarse sand
#10	1089.60	782.60	51.79	48.21	#10	medium sand
#20	1297.50	990.50	65.54	34.46	#20	medium sand
#40	1464.20	1157.20	76.57	23.43	#40	fine sand
#60	1554.50	1247.50	82.55	17.45	#60	fine sand
#100	1607.90	1300.90	86.08	13.92	#100	fine sand
#200	1676.70	1369.70	90.64	9.36	#200	fines
PAN	17512.80	17205.80			PAN	

% COBBLES	0.00
% C GRAVEL	6.14
% F GRAVEL	33.17
% C SAND	12.48
% M SAND	24.79
% F SAND	14.06
% FINES	9.36
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

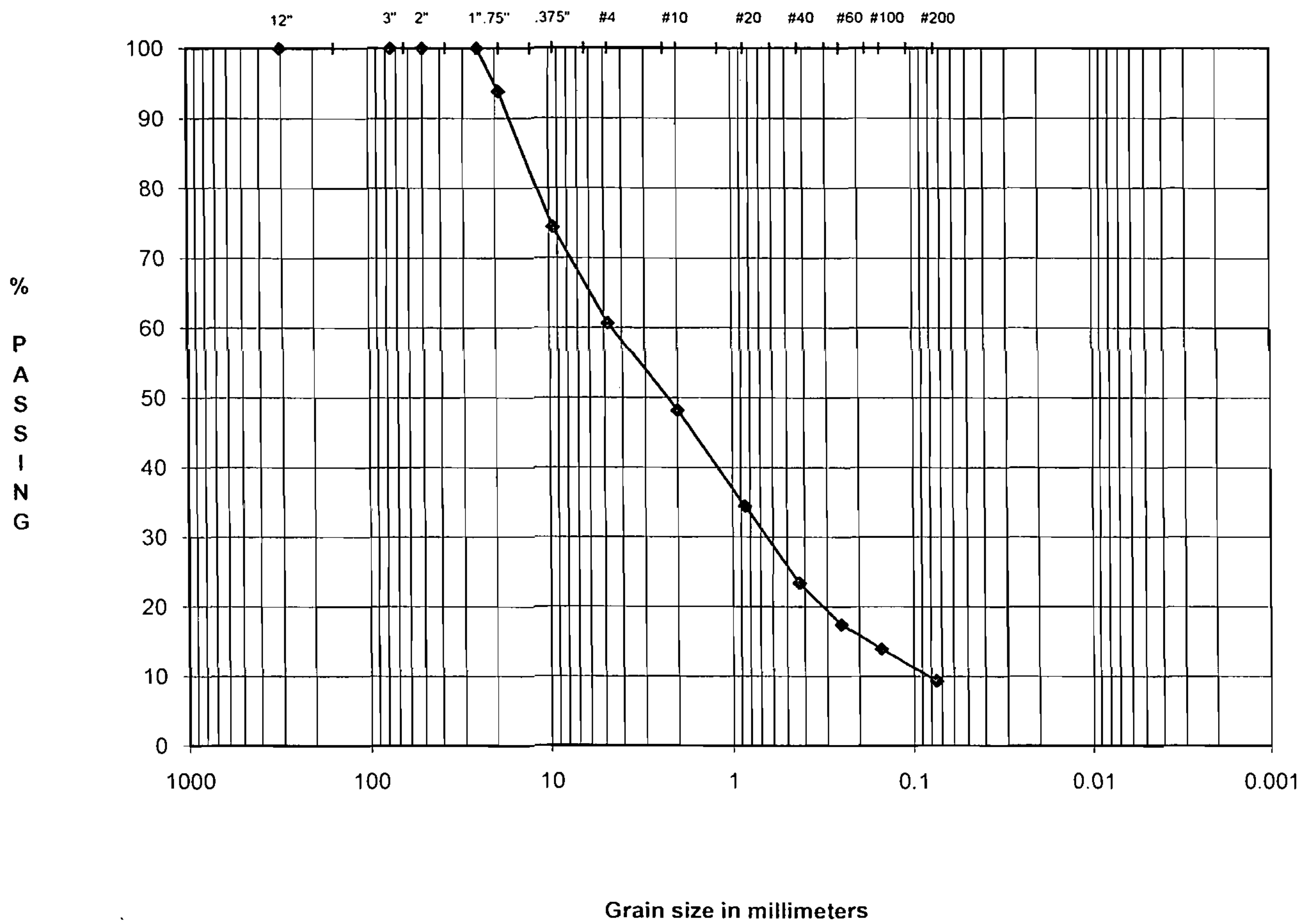
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.08
D30 (mm)	0.66
D60 (mm)	4.70
Cu	57.3
Cc	1.1

DESCRIPTION C-F SAND and C-F GRAVEL little silt

USCS SW/SM

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	238	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION: C-F SAND and C-F GRAVEL
little silt

USCS: SW/SM

AQK

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	239
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3004.30
Wt Dry Soil & Tare (gm)	(w2)	2833.50
Weight of Tare (gm)	(w3)	311.70
Weight of Water (gm)	(w4=w1-w2)	170.80
Weight of Dry Soil (gm)	(w5=w2-w3)	2521.80
Moisture Content (%)	(w4/w5)*100	6.77

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2833.50
Tare Weight (gm)	311.70
(W6) Total Dry Weight (gm)	2521.80

SIEVE ANALYSIS

Tare Weight: 311.70

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	311.70	0.00	0.00	100.00	12.0"	cobbles
3.0"	311.70	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	311.70	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	311.70	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	650.40	338.70	13.43	86.57	1.5"	coarse gravel
1.0"	812.80	501.10	19.87	80.13	1.0"	coarse gravel
0.75"	1101.50	789.80	31.32	68.68	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1602.60	1290.90	51.19	48.81	0.375"	fine gravel
#4	1977.90	1666.20	66.07	33.93	#4	coarse sand
#10	2299.00	1987.30	78.80	21.20	#10	medium sand
#20	2462.00	2150.30	85.27	14.73	#20	medium sand
#40	2534.60	2222.90	88.15	11.85	#40	fine sand
#60	2579.50	2267.80	89.93	10.07	#60	fine sand
#100	2621.10	2309.40	91.58	8.42	#100	fine sand
#200	2694.40	2382.70	94.48	5.52	#200	fines
PAN	17512.80	17201.10			PAN	

% COBBLES	0.00
% C GRAVEL	31.32
% F GRAVEL	34.75
% C SAND	12.73
% M SAND	9.34
% F SAND	6.34
% FINES	5.52
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

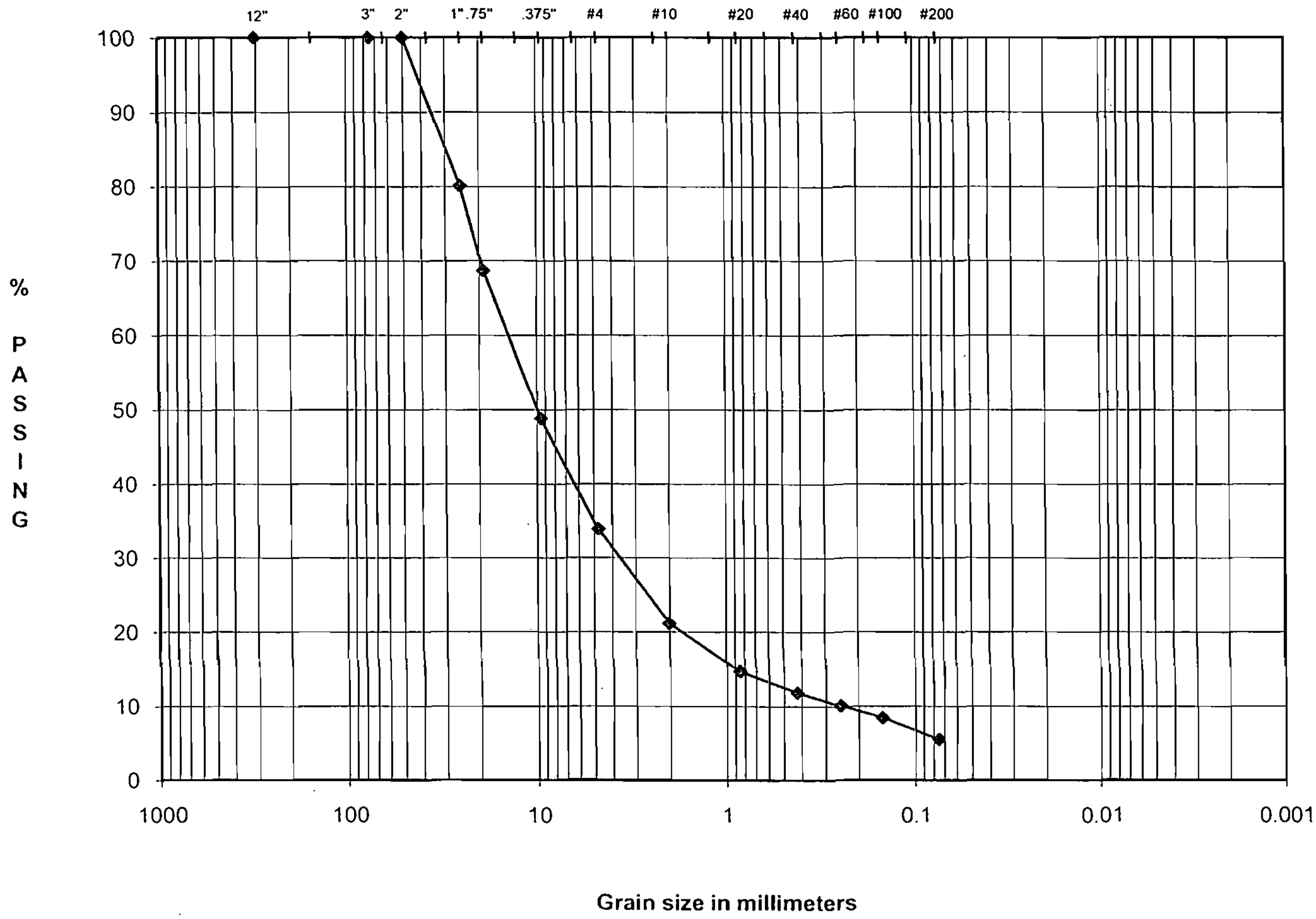
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.26
D30 (mm)	3.80
D60 (mm)	15.00
Cu	57.7
Cc	3.7

DESCRIPTION C-F GRAVEL
some c-f sand, little silt

USCS GP/GM

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	239	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, little silt
USCS	GP/GM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	240
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2799.50
Wt Dry Soil & Tare (gm)	(w2)	2685.10
Weight of Tare (gm)	(w3)	314.50
Weight of Water (gm)	(w4=w1-w2)	114.40
Weight of Dry Soil (gm)	(w5=w2-w3)	2370.60
Moisture Content (%)	(w4/w5)*100	4.83

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2685.10
Tare Weight (gm)	314.50
(W6) Total Dry Weight (gm)	2370.60

SIEVE ANALYSIS

Tare Weight: 314.50

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	314.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	314.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	314.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	314.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	314.50	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	645.20	330.70	13.95	86.05	1.0"	coarse gravel
0.75"	1083.50	769.00	32.44	67.56	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1601.60	1287.10	54.29	45.71	0.375"	fine gravel
#4	1952.10	1637.60	69.08	30.92	#4	coarse sand
#10	2337.30	2022.80	85.33	14.67	#10	medium sand
#20	2541.10	2226.60	93.93	6.07	#20	medium sand
#40	2587.90	2273.40	95.90	4.10	#40	fine sand
#60	2600.50	2286.00	96.43	3.57	#60	fine sand
#100	2608.10	2293.60	96.75	3.25	#100	fine sand
#200	2623.00	2308.50	97.38	2.62	#200	fines
PAN	17512.80	17198.30			PAN	

% COBBLES	0.00
% C GRAVEL	32.44
% F GRAVEL	36.64
% C SAND	16.25
% M SAND	10.57
% F SAND	1.48
% FINES	2.62
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

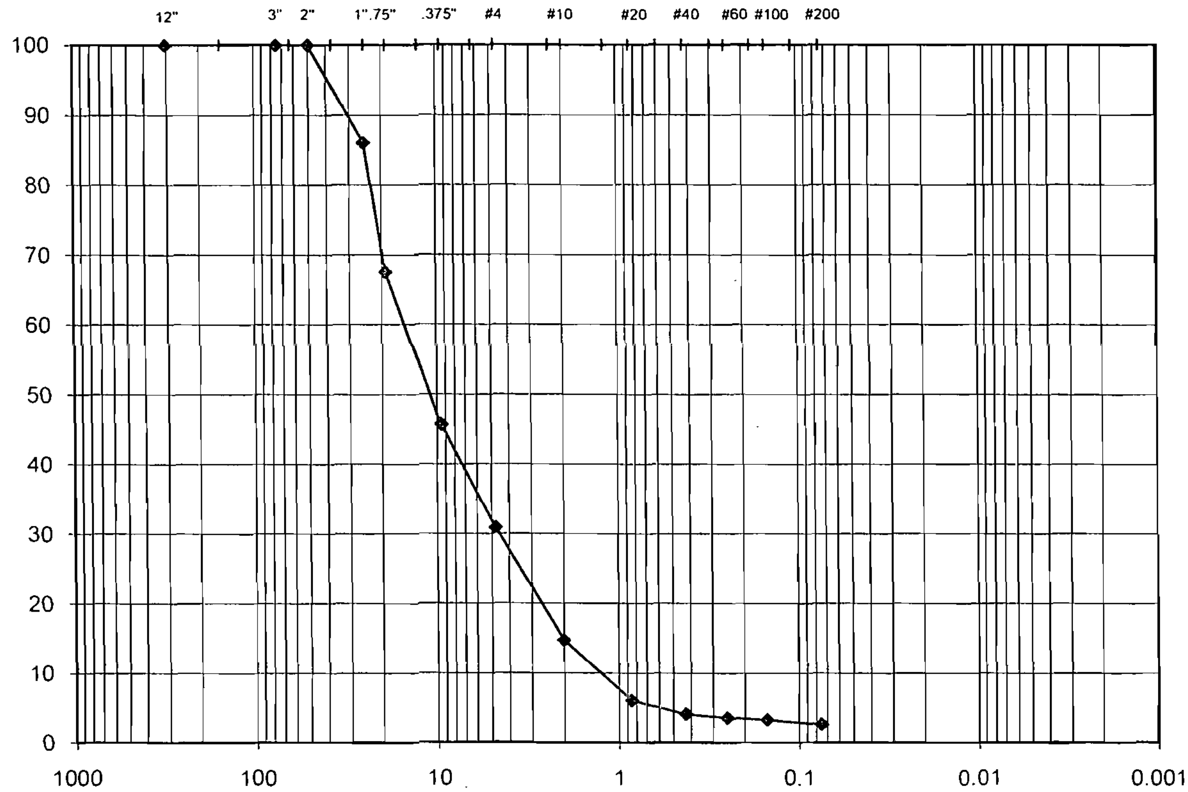
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.40
D30 (mm)	4.70
D60 (mm)	16.00
Cu	11.4
Cc	1.0

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	240	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	242
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3247.10
Wt Dry Soil & Tare (gm)	(w2)	3088.20
Weight of Tare (gm)	(w3)	424.60
Weight of Water (gm)	(w4=w1-w2)	158.90
Weight of Dry Soil (gm)	(w5=w2-w3)	2663.60
Moisture Content (%)	(w4/w5)*100	5.97

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	3088.20
Tare Weight (gm)	424.60
(W6) Total Dry Weight (gm)	2663.60

SIEVE ANALYSIS

Tare Weight: 424.60

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	424.60	0.00	0.00	100.00	12.0"	cobbles
3.0"	424.60	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	424.60	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	424.60	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	424.60	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	735.60	311.00	11.68	88.32	1.0"	coarse gravel
0.75"	962.10	537.50	20.18	79.82	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1603.00	1178.40	44.24	55.76	0.375"	fine gravel
#4	2045.10	1620.50	60.84	39.16	#4	coarse sand
#10	2508.60	2084.00	78.24	21.76	#10	medium sand
#20	2849.50	2424.90	91.04	8.96	#20	medium sand
#40	2967.30	2542.70	95.46	4.54	#40	fine sand
#60	2997.00	2572.40	96.58	3.42	#60	fine sand
#100	3013.50	2588.90	97.20	2.80	#100	fine sand
#200	3036.20	2611.60	98.05	1.95	#200	fines
PAN	17512.80	17088.20			PAN	

% COBBLES	0.00
% C GRAVEL	20.18
% F GRAVEL	40.66
% C SAND	17.40
% M SAND	17.22
% F SAND	2.59
% FINES	1.95
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

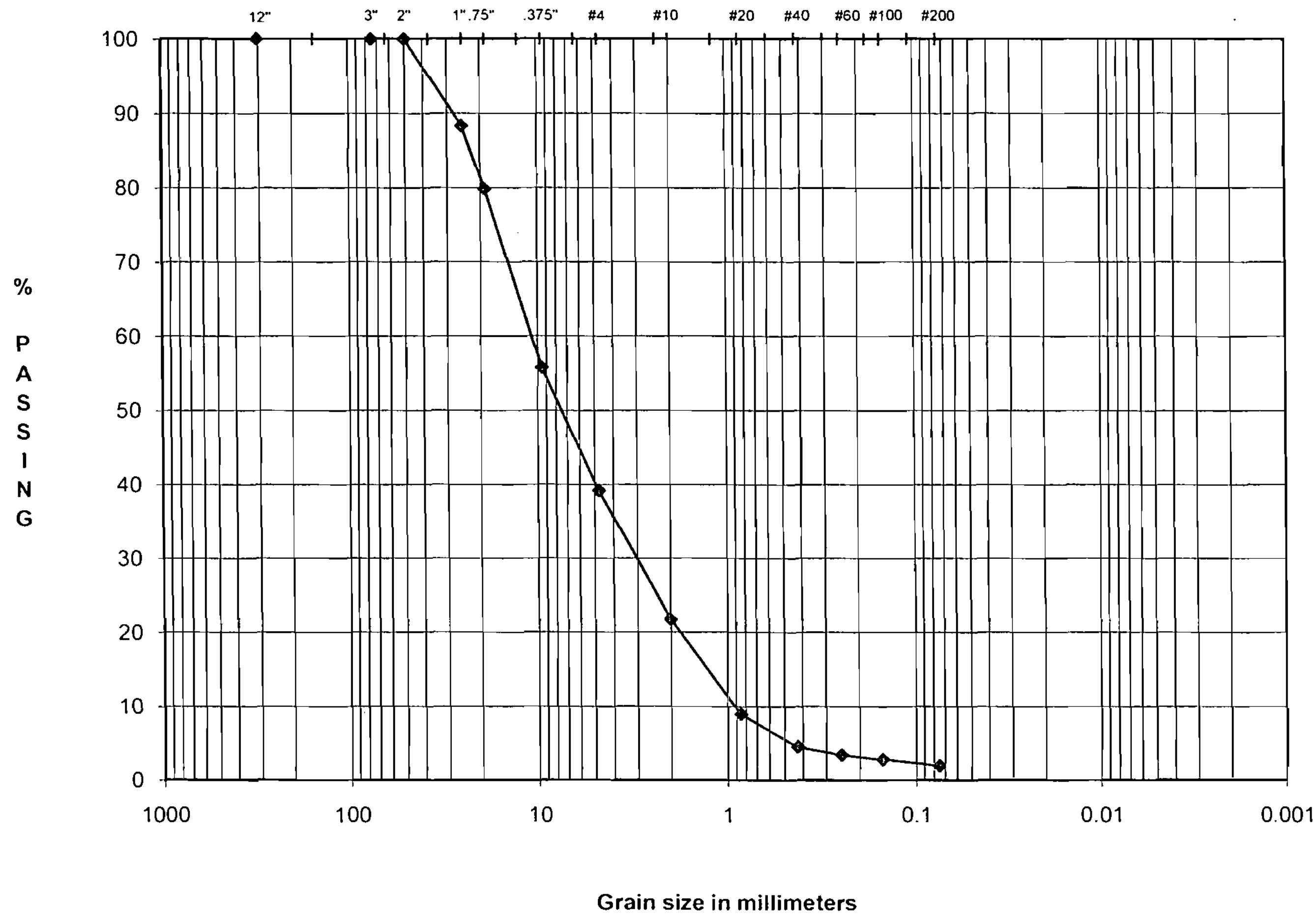
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.95
D30 (mm)	3.00
D60 (mm)	11.00
Cu	11.6
Cc	0.9

DESCRIPTION: C-F GRAVEL and C-F SAND
trace silt

USCS: GP

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	242	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL and C-F SAND trace silt
USCS	GP

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	248
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2941.00
Wt Dry Soil & Tare (gm)	(w2)	2813.20
Weight of Tare (gm)	(w3)	314.40
Weight of Water (gm)	(w4=w1-w2)	127.80
Weight of Dry Soil (gm)	(w5=w2-w3)	2498.80
Moisture Content (%)	(w4/w5)*100	5.11

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	2813.20
	Tare Weight (gm)	314.40
(W6)	Total Dry Weight (gm)	2498.80

SIEVE ANALYSIS

Tare Weight: 314.40

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	314.40	0.00	0.00	100.00	12.0"	cobbles
3.0"	314.40	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	314.40	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	314.40	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	498.80	184.40	7.38	92.62	1.5"	coarse gravel
1.0"	848.90	534.50	21.39	78.61	1.0"	coarse gravel
0.75"	1091.90	777.50	31.11	68.89	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1758.60	1444.20	57.80	42.20	0.375"	fine gravel
#4	2146.80	1832.40	73.33	26.67	#4	coarse sand
#10	2434.50	2120.10	84.84	15.16	#10	medium sand
#20	2647.60	2333.20	93.37	6.63	#20	medium sand
#40	2733.90	2419.50	96.83	3.17	#40	fine sand
#60	2763.90	2449.50	98.03	1.97	#60	fine sand
#100	2778.90	2464.50	98.63	1.37	#100	fine sand
#200	2793.70	2479.30	99.22	0.78	#200	fines
PAN	17512.80	17198.40			PAN	

% COBBLES	0.00
% C GRAVEL	31.11
% F GRAVEL	42.22
% C SAND	11.51
% M SAND	11.98
% F SAND	2.39
% FINES	0.78
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

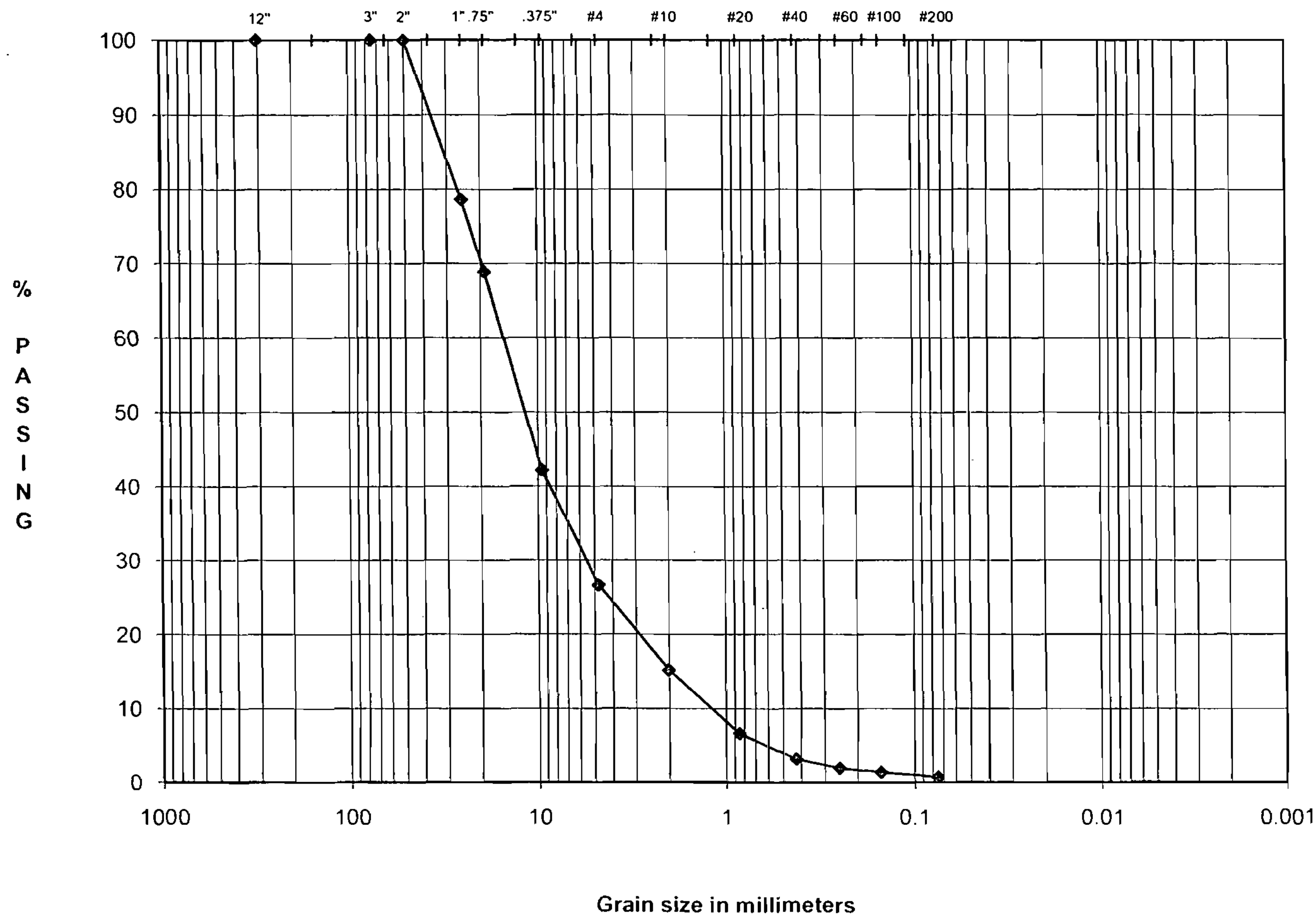
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.30
D30 (mm)	5.60
D60 (mm)	16.00
Cu	12.3
Cc	1.5

DESCRIPTION: C-F GRAVEL
some c-f sand, trace silt

USCS: GW

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	248	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	254
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3075.30
Wt Dry Soil & Tare (gm)	(w2)	3000.50
Weight of Tare (gm)	(w3)	324.20
Weight of Water (gm)	(w4=w1-w2)	74.80
Weight of Dry Soil (gm)	(w5=w2-w3)	2676.30
Moisture Content (%)	(w4/w5)*100	2.79

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	3000.50
	Tare Weight (gm)	324.20
(W6)	Total Dry Weight (gm)	2676.30

SIEVE ANALYSIS

Tare Weight: 324.20

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	324.20	0.00	0.00	100.00	12.0"	cobbles
3.0"	324.20	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	942.70	618.50	23.11	76.89	2.5"	coarse gravel
2.0"	1379.00	1054.80	39.41	60.59	2.0"	coarse gravel
1.5"	1872.50	1548.30	57.85	42.15	1.5"	coarse gravel
1.0"	1928.20	1604.00	59.93	40.07	1.0"	coarse gravel
0.75"	1999.00	1674.80	62.58	37.42	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2210.80	1886.60	70.49	29.51	0.375"	fine gravel
#4	2353.10	2028.90	75.81	24.19	#4	coarse sand
#10	2573.40	2249.20	84.04	15.96	#10	medium sand
#20	2773.60	2449.40	91.52	8.48	#20	medium sand
#40	2855.40	2531.20	94.58	5.42	#40	fine sand
#60	2890.90	2566.70	95.90	4.10	#60	fine sand
#100	2912.90	2588.70	96.73	3.27	#100	fine sand
#200	2939.40	2615.20	97.72	2.28	#200	fines
PAN	17512.80	17188.60			PAN	

% COBBLES	0.00
% C GRAVEL	62.58
% F GRAVEL	13.23
% C SAND	8.23
% M SAND	10.54
% F SAND	3.14
% FINES	2.28
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

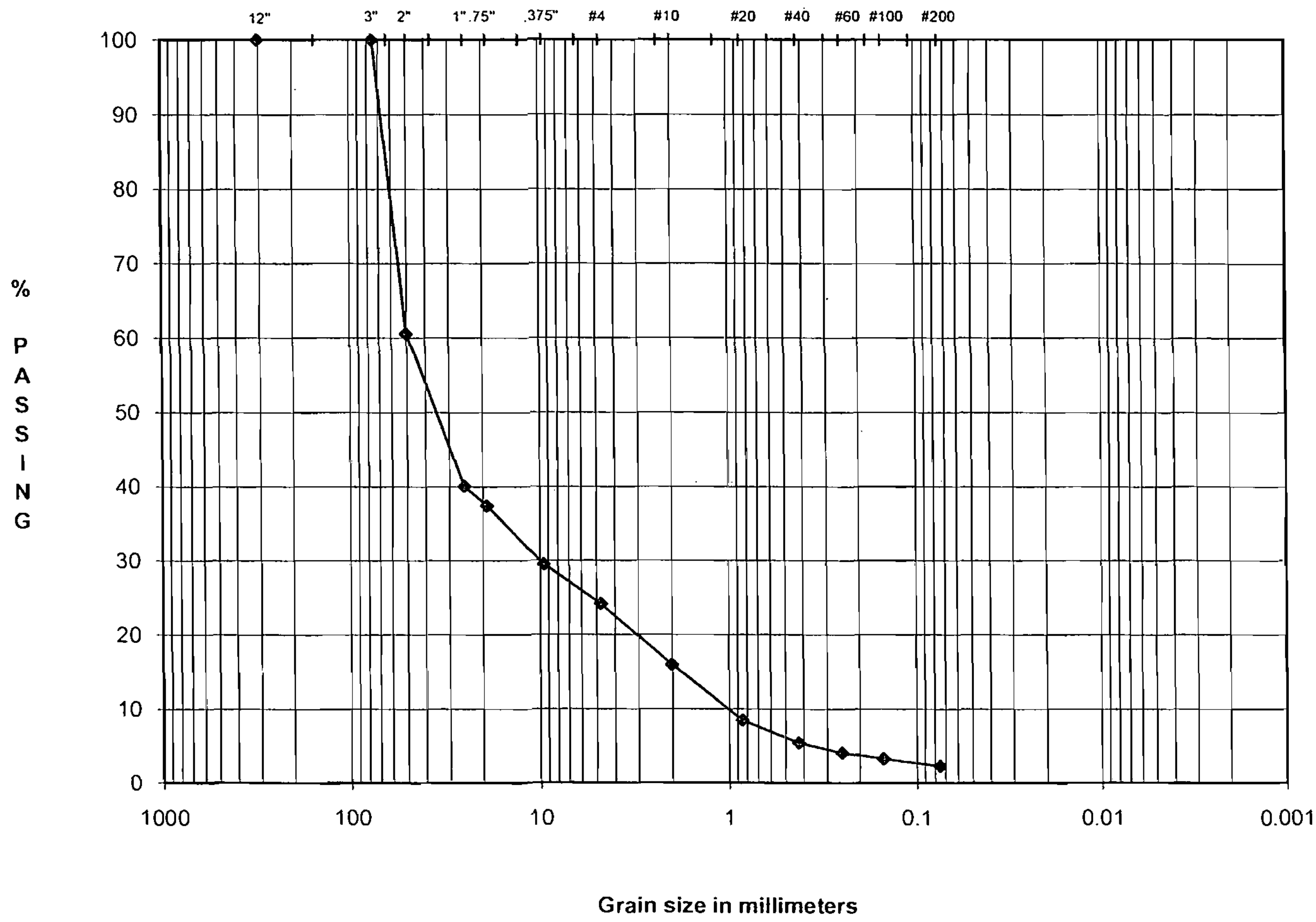
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.00
D30 (mm)	10.00
D60 (mm)	49.00
Cu	49.0
Cc	2.0

DESCRIPTION: C-F GRAVEL
some c-f sand, trace silt

USCS: GW

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	254	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	255
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2665.80
Wt Dry Soil & Tare (gm)	(w2)	2603.20
Weight of Tare (gm)	(w3)	328.50
Weight of Water (gm)	(w4=w1-w2)	62.60
Weight of Dry Soil (gm)	(w5=w2-w3)	2274.70
Moisture Content (%)	(w4/w5)*100	2.75

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	2603.20
	Tare Weight (gm)	328.50
(W6)	Total Dry Weight (gm)	2274.70

SIEVE ANALYSIS

Tare Weight: 328.50

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	328.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	328.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	328.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	560.90	232.40	10.22	89.78	2.0"	coarse gravel
1.5"	945.30	616.80	27.12	72.88	1.5"	coarse gravel
1.0"	1209.60	881.10	38.73	61.27	1.0"	coarse gravel
0.75"	1492.30	1163.80	51.16	48.84	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1935.40	1606.90	70.64	29.36	0.375"	fine gravel
#4	2195.30	1866.80	82.07	17.93	#4	coarse sand
#10	2355.80	2027.30	89.12	10.88	#10	medium sand
#20	2486.70	2158.20	94.88	5.12	#20	medium sand
#40	2536.80	2208.30	97.08	2.92	#40	fine sand
#60	2549.70	2221.20	97.65	2.35	#60	fine sand
#100	2555.90	2227.40	97.92	2.08	#100	fine sand
#200	2566.70	2238.20	98.40	1.60	#200	fines
PAN	17512.80	17184.30			PAN	

% COBBLES	0.00
% C GRAVEL	51.16
% F GRAVEL	30.91
% C SAND	7.06
% M SAND	7.96
% F SAND	1.31
% FINES	1.60
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

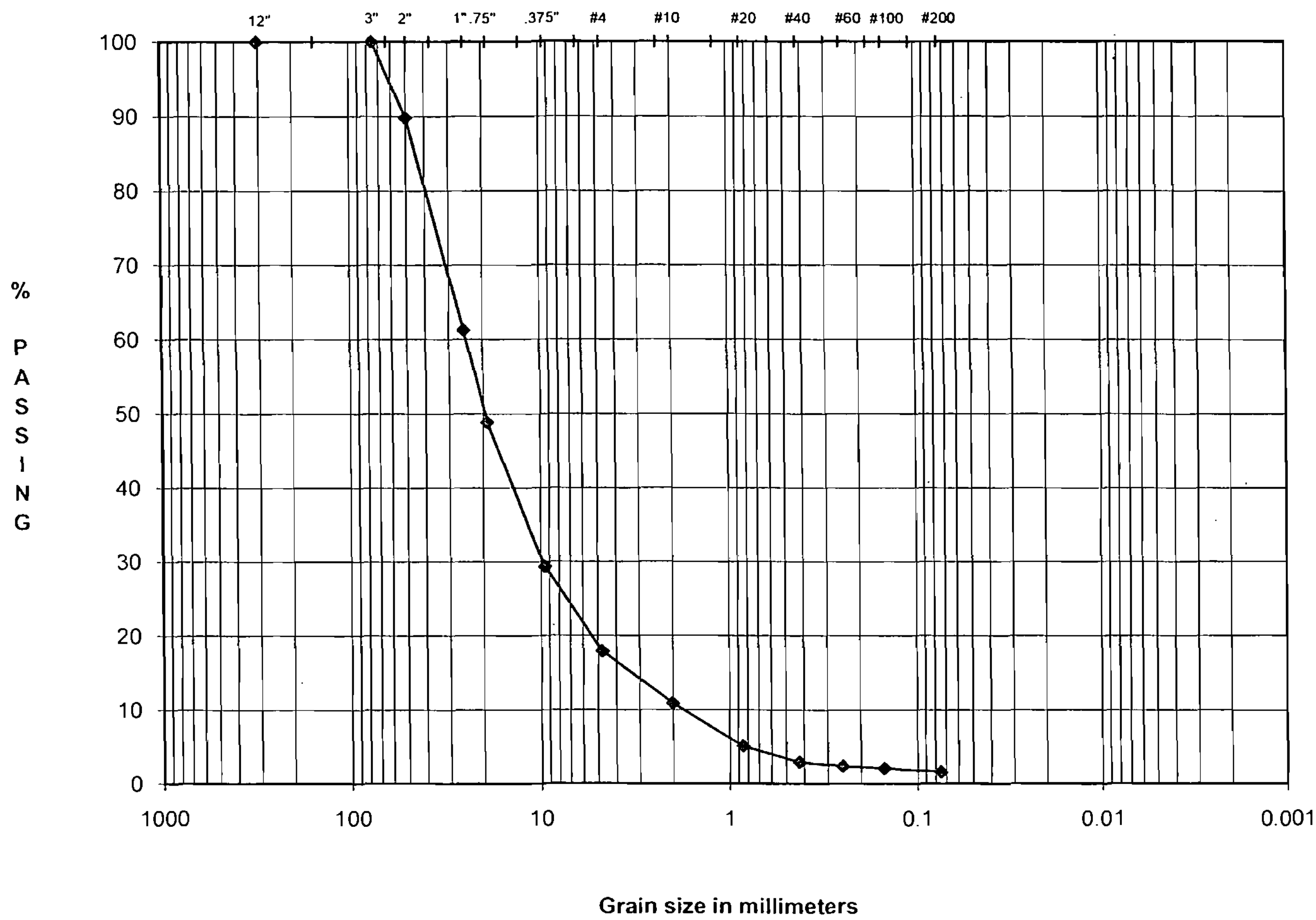
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.80
D30 (mm)	10.00
D60 (mm)	25.00
Cu	13.9
Cc	2.2

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	255	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	258
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3111.60
Wt Dry Soil & Tare (gm)	(w2)	2993.10
Weight of Tare (gm)	(w3)	324.50
Weight of Water (gm)	(w4=w1-w2)	118.50
Weight of Dry Soil (gm)	(w5=w2-w3)	2668.60
Moisture Content (%)	(w4/w5)*100	4.44

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2993.10
Tare Weight (gm)	324.50
(W6) Total Dry Weight (gm)	2668.60

SIEVE ANALYSIS

Tare Weight: 324.50

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	324.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	324.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	324.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	324.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	506.90	182.40	6.84	93.16	1.5"	coarse gravel
1.0"	984.00	659.50	24.71	75.29	1.0"	coarse gravel
0.75"	1146.20	821.70	30.79	69.21	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1764.00	1439.50	53.94	46.06	0.375"	fine gravel
#4	2265.30	1940.80	72.73	27.27	#4	coarse sand
#10	2606.40	2281.90	85.51	14.49	#10	medium sand
#20	2728.60	2404.10	90.09	9.91	#20	medium sand
#40	2763.30	2438.80	91.39	8.61	#40	fine sand
#60	2788.30	2463.80	92.33	7.67	#60	fine sand
#100	2816.80	2492.30	93.39	6.61	#100	fine sand
#200	2875.50	2551.00	95.59	4.41	#200	fines
PAN	17512.80	17188.30			PAN	

% COBBLES	0.00
% C GRAVEL	30.79
% F GRAVEL	41.94
% C SAND	12.78
% M SAND	5.88
% F SAND	4.20
% FINES	4.41
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.90
D30 (mm)	5.30
D60 (mm)	15.00
Cu	16.7
Cc	2.1

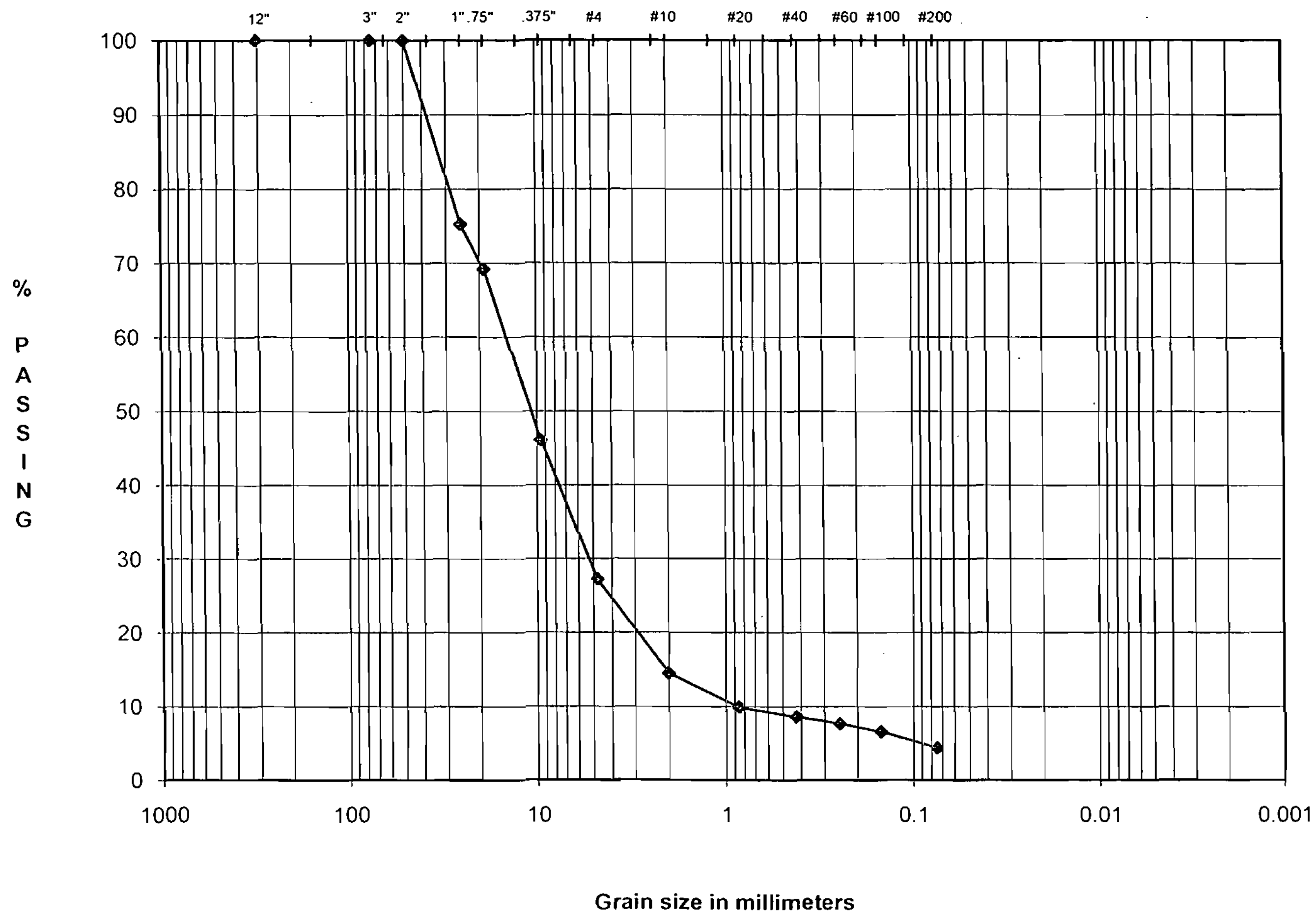
DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

Golder Associates

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	258	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	259
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3246.80
Wt Dry Soil & Tare (gm)	(w2)	3127.30
Weight of Tare (gm)	(w3)	306.90
Weight of Water (gm)	(w4=w1-w2)	119.50
Weight of Dry Soil (gm)	(w5=w2-w3)	2820.40
Moisture Content (%)	(w4/w5)*100	4.24

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	3127.30
Tare Weight (gm)	306.90
(W6) Total Dry Weight (gm)	2820.40

SIEVE ANALYSIS

Tare Weight: 306.90

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	306.90	0.00	0.00	100.00	12.0"	cobbles
3.0"	306.90	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	858.60	551.70	19.56	80.44	2.5"	coarse gravel
2.0"	858.60	551.70	19.56	80.44	2.0"	coarse gravel
1.5"	1149.00	842.10	29.86	70.14	1.5"	coarse gravel
1.0"	1436.60	1129.70	40.05	59.95	1.0"	coarse gravel
0.75"	1654.80	1347.90	47.79	52.21	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2182.40	1875.50	66.50	33.50	0.375"	fine gravel
#4	2455.30	2148.40	76.17	23.83	#4	coarse sand
#10	2650.40	2343.50	83.09	16.91	#10	medium sand
#20	2824.60	2517.70	89.27	10.73	#20	medium sand
#40	2953.50	2646.60	93.84	6.16	#40	fine sand
#60	3013.90	2707.00	95.98	4.02	#60	fine sand
#100	3041.40	2734.50	96.95	3.05	#100	fine sand
#200	3066.10	2759.20	97.83	2.17	#200	fines
PAN	17512.80	17205.90			PAN	

% COBBLES	0.00
% C GRAVEL	47.79
% F GRAVEL	28.38
% C SAND	6.92
% M SAND	10.75
% F SAND	3.99
% FINES	2.17
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

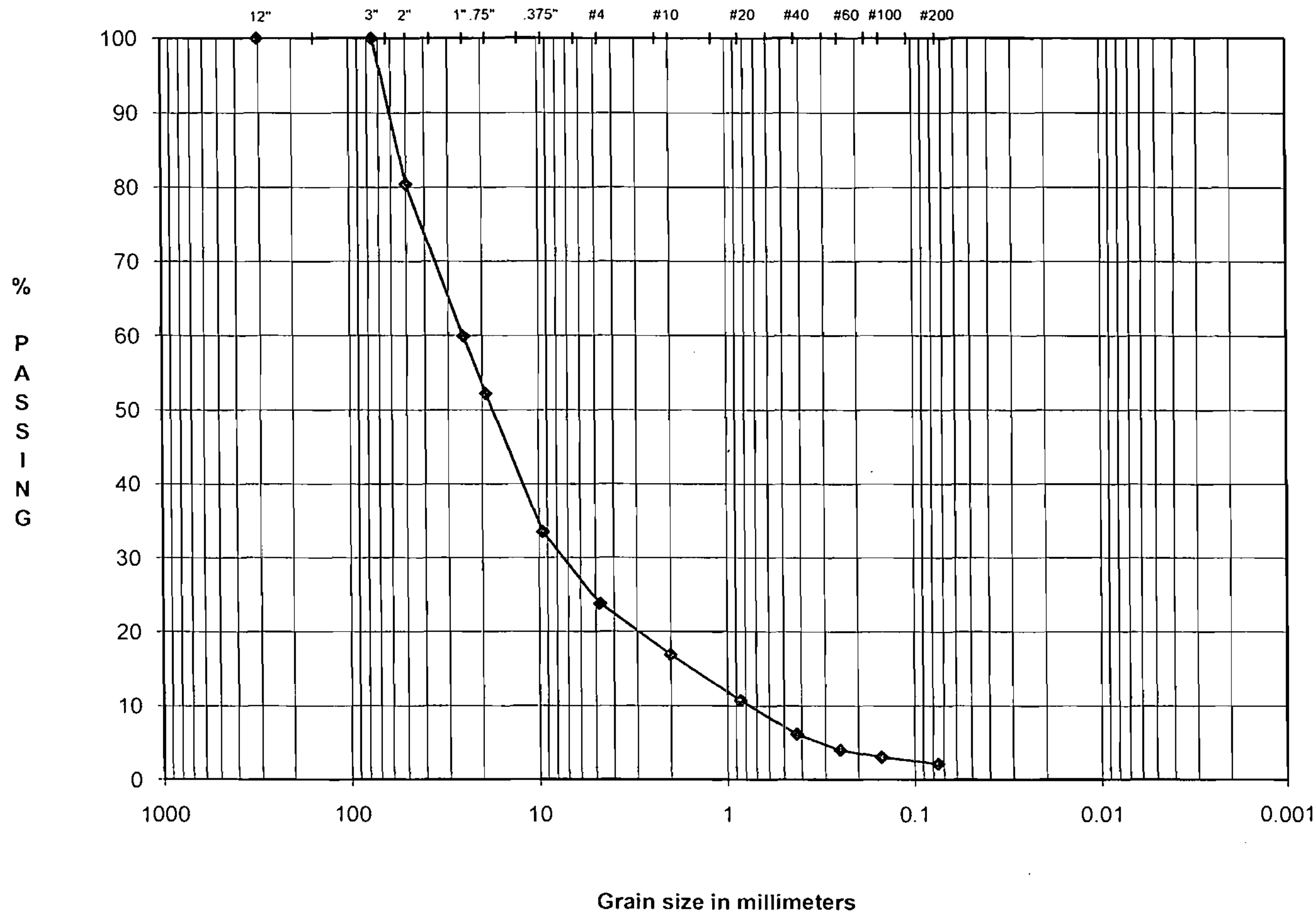
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.80
D30 (mm)	7.40
D60 (mm)	26.00
Cu	32.5
Cc	2.6

DESCRIPTION: C-F GRAVEL
some c-f sand, trace silt

USCS: GW

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	259	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	260
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3077.80
Wt Dry Soil & Tare (gm)	(w2)	2982.80
Weight of Tare (gm)	(w3)	311.50
Weight of Water (gm)	(w4=w1-w2)	95.00
Weight of Dry Soil (gm)	(w5=w2-w3)	2671.30
Moisture Content (%)	(w4/w5)*100	3.56

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2982.80
Tare Weight (gm)	311.50
(W6) Total Dry Weight (gm)	2671.30

SIEVE ANALYSIS

Tare Weight: 311.50

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	311.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	311.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	311.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	311.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	311.50	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	812.30	500.80	18.75	81.25	1.0"	coarse gravel
0.75"	1119.60	808.10	30.25	69.75	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1756.70	1445.20	54.10	45.90	0.375"	fine gravel
#4	2303.30	1991.80	74.56	25.44	#4	coarse sand
#10	2625.90	2314.40	86.64	13.36	#10	medium sand
#20	2789.60	2478.10	92.77	7.23	#20	medium sand
#40	2862.30	2550.80	95.49	4.51	#40	fine sand
#60	2896.30	2584.80	96.76	3.24	#60	fine sand
#100	2915.40	2603.90	97.48	2.52	#100	fine sand
#200	2936.70	2625.20	98.27	1.73	#200	fines
PAN	17512.80	17201.30			PAN	

% COBBLES	0.00
% C GRAVEL	30.25
% F GRAVEL	44.31
% C SAND	12.08
% M SAND	8.85
% F SAND	2.79
% FINES	1.73
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

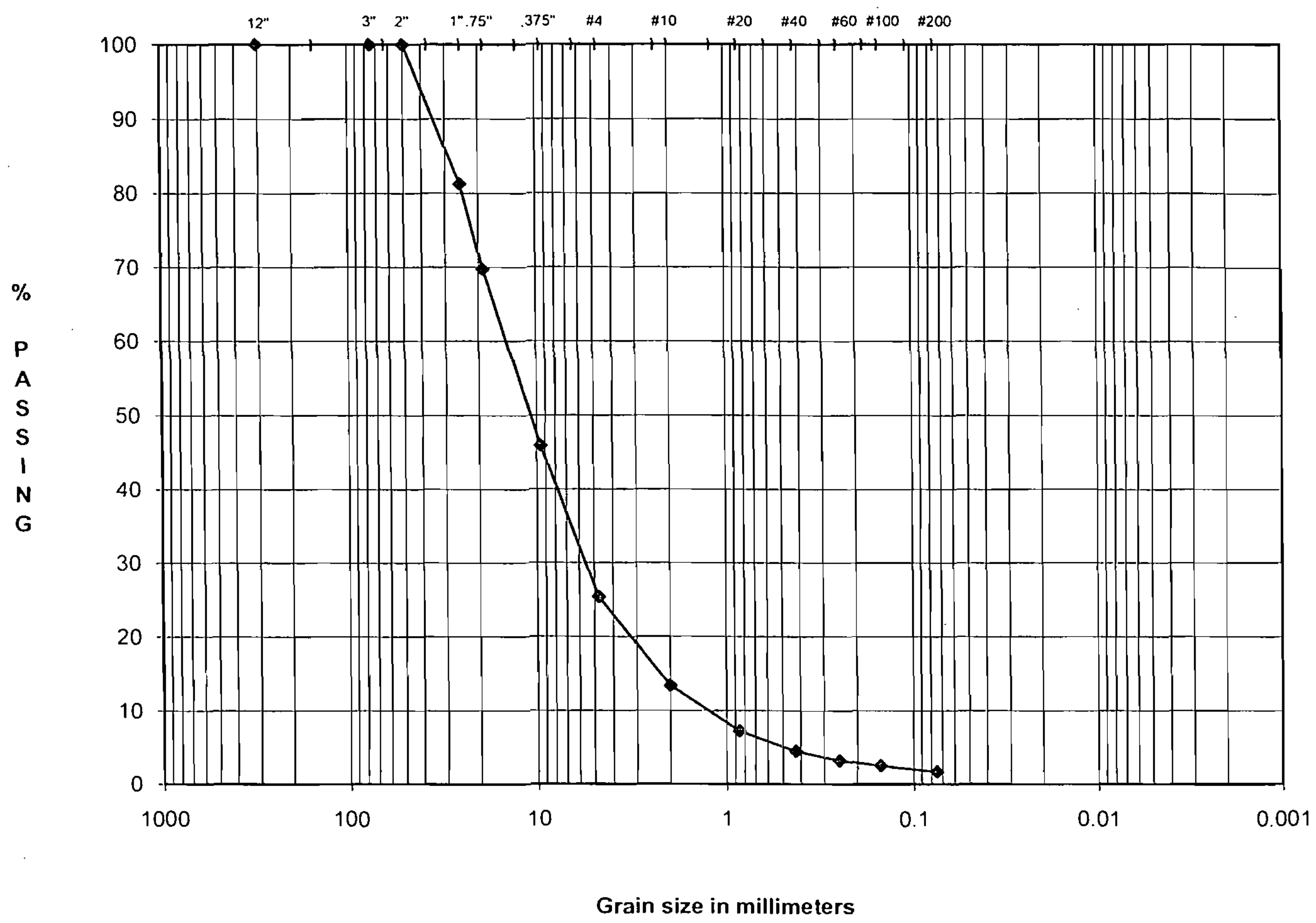
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.30
D30 (mm)	5.80
D60 (mm)	15.00
Cu	11.5
Cc	1.7

DESCRIPTION: C-F GRAVEL
some c-f sand, trace silt

USCS: GW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	260	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

Golder Associates Inc.

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	262
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2955.40
Wt Dry Soil & Tare (gm)	(w2)	2814.70
Weight of Tare (gm)	(w3)	309.70
Weight of Water (gm)	(w4=w1-w2)	140.70
Weight of Dry Soil (gm)	(w5=w2-w3)	2505.00
Moisture Content (%)	(w4/w5)*100	5.62

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	2814.70
	Tare Weight (gm)	309.70
(W6)	Total Dry Weight (gm)	2505.00

SIEVE ANALYSIS

Tare Weight: 309.70

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	309.70	0.00	0.00	100.00	12.0"	cobbles
3.0"	309.70	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	309.70	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	309.70	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	309.70	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	309.70	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	346.00	36.30	1.45	98.55	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	583.40	273.70	10.93	89.07	0.375"	fine gravel
#4	1318.90	1009.20	40.29	59.71	#4	coarse sand
#10	2015.40	1705.70	68.09	31.91	#10	medium sand
#20	2318.00	2008.30	80.17	19.83	#20	medium sand
#40	2529.10	2219.40	88.60	11.40	#40	fine sand
#60	2636.80	2327.10	92.90	7.10	#60	fine sand
#100	2700.00	2390.30	95.42	4.58	#100	fine sand
#200	2751.10	2441.40	97.46	2.54	#200	fines
PAN	17512.80	17203.10			PAN	

% COBBLES	0.00
% C GRAVEL	1.45
% F GRAVEL	38.84
% C SAND	27.80
% M SAND	20.51
% F SAND	8.86
% FINES	2.54
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

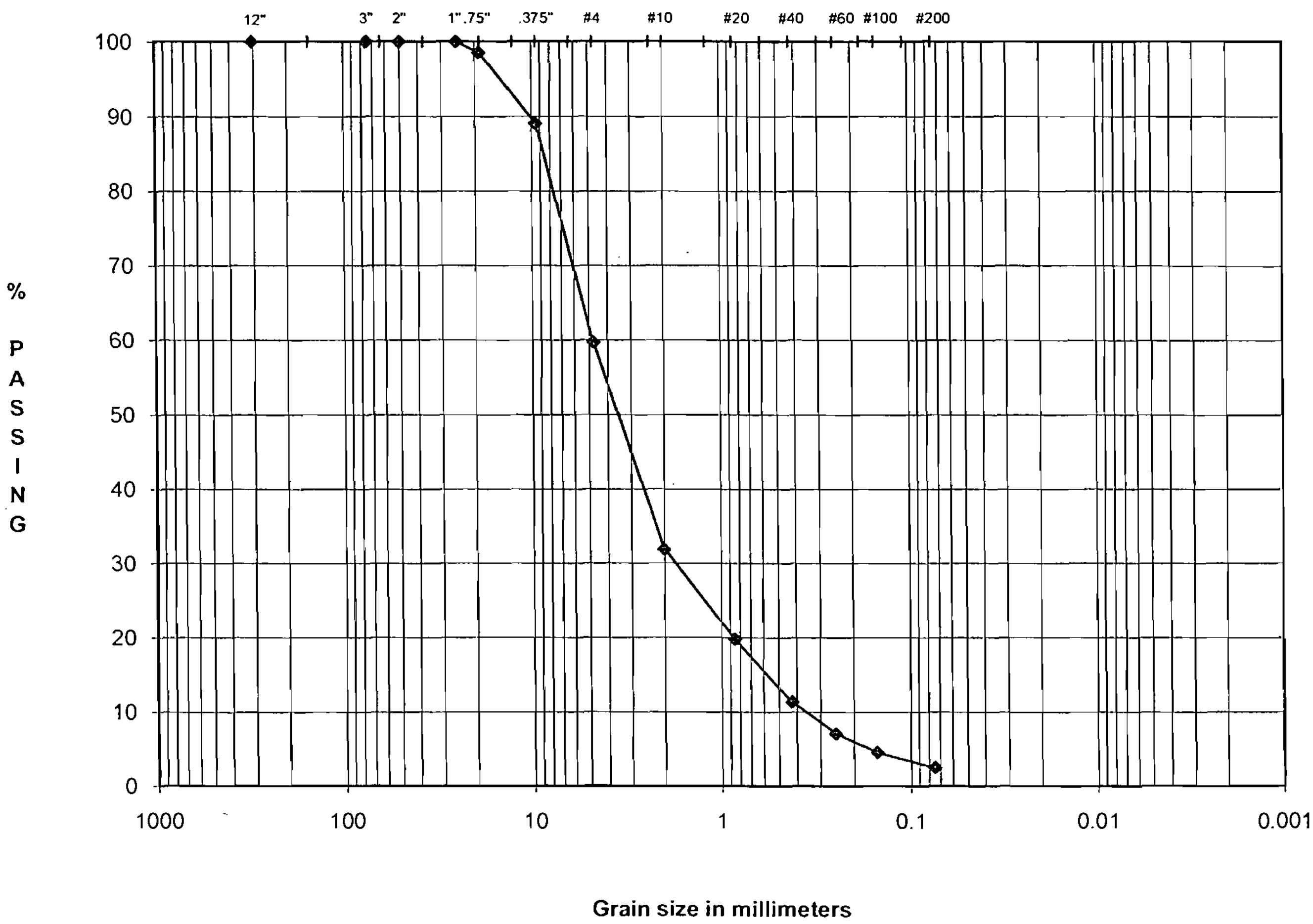
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.38
D30 (mm)	1.80
D60 (mm)	5.00
Cu	13.2
Cc	1.7

DESCRIPTION C-F SAND and C-F GRAVEL
trace silt

USCS SW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	262	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION: C-F SAND and C-F GRAVEL
trace silt

USCS: SW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	265
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2447.10
Wt Dry Soil & Tare (gm)	(w2)	2204.00
Weight of Tare (gm)	(w3)	415.70
Weight of Water (gm)	(w4=w1-w2)	243.10
Weight of Dry Soil (gm)	(w5=w2-w3)	1788.30
Moisture Content (%)	(w4/w5)*100	13.59

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2204.00
Tare Weight (gm)	415.70
(W6) Total Dry Weight (gm)	1788.30

SIEVE ANALYSIS

Tare Weight: 415.70

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	415.70	0.00	0.00	100.00	12.0"	cobbles
3.0"	415.70	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	415.70	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	415.70	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	415.70	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	415.70	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	415.70	0.00	0.00	100.00	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	421.10	5.40	0.30	99.70	0.375"	fine gravel
#4	427.10	11.40	0.64	99.36	#4	coarse sand
#10	448.90	33.20	1.86	98.14	#10	medium sand
#20	583.10	167.40	9.36	90.64	#20	medium sand
#40	955.60	539.90	30.19	69.81	#40	fine sand
#60	1356.70	941.00	52.62	47.38	#60	fine sand
#100	1616.30	1200.60	67.14	32.86	#100	fine sand
#200	1875.70	1460.00	81.64	18.36	#200	fines
PAN	17512.80	17097.10			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.64
% C SAND	1.22
% M SAND	28.33
% F SAND	51.45
% FINES	18.36
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

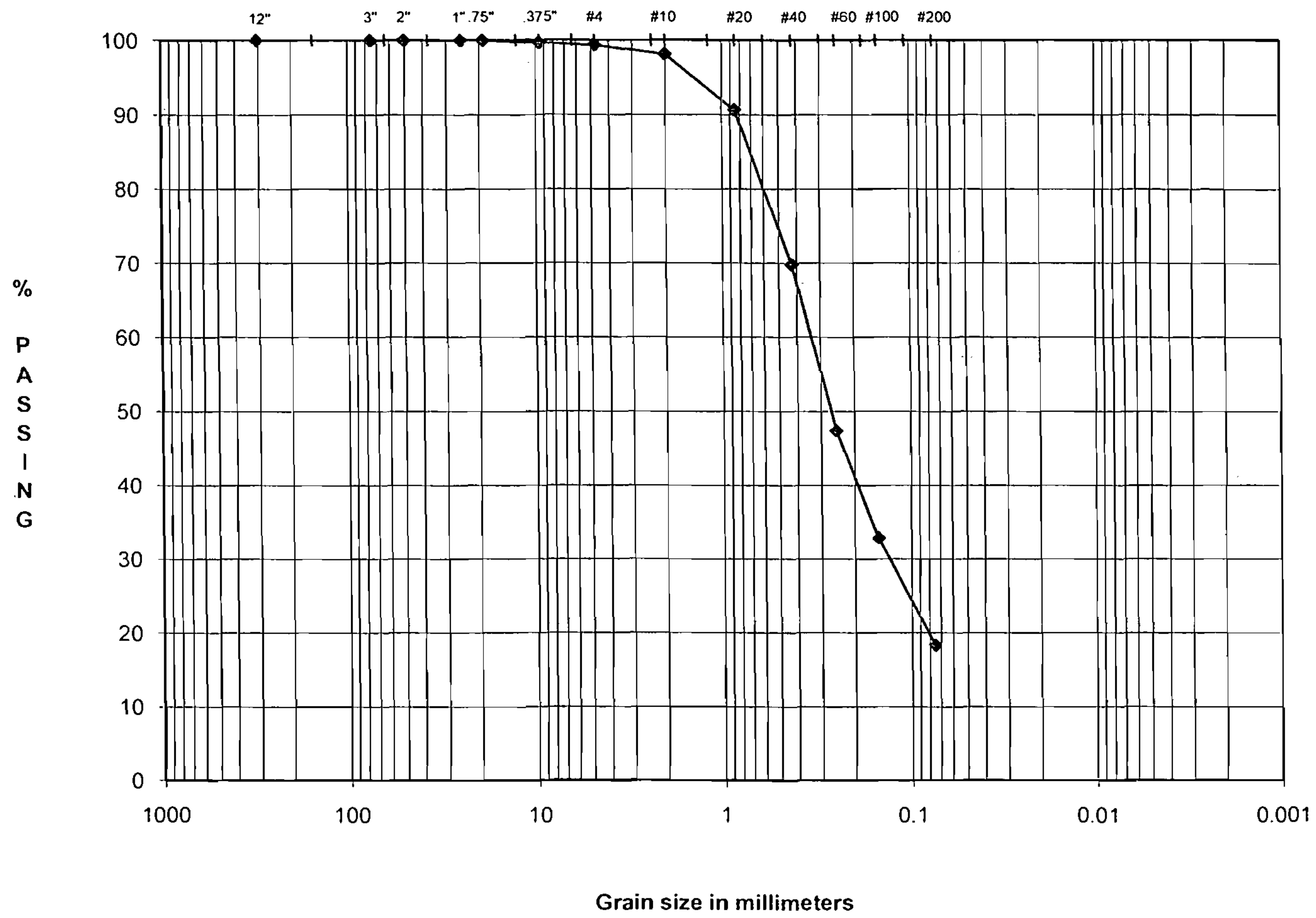
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.05
D30 (mm)	0.14
D60 (mm)	0.34
Cu	7.1
Cc	1.2

DESCRIPTION
C-F SAND
some silt, trace f. gravel,
organic material present

USCS SM

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	265	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F SAND some silt, trace f. gravel, organic material present
USCS	SM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	267
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2930.10
Wt Dry Soil & Tare (gm)	(w2)	2825.70
Weight of Tare (gm)	(w3)	308.80
Weight of Water (gm)	(w4=w1-w2)	104.40
Weight of Dry Soil (gm)	(w5=w2-w3)	2516.90
Moisture Content (%)	(w4/w5)*100	4.15

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	2825.70
	Tare Weight (gm)	308.80
(W6)	Total Dry Weight (gm)	2516.90

SIEVE ANALYSIS

Tare Weight: 308.80

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	308.80	0.00	0.00	100.00	12.0"	cobbles
3.0"	308.80	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	308.80	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	753.10	444.30	17.65	82.35	2.0"	coarse gravel
1.5"	1066.90	758.10	30.12	69.88	1.5"	coarse gravel
1.0"	1827.50	1518.70	60.34	39.66	1.0"	coarse gravel
0.75"	2220.30	1911.50	75.95	24.05	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2521.30	2212.50	87.91	12.09	0.375"	fine gravel
#4	2547.60	2238.80	88.95	11.05	#4	coarse sand
#10	2552.30	2243.50	89.14	10.86	#10	medium sand
#20	2555.30	2246.50	89.26	10.74	#20	medium sand
#40	2563.40	2254.60	89.58	10.42	#40	fine sand
#60	2599.70	2290.90	91.02	8.98	#60	fine sand
#100	2667.10	2358.30	93.70	6.30	#100	fine sand
#200	2746.30	2437.50	96.85	3.15	#200	fines
PAN	17512.80	17204.00			PAN	

% COBBLES	0.00
% C GRAVEL	75.95
% F GRAVEL	13.00
% C SAND	0.19
% M SAND	0.44
% F SAND	7.27
% FINES	3.15
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

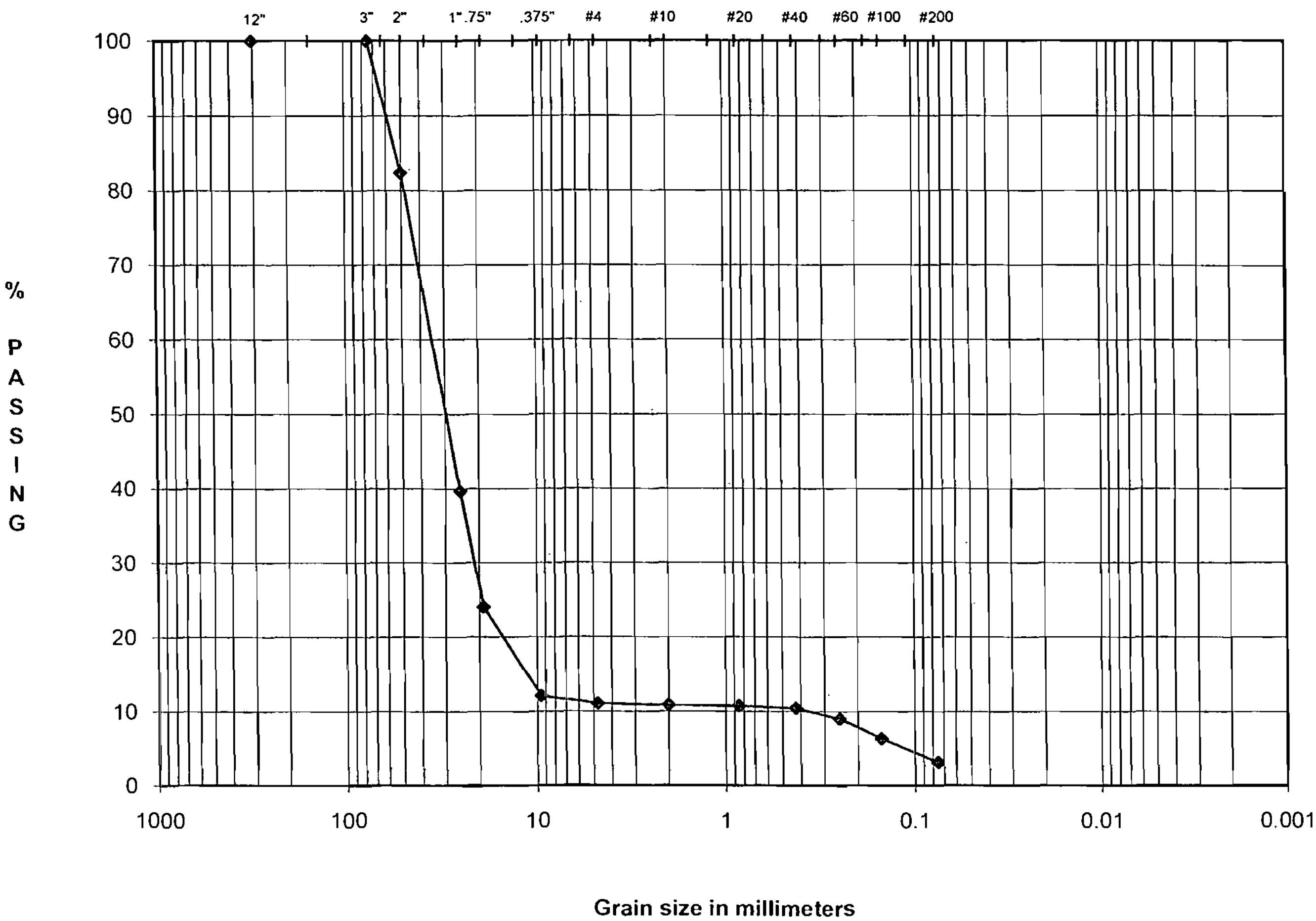
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.35
D30 (mm)	21.00
D60 (mm)	36.00
Cu	102.9
Cc	35.0

DESCRIPTION C-F GRAVEL
little c-f sand, trace silt

USCS GP

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	267	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL little c-f sand, trace silt
USCS	GP

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	269
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2781.30
Wt Dry Soil & Tare (gm)	(w2)	2508.60
Weight of Tare (gm)	(w3)	323.90
Weight of Water (gm)	(w4=w1-w2)	272.70
Weight of Dry Soil (gm)	(w5=w2-w3)	2184.70
Moisture Content (%)	(w4/w5)*100	12.48

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	2508.60
Tare Weight (gm)	323.90
(W6) Total Dry Weight (gm)	2184.70

SIEVE ANALYSIS

Tare Weight: 323.90

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	323.90	0.00	0.00	100.00	12.0"	cobbles
3.0"	323.90	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	323.90	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	323.90	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	590.20	266.30	12.19	87.81	1.5"	coarse gravel
1.0"	884.80	560.90	25.67	74.33	1.0"	coarse gravel
0.75"	975.40	651.50	29.82	70.18	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1230.50	906.60	41.50	58.50	0.375"	fine gravel
#4	1422.10	1098.20	50.27	49.73	#4	coarse sand
#10	1579.20	1255.30	57.46	42.54	#10	medium sand
#20	1683.00	1359.10	62.21	37.79	#20	medium sand
#40	1749.00	1425.10	65.23	34.77	#40	fine sand
#60	1824.60	1500.70	68.69	31.31	#60	fine sand
#100	1927.80	1603.90	73.42	26.58	#100	fine sand
#200	2161.50	1837.60	84.11	15.89	#200	fines
PAN	17512.80	17188.90			PAN	

% COBBLES	0.00
% C GRAVEL	29.82
% F GRAVEL	20.45
% C SAND	7.19
% M SAND	7.77
% F SAND	18.88
% FINES	15.89
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

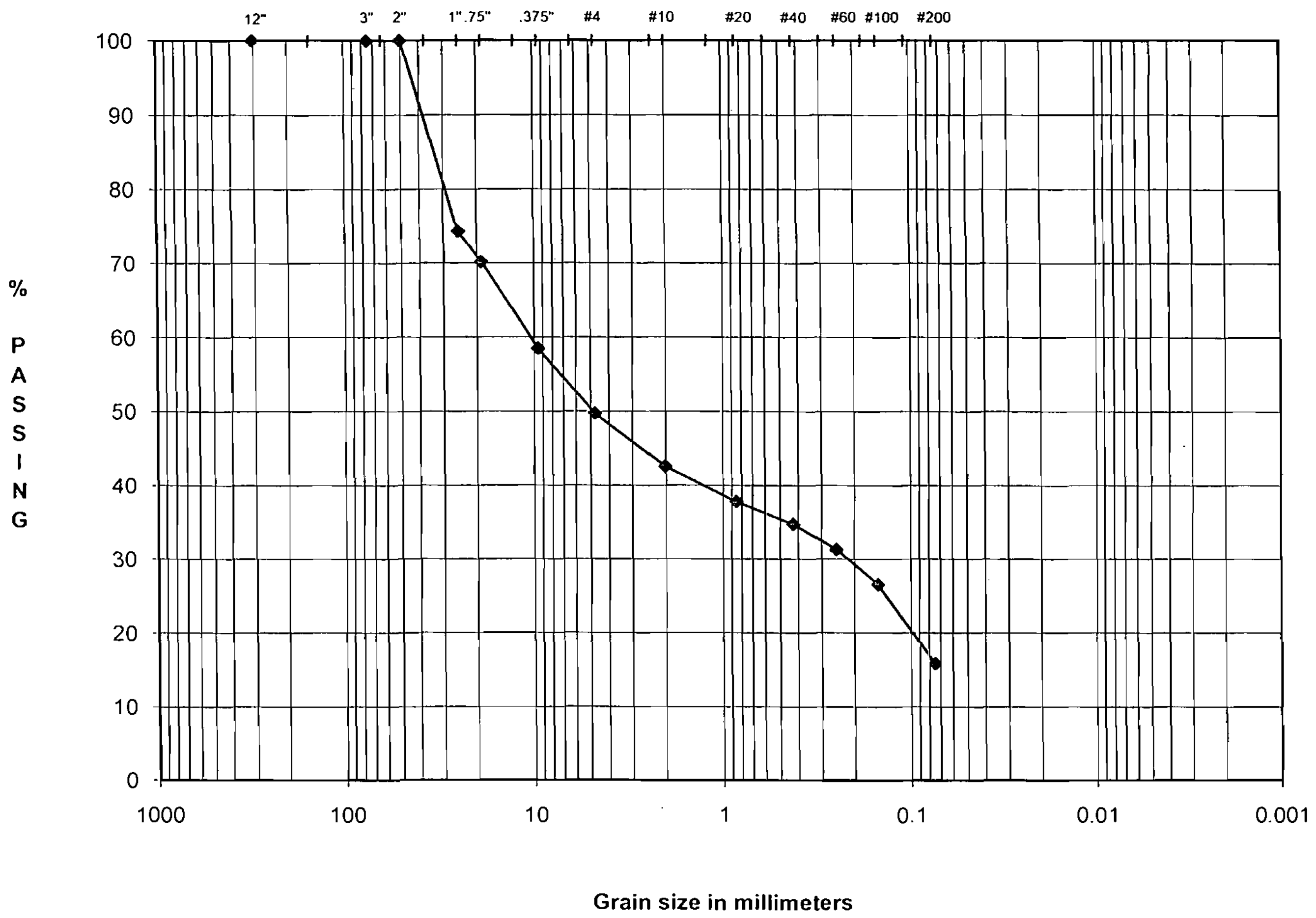
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.05
D30 (mm)	0.22
D60 (mm)	11.00
Cu	220.0
Cc	0.1

DESCRIPTION
C-F GRAVEL and C-F SAND
some silt
organic material present

USCS SM

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			**FINES**

SAMPLE ID	269	0
SAMPLE TYPE	Grab	
C-F GRAVEL and C-F SAND	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION C-F GRAVEL and C-F SAND
some silt
organic material present

USCS SM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	272
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2502.30
Wt Dry Soil & Tare (gm)	(w2)	2094.30
Weight of Tare (gm)	(w3)	321.00
Weight of Water (gm)	(w4=w1-w2)	408.00
Weight of Dry Soil (gm)	(w5=w2-w3)	1773.30
Moisture Content (%)	(w4/w5)*100	23.01

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	2094.30
	Tare Weight (gm)	321.00
(W6)	Total Dry Weight (gm)	1773.30

SIEVE ANALYSIS

Tare Weight: 321.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	321.00	0.00	0.00	100.00	12.0"	cobbles
3.0"	321.00	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	321.00	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	321.00	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	321.00	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	337.40	16.40	0.92	99.08	1.0"	coarse gravel
0.75"	337.40	16.40	0.92	99.08	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	444.30	123.30	6.95	93.05	0.375"	fine gravel
#4	567.00	246.00	13.87	86.13	#4	coarse sand
#10	643.00	322.00	18.16	81.84	#10	medium sand
#20	686.20	365.20	20.59	79.41	#20	medium sand
#40	727.20	406.20	22.91	77.09	#40	fine sand
#60	926.30	605.30	34.13	65.87	#60	fine sand
#100	1514.10	1193.10	67.28	32.72	#100	fine sand
#200	1825.90	1504.90	84.86	15.14	#200	fines
PAN	17512.80	17191.80			PAN	

% COBBLES	0.00
% C GRAVEL	0.92
% F GRAVEL	12.95
% C SAND	4.29
% M SAND	4.75
% F SAND	61.96
% FINES	15.14
% TOTAL	100.00

Descriptive Terms		
		> 10% mostly coarse (c)
trace	0 to 5%	> 10% mostly medium (m)
little	5 to 12%	< 10% fine (c-m)
some	12 to 30%	< 10% coarse (m-f)
and	30 to 50%	< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

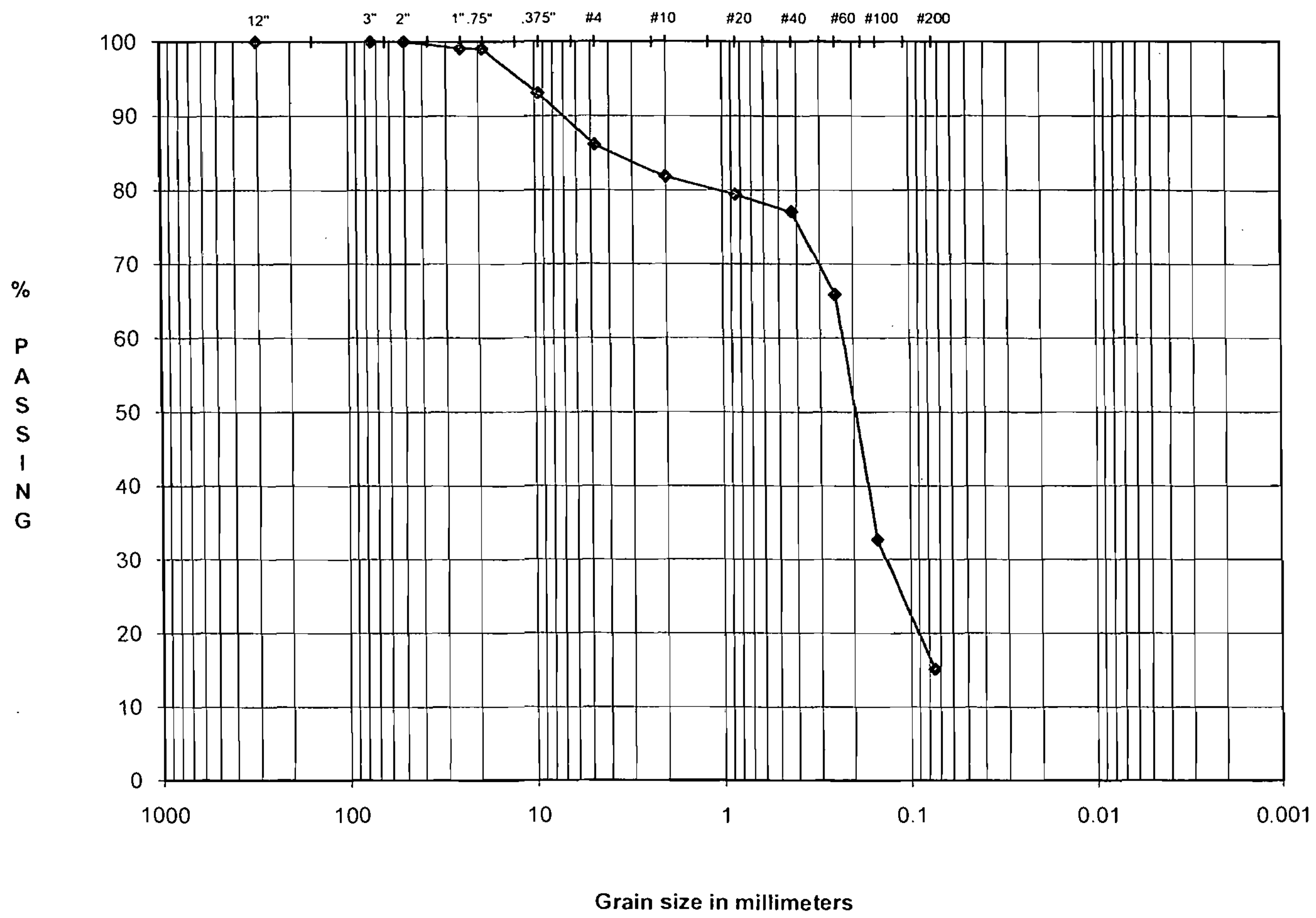
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.06
D30 (mm)	0.15
D60 (mm)	0.24
Cu	3.9
Cc	1.5

DESCRIPTION
C-F SAND
some silt, some c-f gravel

USCS SM

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	272	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION C-F SAND
some silt, some c-f gravel

USCS SM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	273
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3398.40
Wt Dry Soil & Tare (gm)	(w2)	3182.60
Weight of Tare (gm)	(w3)	312.10
Weight of Water (gm)	(w4=w1-w2)	215.80
Weight of Dry Soil (gm)	(w5=w2-w3)	2870.50
Moisture Content (%)	(w4/w5)*100	7.52

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	3182.60
Tare Weight (gm)	312.10
(W6) Total Dry Weight (gm)	2870.50

SIEVE ANALYSIS

Tare Weight: 312.10

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	312.10	0.00	0.00	100.00	12.0"	cobbles
3.0"	312.10	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	312.10	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	312.10	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	668.90	356.80	12.43	87.57	1.5"	coarse gravel
1.0"	1017.90	705.80	24.59	75.41	1.0"	coarse gravel
0.75"	1125.30	813.20	28.33	71.67	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1700.70	1388.60	48.37	51.63	0.375"	fine gravel
#4	2106.80	1794.70	62.52	37.48	#4	coarse sand
#10	2502.00	2189.90	76.29	23.71	#10	medium sand
#20	2754.10	2442.00	85.07	14.93	#20	medium sand
#40	2843.40	2531.30	88.18	11.82	#40	fine sand
#60	2899.00	2586.90	90.12	9.88	#60	fine sand
#100	2963.90	2651.80	92.38	7.62	#100	fine sand
#200	3062.30	2750.20	95.81	4.19	#200	fines
PAN	17512.80	17200.70			PAN	

% COBBLES	0.00
% C GRAVEL	28.33
% F GRAVEL	34.19
% C SAND	13.77
% M SAND	11.89
% F SAND	7.63
% FINES	4.19
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

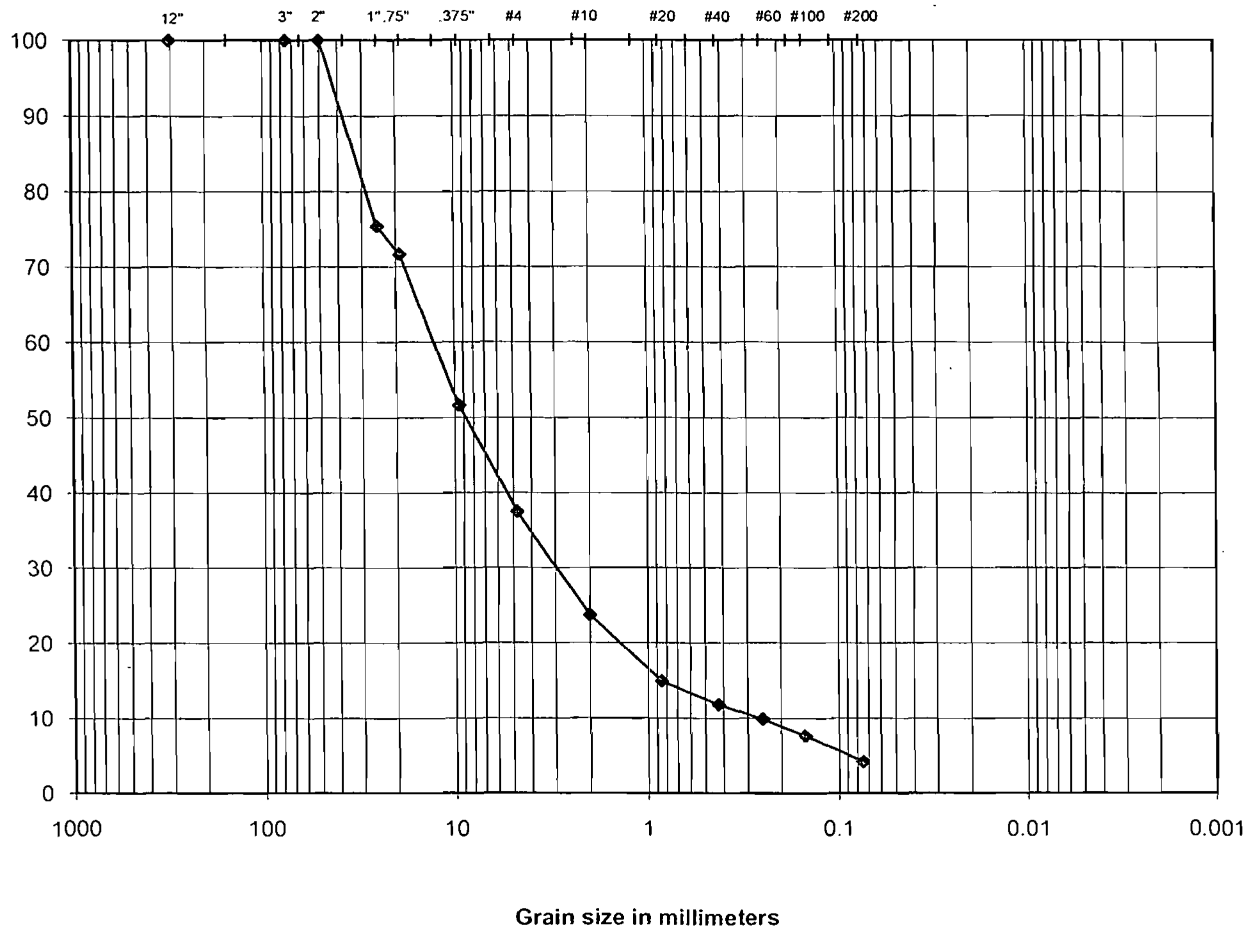
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.28
D30 (mm)	3.00
D60 (mm)	13.00
Cu	46.4
Cc	2.5

DESCRIPTION C-F GRAVEL and C-F SAND
trace silt

USCS GW

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	273	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL and C-F SAND trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	276
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3599.30
Wt Dry Soil & Tare (gm)	(w2)	3281.90
Weight of Tare (gm)	(w3)	309.60
Weight of Water (gm)	(w4=w1-w2)	317.40
Weight of Dry Soil (gm)	(w5=w2-w3)	2972.30
Moisture Content (%)	(w4/w5)*100	10.68

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	3281.90
Tare Weight (gm)	309.60
(W6) Total Dry Weight (gm)	2972.30

SIEVE ANALYSIS

Tare Weight: 309.60

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	309.60	0.00	0.00	100.00	12.0"	cobbles
3.0"	309.60	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	309.60	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	309.60	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	747.40	437.80	14.73	85.27	1.5"	coarse gravel
1.0"	1390.20	1080.60	36.36	63.64	1.0"	coarse gravel
0.75"	1542.30	1232.70	41.47	58.53	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1944.30	1634.70	55.00	45.00	0.375"	fine gravel
#4	2190.60	1881.00	63.28	36.72	#4	coarse sand
#10	2403.40	2093.80	70.44	29.56	#10	medium sand
#20	2571.50	2261.90	76.10	23.90	#20	medium sand
#40	2766.90	2457.30	82.67	17.33	#40	fine sand
#60	2884.50	2574.90	86.63	13.37	#60	fine sand
#100	2962.30	2652.70	89.25	10.75	#100	fine sand
#200	3079.70	2770.10	93.20	6.80	#200	fines
PAN	17512.80	17203.20			PAN	

% COBBLES	0.00
% C GRAVEL	41.47
% F GRAVEL	21.81
% C SAND	7.16
% M SAND	12.23
% F SAND	10.52
% FINES	6.80
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

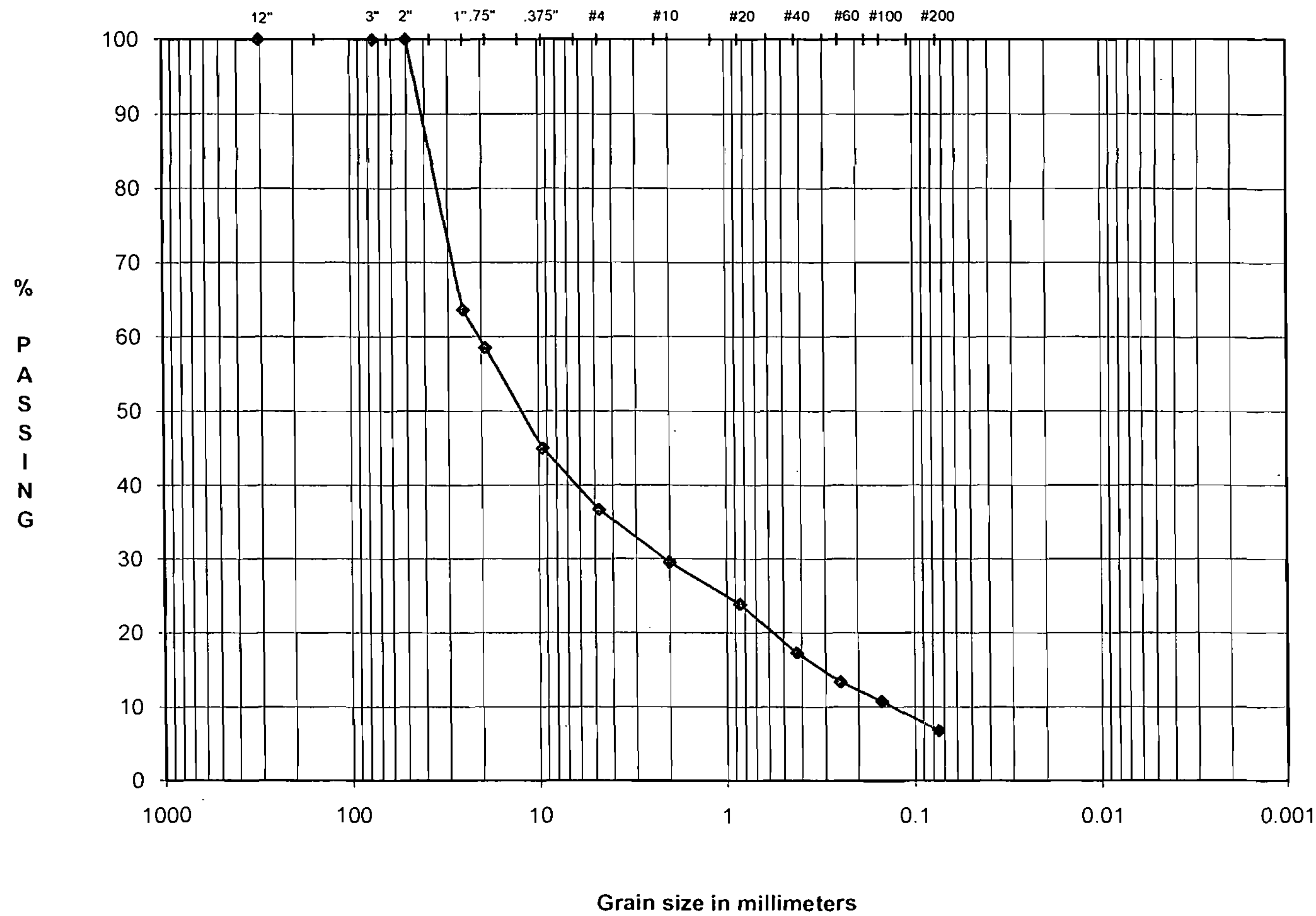
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.14
D30 (mm)	2.20
D60 (mm)	20.00
Cu	142.9
Cc	1.7

DESCRIPTION C-F GRAVEL
some c-f sand, little silt

USCS GW/GM

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	276	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, little silt
USCS	GW/GM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	278
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2408.20
Wt Dry Soil & Tare (gm)	(w2)	1932.30
Weight of Tare (gm)	(w3)	308.90
Weight of Water (gm)	(w4=w1-w2)	475.90
Weight of Dry Soil (gm)	(w5=w2-w3)	1623.40
Moisture Content (%)	(w4/w5)*100	29.32

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	1932.30
	Tare Weight (gm)	308.90
(W6)	Total Dry Weight (gm)	1623.40

SIEVE ANALYSIS

Tare Weight: 308.90

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	308.90	0.00	0.00	100.00	12.0"	cobbles
3.0"	308.90	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	308.90	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	308.90	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	308.90	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	308.90	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	308.90	0.00	0.00	100.00	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	315.80	6.90	0.43	99.57	0.375"	fine gravel
#4	323.70	14.80	0.91	99.09	#4	coarse sand
#10	338.10	29.20	1.80	98.20	#10	medium sand
#20	383.50	74.60	4.60	95.40	#20	medium sand
#40	478.80	169.90	10.47	89.53	#40	fine sand
#60	604.80	295.90	18.23	81.77	#60	fine sand
#100	1097.50	788.60	48.58	51.42	#100	fine sand
#200	1553.20	1244.30	76.65	23.35	#200	fines
PAN	17512.80	17203.90			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.91
% C SAND	0.89
% M SAND	8.67
% F SAND	66.18
% FINES	23.35
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

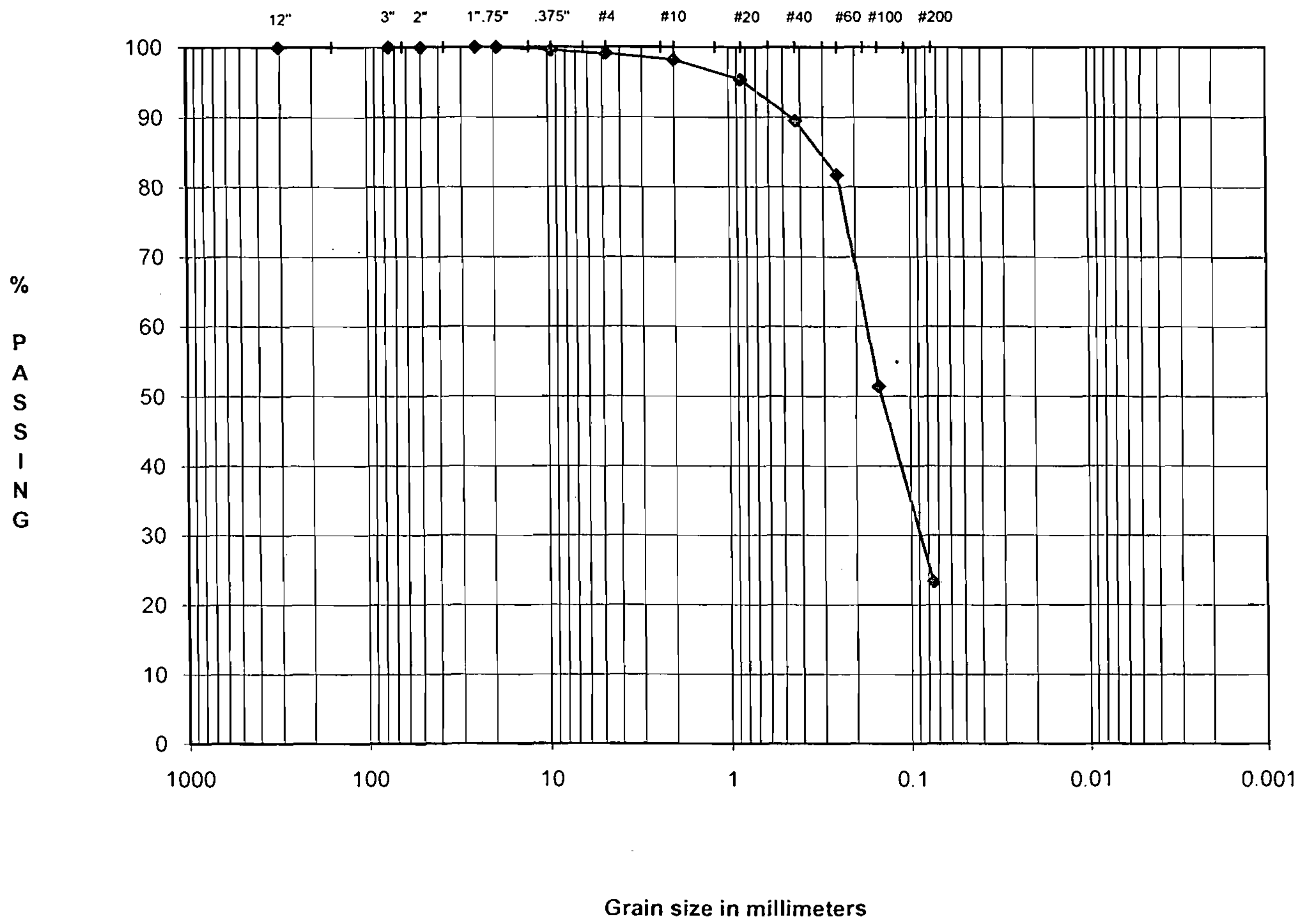
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.05
D30 (mm)	0.09
D60 (mm)	0.17
Cu	3.3
Cc	0.9

DESCRIPTION C-F SAND
some silt, trace f. gravel,
organic material present

USCS SM

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Gravel		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY

SAMPLE ID	278	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F SAND some silt, trace f. gravel, organic material present
USCS	SM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	279
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3593.30
Wt Dry Soil & Tare (gm)	(w2)	3458.10
Weight of Tare (gm)	(w3)	311.40
Weight of Water (gm)	(w4=w1-w2)	135.20
Weight of Dry Soil (gm)	(w5=w2-w3)	3146.70
Moisture Content (%)	(w4/w5)*100	4.30

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	3458.10
Tare Weight (gm)	311.40
(W6) Total Dry Weight (gm)	3146.70

SIEVE ANALYSIS

Tare Weight: 311.40

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	311.40	0.00	0.00	100.00	12.0"	cobbles
3.0"	311.40	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	311.40	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	311.40	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	311.40	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	459.70	148.30	4.71	95.29	1.0"	coarse gravel
0.75"	843.60	532.20	16.91	83.09	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2244.70	1933.30	61.44	38.56	0.375"	fine gravel
#4	2769.70	2458.30	78.12	21.88	#4	coarse sand
#10	3019.50	2708.10	86.06	13.94	#10	medium sand
#20	3172.70	2861.30	90.93	9.07	#20	medium sand
#40	3244.80	2933.40	93.22	6.78	#40	fine sand
#60	3277.40	2966.00	94.26	5.74	#60	fine sand
#100	3317.10	3005.70	95.52	4.48	#100	fine sand
#200	3383.40	3072.00	97.63	2.37	#200	fines
PAN	17512.80	17201.40			PAN	

% COBBLES	0.00
% C GRAVEL	16.91
% F GRAVEL	61.21
% C SAND	7.94
% M SAND	7.16
% F SAND	4.40
% FINES	2.37
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

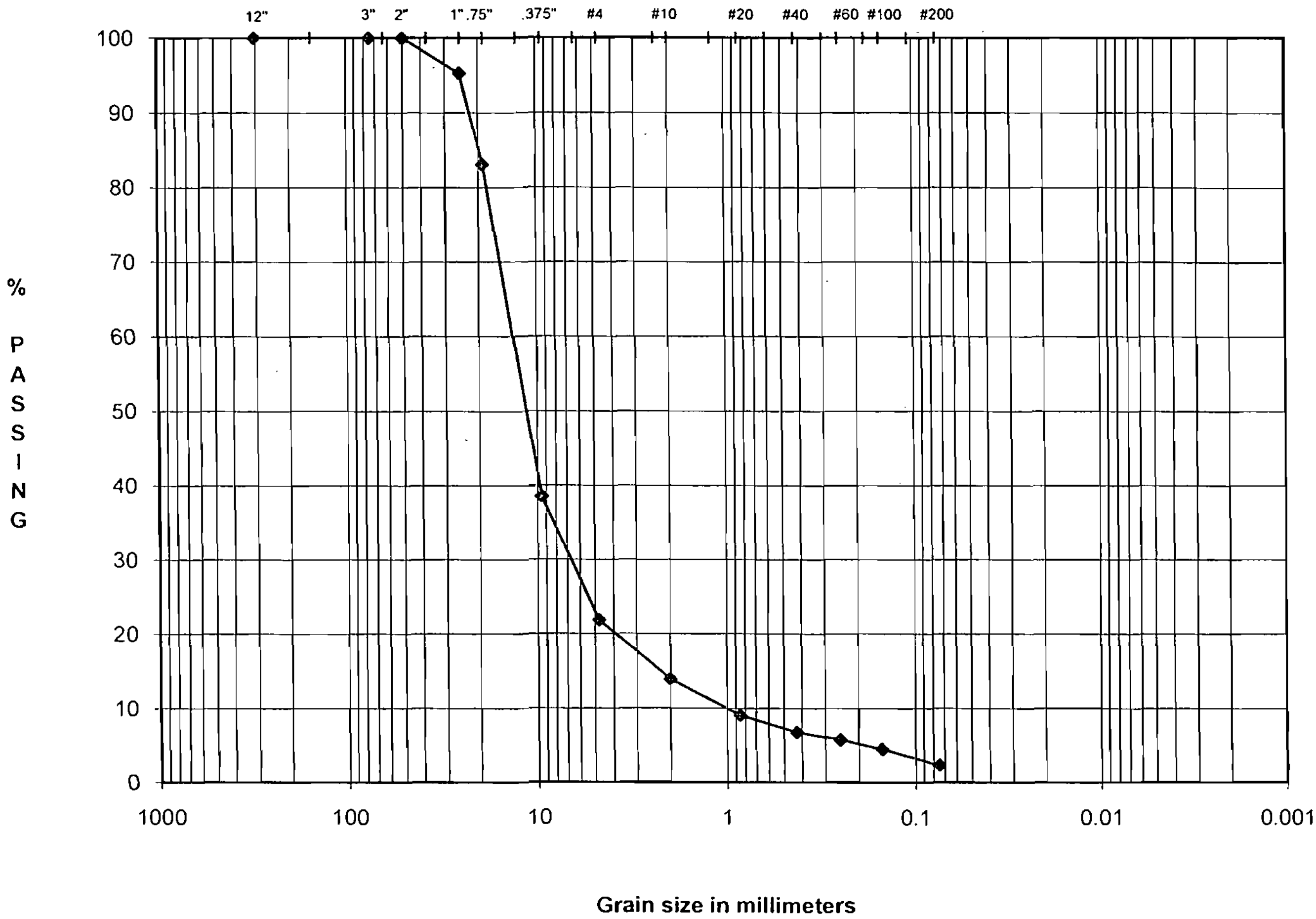
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.00
D30 (mm)	6.80
D60 (mm)	14.00
Cu	14.0
Cc	3.3

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GP

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	279	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GP

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	282
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	2251.50
Wt Dry Soil & Tare (gm)	(w2)	1989.50
Weight of Tare (gm)	(w3)	312.30
Weight of Water (gm)	(w4=w1-w2)	262.00
Weight of Dry Soil (gm)	(w5=w2-w3)	1677.20
Moisture Content (%)	(w4/w5)*100	15.62

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	1989.50
Tare Weight (gm)	312.30
(W6) Total Dry Weight (gm)	1677.20

SIEVE ANALYSIS

Tare Weight: 312.30

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	312.30	0.00	0.00	100.00	12.0"	cobbles
3.0"	312.30	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	312.30	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	312.30	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	312.30	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	486.00	173.70	10.36	89.64	1.0"	coarse gravel
0.75"	731.60	419.30	25.00	75.00	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	873.20	560.90	33.44	66.56	0.375"	fine gravel
#4	916.10	603.80	36.00	64.00	#4	coarse sand
#10	932.20	619.90	36.96	63.04	#10	medium sand
#20	993.70	681.40	40.63	59.37	#20	medium sand
#40	1113.90	801.60	47.79	52.21	#40	fine sand
#60	1247.30	935.00	55.75	44.25	#60	fine sand
#100	1445.60	1133.30	67.57	32.43	#100	fine sand
#200	1726.20	1413.90	84.30	15.70	#200	fines
PAN	17512.80	17200.50			PAN	

% COBBLES	0.00
% C GRAVEL	25.00
% F GRAVEL	11.00
% C SAND	0.96
% M SAND	10.83
% F SAND	36.51
% FINES	15.70
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

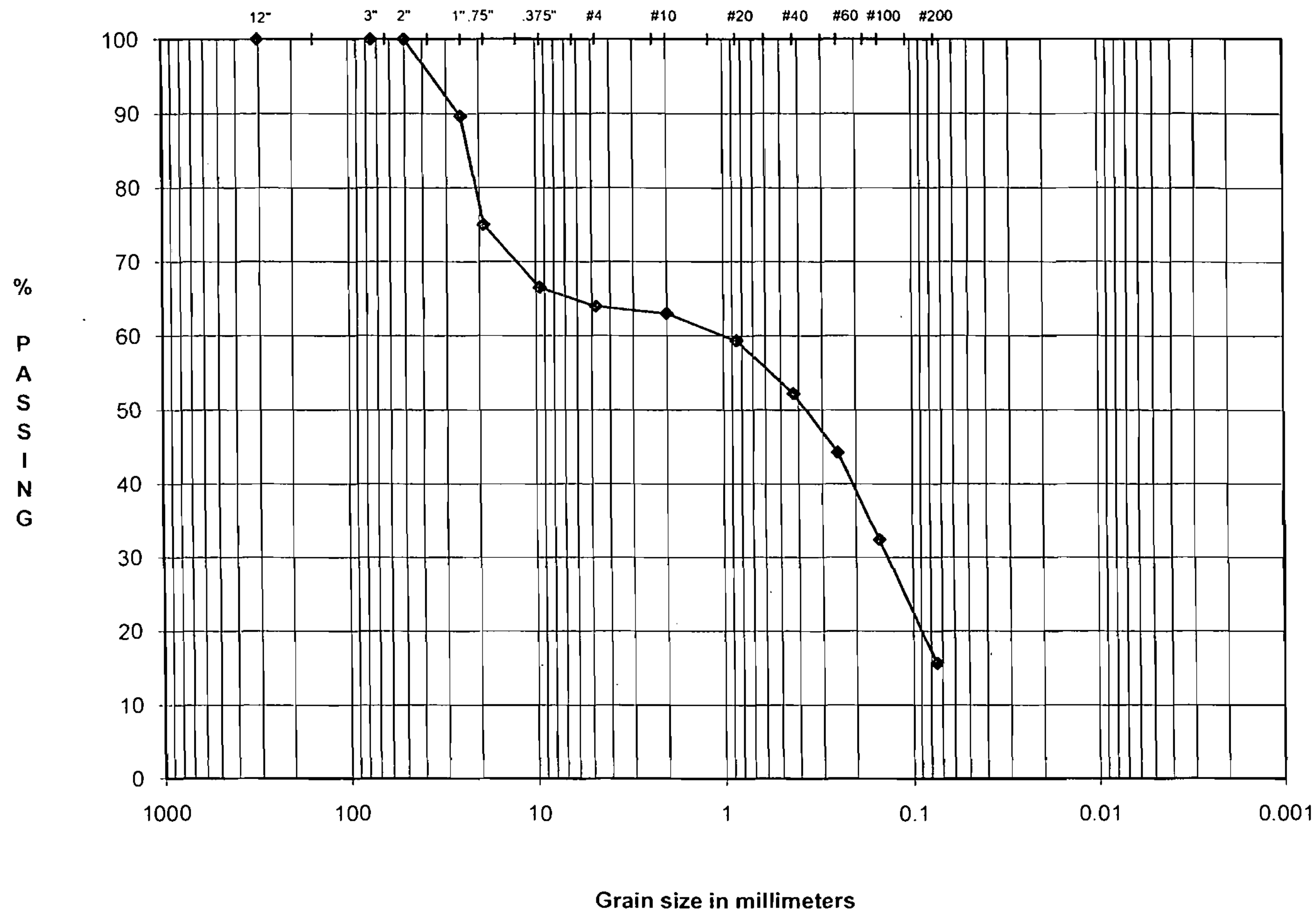
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.06
D30 (mm)	0.15
D60 (mm)	1.10
Cu	18.3
Cc	0.3

DESCRIPTION: C-F SAND and C-F GRAVEL
some silt

USCS: SM

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	282	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F SAND and C-F GRAVEL some silt
USCS	SM

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	285
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	4154.40
Wt Dry Soil & Tare (gm)	(w2)	4033.60
Weight of Tare (gm)	(w3)	311.40
Weight of Water (gm)	(w4=w1-w2)	120.80
Weight of Dry Soil (gm)	(w5=w2-w3)	3722.20
Moisture Content (%)	(w4/w5)*100	3.25

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	4033.60
Tare Weight (gm)	311.40
(W6) Total Dry Weight (gm)	3722.20

SIEVE ANALYSIS

Tare Weight: 311.40

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	311.40	0.00	0.00	100.00	12.0"	cobbles
3.0"	311.40	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	311.40	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	311.40	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	412.40	101.00	2.71	97.29	1.5"	coarse gravel
1.0"	1021.00	709.60	19.06	80.94	1.0"	coarse gravel
0.75"	1836.00	1524.60	40.96	59.04	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2906.60	2595.20	69.72	30.28	0.375"	fine gravel
#4	3204.00	2892.60	77.71	22.29	#4	coarse sand
#10	3477.00	3165.60	85.05	14.95	#10	medium sand
#20	3713.60	3402.20	91.40	8.60	#20	medium sand
#40	3868.80	3557.40	95.57	4.43	#40	fine sand
#60	3935.80	3624.40	97.37	2.63	#60	fine sand
#100	3963.40	3652.00	98.11	1.89	#100	fine sand
#200	3994.10	3682.70	98.94	1.06	#200	fines
PAN	17512.80	17201.40			PAN	

% COBBLES	0.00
% C GRAVEL	40.96
% F GRAVEL	36.75
% C SAND	7.33
% M SAND	10.53
% F SAND	3.37
% FINES	1.06
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

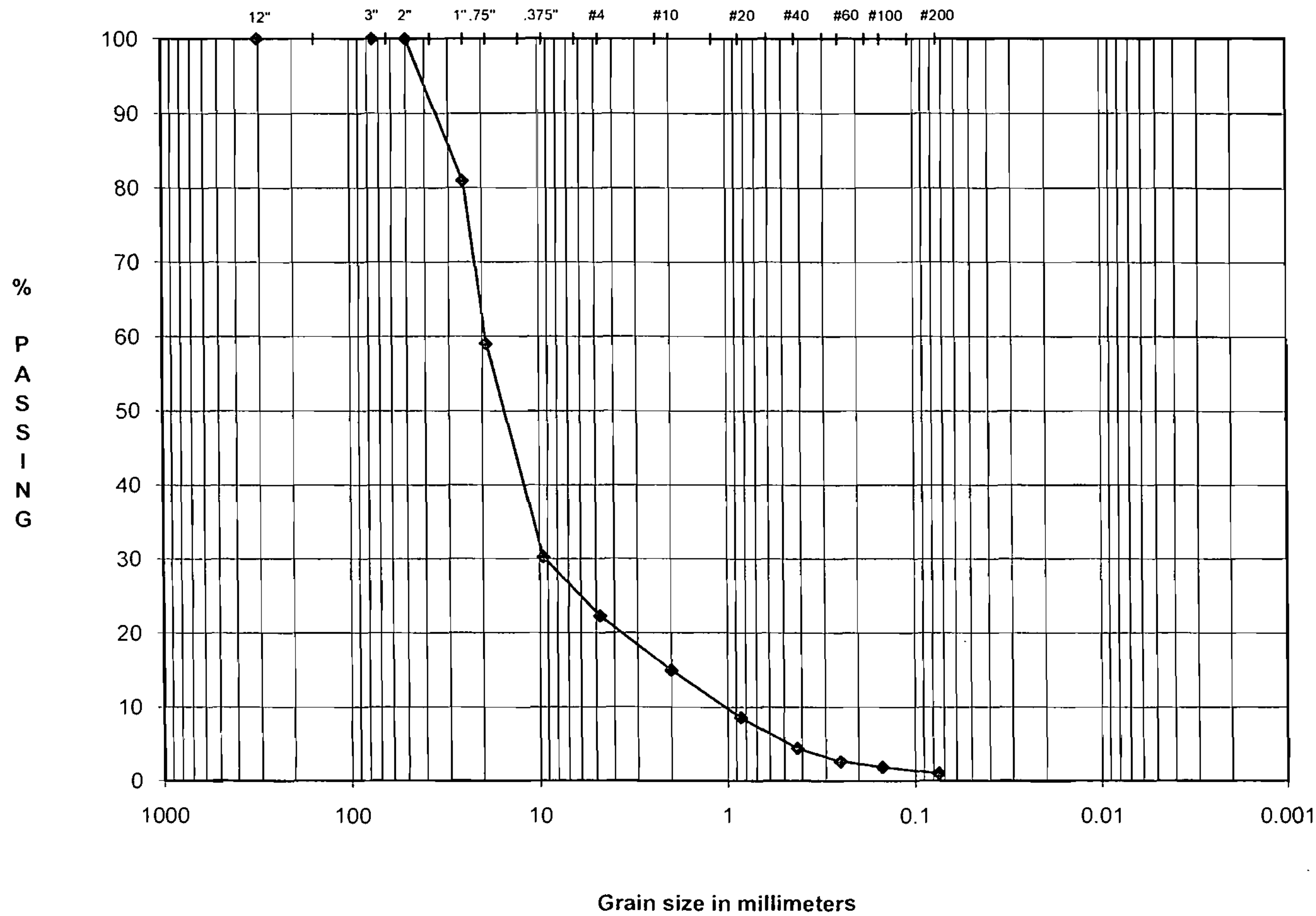
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.10
D30 (mm)	9.50
D60 (mm)	19.00
Cu	17.3
Cc	4.3

DESCRIPTION: C-F GRAVEL
some c-f sand, trace silt

USCS: GP

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	285	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GP

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	2/5/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	**SAMPLE ID**	289
PROJECT NO.	993-1595-004.1242	**SAMPLE TYPE**	Grab
REMARKS		**SAMPLE DEPTH**	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	4112.50
Wt Dry Soil & Tare (gm)	(w2)	3994.50
Weight of Tare (gm)	(w3)	422.50
Weight of Water (gm)	(w4=w1-w2)	118.00
Weight of Dry Soil (gm)	(w5=w2-w3)	3572.00
Moisture Content (%)	(w4/w5)*100	3.30

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	3994.50
Tare Weight (gm)	422.50
(W6) Total Dry Weight (gm)	3572.00

SIEVE ANALYSIS

Tare Weight: 422.50

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	422.50	0.00	0.00	100.00	12.0"	cobbles
3.0"	422.50	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	422.50	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	422.50	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	1127.70	705.20	19.74	80.26	1.5"	coarse gravel
1.0"	1529.60	1107.10	30.99	69.01	1.0"	coarse gravel
0.75"	2028.40	1605.90	44.96	55.04	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2729.60	2307.10	64.59	35.41	0.375"	fine gravel
#4	3055.50	2633.00	73.71	26.29	#4	coarse sand
#10	3360.60	2938.10	82.25	17.75	#10	medium sand
#20	3660.70	3238.20	90.66	9.34	#20	medium sand
#40	3834.80	3412.30	95.53	4.47	#40	fine sand
#60	3891.50	3469.00	97.12	2.88	#60	fine sand
#100	3914.40	3491.90	97.76	2.24	#100	fine sand
#200	3947.00	3524.50	98.67	1.33	#200	fines
PAN	17512.80	17090.30			PAN	

% COBBLES	0.00
% C GRAVEL	44.96
% F GRAVEL	28.75
% C SAND	8.54
% M SAND	13.28
% F SAND	3.14
% FINES	1.33
% TOTAL	100.00

Descriptive Terms		
		> 10% mostly coarse (c)
trace	0 to 5%	> 10% mostly medium (m)
little	5 to 12%	< 10% fine (c-m)
some	12 to 30%	< 10% coarse (m-f)
and	30 to 50%	< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

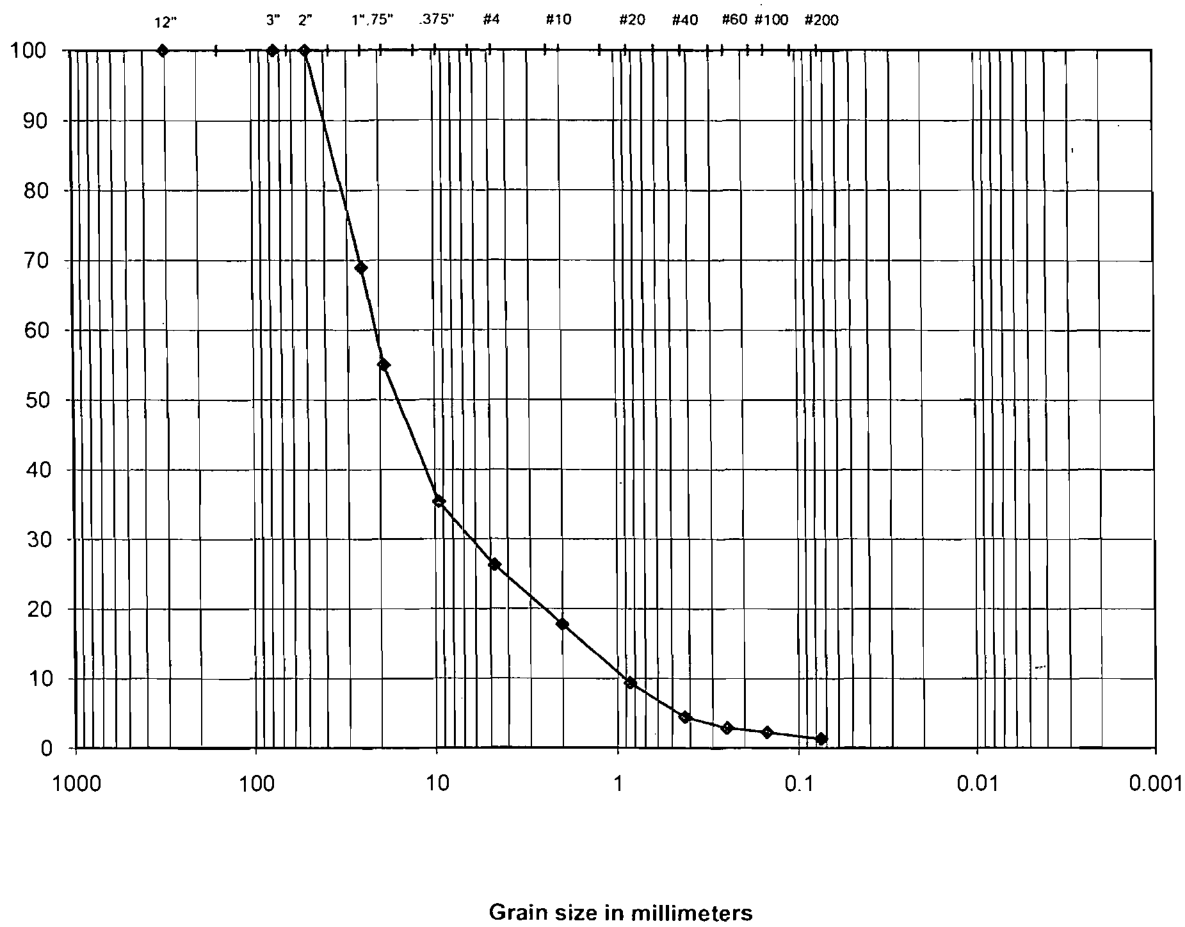
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.95
D30 (mm)	6.40
D60 (mm)	21.00
Cu	22.1
Cc	2.1

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	289	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	292
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	4211.00
Wt Dry Soil & Tare (gm)	(w2)	4095.40
Weight of Tare (gm)	(w3)	425.20
Weight of Water (gm)	(w4=w1-w2)	115.60
Weight of Dry Soil (gm)	(w5=w2-w3)	3670.20
Moisture Content (%)	(w4/w5)*100	3.15

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	4095.40
Tare Weight (gm)	425.20
(W6) Total Dry Weight (gm)	3670.20

SIEVE ANALYSIS

Tare Weight: 425.20

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	425.20	0.00	0.00	100.00	12.0"	cobbles
3.0"	425.20	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	425.20	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	425.20	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	536.90	111.70	3.04	96.96	1.5"	coarse gravel
1.0"	892.90	467.70	12.74	87.26	1.0"	coarse gravel
0.75"	1338.70	913.50	24.89	75.11	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	2540.10	2114.90	57.62	42.38	0.375"	fine gravel
#4	3284.70	2859.50	77.91	22.09	#4	coarse sand
#10	3629.30	3204.10	87.30	12.70	#10	medium sand
#20	3827.20	3402.00	92.69	7.31	#20	medium sand
#40	3948.20	3523.00	95.99	4.01	#40	fine sand
#60	4000.40	3575.20	97.41	2.59	#60	fine sand
#100	4025.30	3600.10	98.09	1.91	#100	fine sand
#200	4051.50	3626.30	98.80	1.20	#200	fines
PAN	17512.80	17087.60			PAN	

% COBBLES	0.00
% C GRAVEL	24.89
% F GRAVEL	53.02
% C SAND	9.39
% M SAND	8.69
% F SAND	2.81
% FINES	1.20
% TOTAL	100.00

Descriptive Terms		
trace	0 to 5%	> 10% mostly coarse (c)
little	5 to 12%	> 10% mostly medium (m)
some	12 to 30%	< 10% fine (c-m)
and	30 to 50%	< 10% coarse (m-f)
		< 10% coarse and fine (m)
		< 10% coarse and medium (f)
		> 10% equal amounts each (c-f)

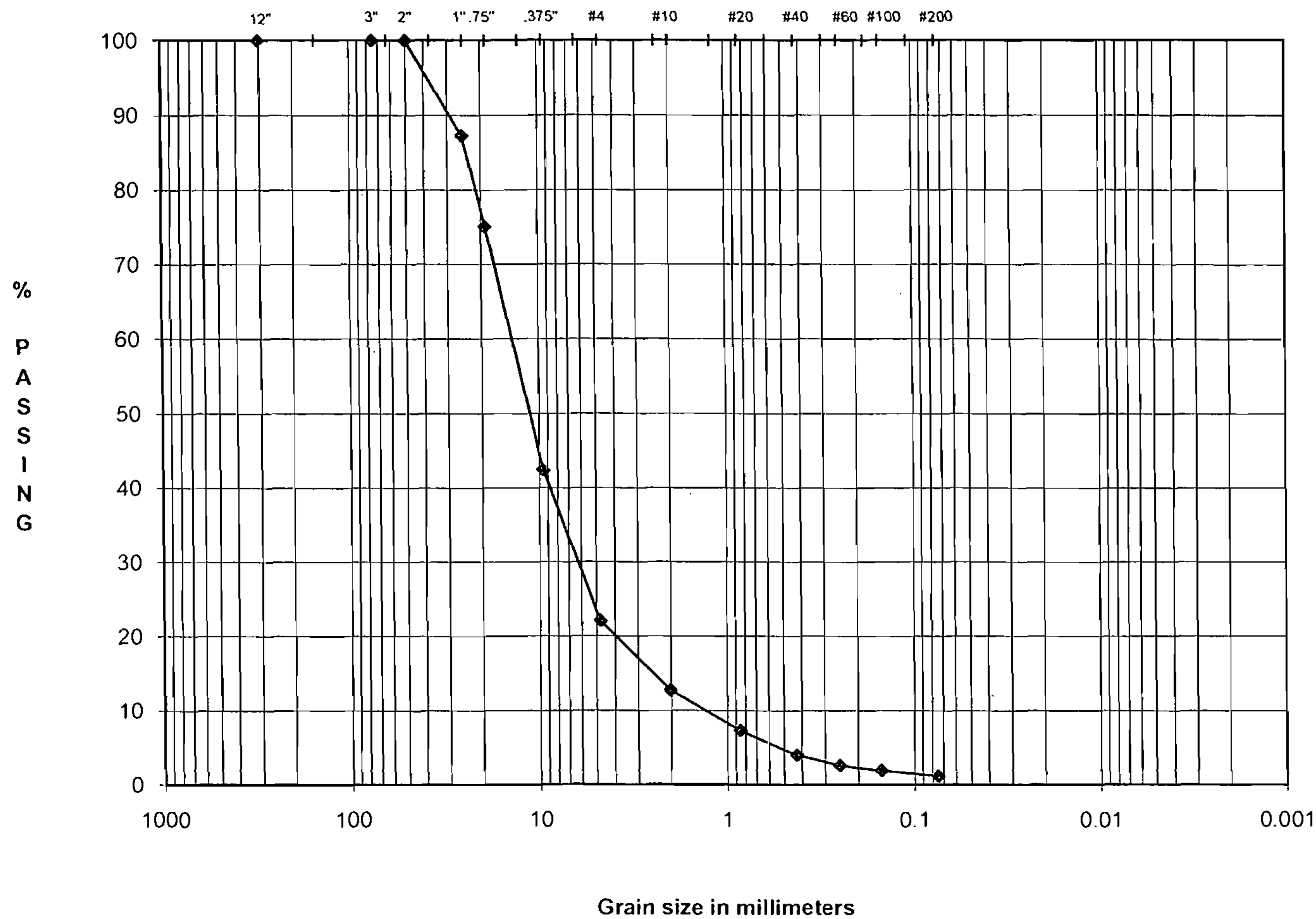
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	1.40
D30 (mm)	6.20
D60 (mm)	15.00
Cu	10.7
Cc	1.8

DESCRIPTION C-F GRAVEL
some c-f sand, trace silt

USCS GW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			**FINES**

SAMPLE ID	292	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL some c-f sand, trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	BMSG / Blackbird Mine / ID	SAMPLE ID	294
PROJECT NO.	993-1595-004.1242	SAMPLE TYPE	Grab
REMARKS		SAMPLE DEPTH	Substrate

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	3612.80
Wt Dry Soil & Tare (gm)	(w2)	3442.70
Weight of Tare (gm)	(w3)	328.90
Weight of Water (gm)	(w4=w1-w2)	170.10
Weight of Dry Soil (gm)	(w5=w2-w3)	3113.80
Moisture Content (%)	(w4/w5)*100	5.46

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	3442.70
	Tare Weight (gm)	328.90
(W6)	Total Dry Weight (gm)	3113.80

SIEVE ANALYSIS

Tare Weight: 328.90

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
12.0"	328.90	0.00	0.00	100.00	12.0"	cobbles
3.0"	328.90	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	328.90	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	328.90	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	328.90	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	523.90	195.00	6.26	93.74	1.0"	coarse gravel
0.75"	718.70	389.80	12.52	87.48	0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	1720.40	1391.50	44.69	55.31	0.375"	fine gravel
#4	2335.60	2006.70	64.45	35.55	#4	coarse sand
#10	2694.40	2365.50	75.97	24.03	#10	medium sand
#20	2895.30	2566.40	82.42	17.58	#20	medium sand
#40	3063.60	2734.70	87.83	12.17	#40	fine sand
#60	3192.70	2863.80	91.97	8.03	#60	fine sand
#100	3269.70	2940.80	94.44	5.56	#100	fine sand
#200	3349.80	3020.90	97.02	2.98	#200	fines
PAN	17512.80	17183.90			PAN	

% COBBLES	0.00
% C GRAVEL	12.52
% F GRAVEL	51.93
% C SAND	11.52
% M SAND	11.86
% F SAND	9.19
% FINES	2.98
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

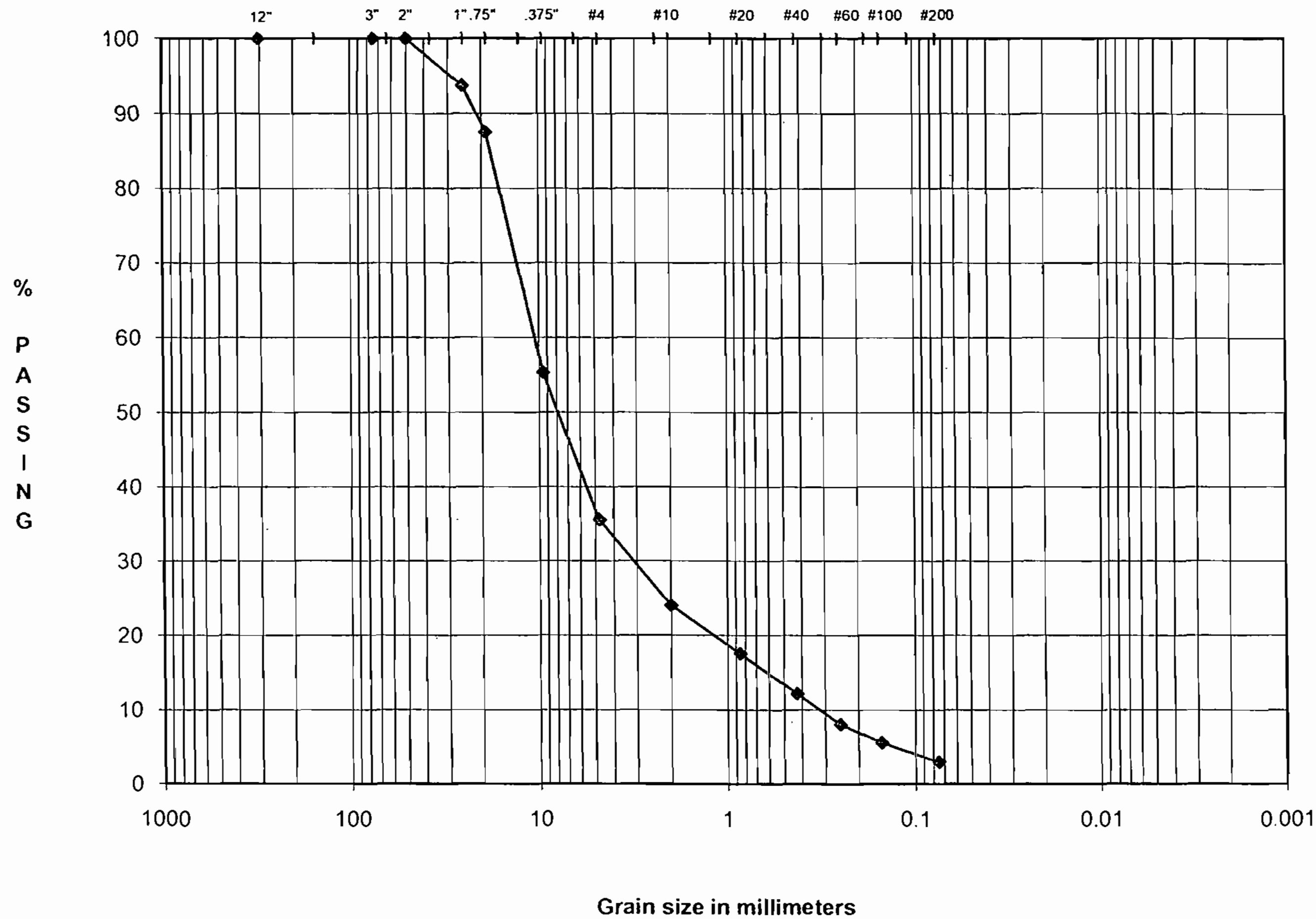
LL	-
PL	-
PI	-
Gs	-
D10 (mm)	0.33
D30 (mm)	3.10
D60 (mm)	11.00
Cu	33.3
Cc	2.6

DESCRIPTION C-F GRAVEL and C-F SAND
trace silt

USCS GW

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Gravel		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY

SAMPLE ID	294	0
SAMPLE TYPE	Grab	
SAMPLE DEPTH	Substrate	

LL	-
PL	-
PI	-

DESCRIPTION	C-F GRAVEL and C-F SAND trace silt
USCS	GW

BMSG / Blackbird Mine / ID
993-1595-004.1242

TECH	TCM
DATE	1/16/09
CHECK	TCM
REVIEW	AQK

APPENDIX D2

BLACKBIRD CREEK CHANNEL SURFACE SEDIMENT CALCULATIONS FOR IN-STREAM STABILIZATION EFFECTIVENESS

Blackbird Creek Evaluation Report

Blackbird Creek Armor Layer Development Calculations

Made by:	*CC, AR, SLH*	*Date:*	*23-Feb-10*
Reviewed by:	*MLB, AQK*	*Date:*	*24-Feb-10*
Modified by:	*JMS*	*Date:*	*7-May-10*

OBJECTIVES:

1) Determine the anticipated depth of degradation for armor layer development
2) Determine the estimated amount of time (# of years) needed to allow development of an armor layer within the project area in Blackbird Creek'
3) Determine the effectiveness of stabilizing potentially contaminated fine grain sediments in place using in-stream stabilization measures (recognizing that fine-grained surface sediments will be winnowed out while an armor layor develops)

Objective 1:

Determine the anticipated depth of degradation for armor layer development

Assumptions:

- The minimum sediment particle diameter (d_{sc}) that is stable under bank-full flows corresponds to the minimum particle diameter in the armor layer.
- This diameter (d_{sc}) and the depth of degradation can be estimated by relationships developed by Julien (2002).

Calculations:

A) Calculate minimum sediment particle diameter (d_{sc}), per Julien (2002)

$d_{sc} \sim 10 * h * S$ *where:* h = flow depth for bank-full event
S = slope (ft/ft)

For Blackbird Creek reference location STA 138+00:

h =	1.5	ft
S =	0.03	ft/ft
d_{sc} =	**0.45**	**ft**

Blackbird Creek Evaluation Report

Blackbird Creek Armor Layer Development Calculations

Made by:	*CC, AR, SLH*	*Date:*	*23-Feb-10*
Reviewed by:	*MLB, AQK*	*Date:*	*24-Feb-10*
Modified by:	*JMS*	*Date:*	*7-May-10*

B) Determine the fraction of sediment material coarser than d_{sc} (δ_{pc}), and calculate the depth of degradation necessary for armor layer development (δ_z), whereby $\delta_z = 2\,\delta_{sc}[(1/\delta_{pc})-1]$ from (Julien, 2002).

The calculated d_{sc} = 0.45 ft (approximately 137 mm). Armor layer pebble counts were taken throughout Blackbird Creek. The results are shown on Figure D-2 (Appendix D1). The development of an armor layer is dependent on the coarse fraction in the available sediment. Observations, experience at the site, and the sediment sample results show there is abundant coarse material for development of an armor layer along all reaches of Blackbird Creek. Based on review of the results shown in Figure D-2, the percentage of sediments passing the d_{sc} ranges from approximately 55% for the coarse (i.e. large diameter) sediments to 100%+ for the smaller diameter sediments. Larger diameter sediments will require less degradation to form an armor layer, while smaller diameter sediments will need a greater magnitude of degradation to accumulate enough coarser grained sediments and form an armor layer (Julien 2002). For instance: assuming a value at the high range of percent passing (i.e. smallest sediment size curves on right side of plotted data in Figure D-2) of approximately 90% with a corresponding percent larger (δ_{pc}) = (100% - 90%) = 10%, the depth of degradation resulting from armor layer development (δ_z) would be approximately 8.10 feet (Julien 2002). This value seems very high, and unrealistic considering the proposed in-channel grade-control structures which will limit significant degradation in the channel and floodplain, thereby limiting large vertical changes (downward) associated with any channel processes, including armor layer development.

Therefore, based on experience at the site along Blackbird Creek and in consideration of the proposed in-channel grade-control structures, the coarser (i.e. larger) sediment sampling results were used for estimating the depth of armor layer development. From Figure D-2, the percent passing the d_{sc} = 0.45 ft

The fraction of sediment materials larger than d_{sc} is estimated to be:

δ_{pc} = **(100% - 55%) = 45%**

The corresponding calculated depth of degradation (δ_z) resulting from armor layer development is estimated to be:

$$\delta_z = 2\, d_{sc}\, [(1/\delta_{pc}) - 1]$$

δ_z = **1.1 ft (Julien 2002)**

Golder Associates, Inc.

943-1595-004.1280

Blackbird Creek Evaluation Report

Blackbird Creek Armor Layer Development Calculations

Made by:	*CC, AR, SLH*	*Date:*	*23-Feb-10*
Reviewed by:	*MLB, AQK*	*Date:*	*24-Feb-10*
Modified by:	*JMS*	*Date:*	*7-May-10*

Objective 2:

Determine the estimated amount of time (# of years) needed to allow development of an armor layer throughout the channel of Blackbird Creek.

Assumptions:

- Average annual volume of sediment transported through Blackbird Creek is ~4,000 cubic yards (per Section 3.1.3.2 - Average Annual Mass of Sediment Transported)

Calculations:

A) Calculate the anticipated volume of degraded material through the project area:

Area =	597,664	sq ft	(project area for proposed in-stream stabilization areas 1-8)
δ_z =	1.1	ft	
Volume =	657,430	cu ft	
Volume =	**24,349**	**cy**	

B) Calculate the approximate time (in years) needed to develop an armor layer through the Blackbird Creek project area:

Ave annual sediment =	4,000	cy	(per Section 3.1.3.2)
Total degraded volume =	24,349	cy	

Time for armor layer development = 6 years

Comments:

1) The time to develop an armor layer may vary considerably from the assumed 6 years because of uncertainties regarding the magnitude and timing of future high flow events, the assumptions regarding depth of scour, the amount of clean sediment generated and transported to act as an armor layer, and the concentrations of COCs in the sediment materials that could be mobilized.

2) Bank-full floods have a P=0.50 probability of occurring in any given year, and a P=0.98 probability of occurring at least one time within 6 years. These relatively high probabilities and observed recent floods in Blackbird Creek suggest the armor layer would develop in the assumed period of time (6 years). Note that the in-stream stabilization structures would stabilize the in-stream sediments immediately upon installation, with the exception of approximately the top foot of material. The 6 years described is the approximate time it would take for the in-stream stabilization structures to develop an effective armor layer.

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943-1595-004.1280

Blackbird Creek Evaluation Report

Blackbird Creek Armor Layer Development Calculations

Made by:	*CC, AR, SLH*	*Date:*	*23-Feb-10*
Reviewed by:	*MLB, AQK*	*Date:*	*24-Feb-10*
Modified by:	*JMS*	*Date:*	*7-May-10*

Objective 3:

Determine the effectiveness of stabilizing potentially contaminated fine grain sediments in place using in-stream stabilization measures

Assumptions:

- Percent fines less than or equal to #200 sieve ranges from 1 to 20%, based on grab samples of substrate sediments below armor layers
- Assume the percent fines in substrate sediments below armor layer is 20% (conservative estimate)
- Based on the feasibility study (Golder, 2002a), the amount of potentially contaminated sediments available is approximately 650,000 cy
- Assume percent fines of mobilized soil = 25%
- Assume percent fines of stabilized soil = 10%
- Fraction of mobilzed soil is ratio of percent fines of mobilzed soils of the total degraded volume to the percent fines of the sabilized soils in the total potentially contaminated sediments.

Calculations:

A) Determine the percentage of the total volume of potentially contaminated fine-grained sediments that may mobilize. Assume the remaining potentially contaminated sediments will remain in place:

Percent fines, substrate =	20%	(based on assumptions)
Total degraded volume =	24,349 cy	(from Objective 2)
Potentially mobilized fines =	4,870 cy	

Volume of potentially contaminated sediments =	650,000 cy
Potential fine volume =	130,000 cy

Fraction mobilized =	3.7%	(mobilized fines/total fines)
Fraction remaining in place =	**96.3%**	

B) Determine high-end range of potentially contaminated sediments that may mobilize, assuming the following percent fines in mobilized and stabilized soils:

Percent fines, mobilized soil =	25% Assumed
Percent fines, stabilized soil =	10% Assumed

Fraction mobilized = 9.4% $= \frac{25\% \cdot 24{,}349cy}{10\% \cdot 650{,}000cy}$

Fraction remaining in place = 90.6%

Based on these calculations, in-stream stabilization is approximately 90% to 96% effective.

APPENDIX E
SEDDISCH FLUVIAL SEDIMENT DISCHARGE ANALYSIS RESULTS

Objective: Use SEDDISCH to complete preliminary assessment of bedload sediment transport potential in Blackbird Creek.

Discussion:
SEDDISCH computes fluvial sediment discharge with the option of using several bedload sediment transport formulas. The calculation is limited to a peak flow input for a defined channel cross-section and corresponding hydraulic parameters. The bedload discharge formula options include Schoklitsch (1934), Kalinske , Meyer-Peter and Muller (1948), Rottner, and Einstein. The Meyer-Peter and Muller (MPM) equations were targeted for this assessment as being the most applicable for evaluating the coarse grained bedload materials observed and measured in Blackbird Creek.

Peak flow results for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr and 500-yr events calculated using HEC-RAS (see Appendix C1) were used to determine hydraulic parameters at two reference locations. Flow parameters (i.e. flow width, depth, velocity) were used as inputs to the SEDDISCH calculations. The upper reach reference location, located at approximately STA 214+00 represents a confined, bedrock limited, steep gradient channel geometry. The lower reach reference location is located at approximately STA 31+00, which has wide and shallow flow conditions, flatter gradients, and readily available sediment in the bed, banks, and overbank areas.

Sediment grain size distributions derived from the sediment sampling program were used as inputs to the SEDDISCH calculations. Refer to Appendix D for detailed summaries and reporting. The following summarizes the approximate range of sediment grain size distribution used in the model:

Particle Diameter	Percent Passing (mm)	
	High	Low
D100	60	60
D90	45	5
D65	25	0.4
D50	15	0.25
D35	7	0.15
D10	1.5	0.1

Results:
Results are attached for the two reference locations. The range of reported values correspond to the high and low grain size distribution (see above) inputs to the calculations. Detailed calculation summaries are attached. The table below summarizes the results for the two representative locations at STA 31+00 (lower reach of Blackbird Creek) and STA 214+00 in the upper Blackbird Creek reach.

Summary of SEDDISCH Sediment Discharge Calculations at
Stations 214+00 and at 31+00 for the 100-year Design Event

Sediment Reference Section/Location	Estimated Bedload (tons/day)
STA. 214+00 (U/S)	3,500 – 8,100
STA. 31+00 (D/S)	6,200 – 14,100

2-5-10
STA 214+00
[illegible]

REVBB3OU

1
blackbird, idaho

Top width	19.77 feet	Water surf. slope	0.0269100 ft/ft
Mean depth	1.80 feet	D50	15.000 Millimeters
Mean velocity	7.61 ft/sec	Kinematic viscosity	0.00001492
Water discharge	270.81 cfs	Sed. fall velocity	1.3304 ft/sed
Water temperature	8.0 deg C		

Computed bedload concentration and discharge

Formula	Conc. ppm	Unit disch lbs/sec/ft	Discharge tons/day
Kalinske	54.37	0.0466	39.76
Meyer-Peter & Muller			
QS/Q=1 AND NS=STRICKLER ROUGHNESS			
D90 = 45.000 MM M-P DM = 0.000			
QS/Q = 1.000 NS = 0.0474	11051.20	9.4612	8080.48
Meyer-Peter & Muller			
RECTANGULAR CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 45.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.846 NS = 0.0450	9669.03	8.2779	7069.85
Meyer-Peter & Muller Bot width = 19.77			
TRAPEZOIDAL CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 45.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.846 NS = 0.0450	9669.03	8.2779	7069.85
Rottner	2126.87	1.8209	1555.14
Einstein			
D35 = 7.000 MM D65 = 25.000 MM	0.00	0.0000	0.00

* *

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2-5-10
STA 214+00
a96k

REVBB40U

1
blackbird, idaho

Top width	19.77 feet	Water surf. slope	0.0269100 ft/ft
Mean depth	1.80 feet	D50	0.250 Millimeters
Mean velocity	7.61 ft/sec	Kinematic viscosity	0.00001492
Water discharge	270.81 cfs	Sed. fall velocity	0.0945 ft/sed
Water temperature	8.0 deg C		

Computed bedload concentration and discharge

Formula	conc. ppm	Unit disch lbs/sec/ft	Discharge tons/day
Kalinske	54.37	0.0466	39.76
Meyer-Peter & Muller			
QS/Q=1 AND NS=STRICKLER ROUGHNESS			
D90 = 5.000 MM M-P DM = 0.000			
QS/Q = 1.000 NS = 0.0474	4847.24	4.1498	3544.23
Meyer-Peter & Muller			
RECTANGULAR CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 5.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.846 NS = 0.0450	4241.00	3.6308	3100.95
Meyer-Peter & Muller Bot width = 19.77			
TRAPEZOIDAL CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 5.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.846 NS = 0.0450	4241.00	3.6308	3100.95
Rottner	4217.46	3.6107	3083.74
Einstein			
D35 = 0.150 MM D65 = 0.400 MM	0.04	0.0000	0.03

* *

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BCER

2-5-10
STA 31+00
aak

REVBB9OU

1
blackbird, idaho

Top width	120.21 feet	Water surf. slope	0.0162010 ft/ft
Mean depth	1.06 feet	D50	15.000 Millimeters
Mean velocity	4.75 ft/sec	Kinematic viscosity	0.00001492
Water discharge	605.26 cfs	Sed. fall velocity	1.3304 ft/sed
Water temperature	8.0 deg C		

Computed bedload concentration and discharge

Formula	conc. ppm	Unit disch lbs/sec/ft	Discharge tons/day
Kalinske	87.91	0.0277	143.66
Meyer-Peter & Muller			
QS/Q=1 AND NS=STRICKLER ROUGHNESS			
D90 = 45.000 MM M-P DM = 0.000			
QS/Q = 1.000 NS = 0.0414	8610.75	2.7097	14071.65
Meyer-Peter & Muller			
RECTANGULAR CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 45.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.983 NS = 0.0450	6952.12	2.1877	11361.12
Meyer-Peter & Muller Bot width = 120.21			
TRAPEZOIDAL CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 45.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.983 NS = 0.0450	6952.12	2.1877	11361.12
Rottner	326.59	0.1028	533.71
Einstein			
D35 = 7.000 MM D65 = 25.000 MM	0.00	0.0000	0.00

*

943-1595-004.1280
BCER

2-5-10
STA 31+00
[illegible]

REVBB100

1
blackbird, idaho

Top width	120.21 feet	Water surf. slope	0.0162010 ft/ft
Mean depth	1.06 feet	D50	0.250 Millimeters
Mean velocity	4.75 ft/sec	Kinematic viscosity	0.00001492
Water discharge	605.26 cfs	Sed. fall velocity	0.0945 ft/sed
Water temperature	8.0 deg C		

Computed bedload concentration and discharge

Formula	conc. ppm	Unit disch lbs/sec/ft	Discharge tons/day
Kalinske	87.91	0.0277	143.66
Meyer-Peter & Muller			
QS/Q=1 AND NS=STRICKLER ROUGHNESS			
D90 = 5.000 MM M-P DM = 0.000			
QS/Q = 1.000 NS = 0.0414	3776.79	1.1885	6172.02
Meyer-Peter & Muller			
RECTANGULAR CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 5.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.983 NS = 0.0450	3049.29	0.9596	4983.13
Meyer-Peter & Muller Bot width = 120.21			
TRAPEZOIDAL CHANNEL AND COMPUTE NS AND QS/Q			
D90 = 5.000 MM M-P DM = 0.000			
NW = 0.045 NM = 0.045			
QS/Q = 0.983 NS = 0.0450	3049.29	0.9596	4983.13
Rottner	2626.19	0.8264	4291.70
Einstein			
D35 = 0.150 MM D65 = 0.400 MM	0.03	0.0000	0.05

* *

943-1595-004.1280
BCER

Water Resources Applications Software

Geochemical || Ground Water || Surface Water || Water Quality || General

Summary of SEDDISCH

NAME

seddisch - Computation of fluvial sediment discharge

ABSTRACT

SEDDISCH computes fluvial sediment discharge by allowing the user to choose between five described bedload formulas and eight described bed-material formulas. The bedload discharge formulas are those of Schoklitsch (1934), Kalinske, Meyer-Peter and Muller (1948), Rottner, and Einstein. The bed-material formulas are those of Laursen, Engelund and Hansen, Colby, Ackers and White, Yang sand formula, Yang gravel formula, Einstein, and Toffaleti.

METHOD

Numerous sediment-discharge formulas have been proposed in literature. Selection of the thirteen formulas used in SEDDISCH was based on: (1) theoretical background, (2) extent of testing by original author and independent investigator(s), and (3) extent of use by engineers and researchers. The user is asked to choose from these formulas based on which field data are available.

Bedload Discharge Formulas

Bedload discharge is the discharge of sediment that moves in essentially continuous contact with the bed.

Schoklitsch developed a bedload formula based mainly on Gilbert's (1914) flume data with median sediment sizes ranging from 0.3 to 5 mm. The basis for this formula is that bed material begins to move at some critical discharge and that the bedload discharge is proportional to the rate of work done by the part of the tractive force in excess of that needed to overcome the resistance along the wetted perimeter.

The formula developed by Kalinske for computing bedload discharge of unigranular material is based on the continuity equation which states that the bedload discharge is equal to the product of the average velocity of the particles in motion, the weight of each particle, and the number of particles.

Meyer-Peter and Muller developed an empirical formula for the bedload discharge in natural streams. The computer program computes the effective diameter of the bed-material mixture from the entered sediment size-fraction data. However, the program does not compute the bedload discharge by size fractions.

Rottner developed an equation to express bedload discharge in terms of the flow parameters based on dimensional considerations and empirical coefficients. In his derivation, wall and bed form effects were excluded, and Rottner stated that the equation may not be applicable when small quantities of bed material are being moved.

The bedload relation developed by Einstein is derived from the concept of probabilities of particle motion.

Bed-Materal Discharge Formulas

Bed-material discharge is the discharge of sediment which is derived from and readily exchanges with the particles in the bed material; particles comprising the bed-material discharge move both as bedload and in suspension.

The equation developed by Laursen to compute the mean concentration of bed-material discharge is based on empirical relations using natural sediments with a specific gravity of 2.65, and medium diameters that range from 0.011 to 4.08 mm.

Engelund and Hansen applied Bagnold's (1966) stream power concept and the similarity principle to derive a sediment transport equation. This equation can be used with moderately sorted bed materials having mean fall diameters larger than 0.15 mm.

Colby presented a graphical method to determine the discharge of sand-size bed material that ranged from 0.1 to 0.8 mm in water at a temperature of 15.6 degrees Celsius. This program uses a set of equations derived by Carl Nordin (U.S. Geological Survey) that represent Colby's curves at 0, 5, 10, 15.6, 20, 30, and 40 degrees Celsius.

Ackers and White developed a general sediment-discharge function in terms of three dimensionless groups: size, mobility, and discharge.

Yang derived an equation to compute concentration of the bed-material discharge, for sand-bed streams, based on dimensional analysis and the concept of unit stream power. He defined unit stream power as the rate of potential energy dissipated per unit weight of water, which is expressed by the velocity and slope product.

Yang, using the same dimensional analysis and multiple regression methods as was used to derive discharge rates in sand-bed streams, derived an equation to compute the bed-material discharge concentration, in gravel-bed streams. The same definition of unit stream power is used in both the sand and gravel transport equations.

Einstein's method combines his computed bedload discharge with a computed suspended bed-material discharge to yield the total bed-material discharge.

Toffaleti's method is based on the concepts of Einstein with three modifications: (1) velocity distribution in the vertical is obtained from an expression different from that used by Einstein;

(2) several of Einstein's correction factors are adjusted and combined; and (3) the height of the zone of bedload transport is changed from Einstein's two grain diameters. Toffaleti defines his bed-material discharge as total river sand discharge even though he defines the range of bed-size material from 0.062 to 16 mm.

HISTORY

Version 1.2 1998/01/16 - First release of original program as ported and after code clean-up for use on UNIX workstations.

DATA REQUIREMENTS

Input for SEDDISCH is generated during an interactive session using the program DISDATA. DISDATA generates a direct access file that is read by SEDDISCH. The following data are prompted for by DISDATA to form the *SEDDISCH* data set:

- measurement location
- top width
- mean depth
- mean velocity
- water-surface slope
- water temperature
- particle size, in millimeters, at which the 35, 50, 65, and 90 percent by weight is finer (enter zero if not required)

Bed-material particle size data are entered depending on the value of the option code selected at the start of the run. One option is that no size distribution data are to be entered. Zero values are given to the percent-in-class variables for the size fractions. The other two options are to enter the size data as percent-finer values or as percent-in-class values.

SYSTEM REQUIREMENTS

SEDDISCH is written in Fortran 77. Generally, the program is easily installed on most computer systems. The code has been used on UNIX-based computers and DOS-based 386 or greater computers having a math coprocessor and 1 mb of memory.

DOCUMENTATION

Stevens, H.H., and Yang, Chih Ted, 1989, Summary and use of selected fluvial sediment-discharge formulas: U.S. Geological Survey Water-Resources Investigations Report 89-4026, 121 p.

CONTACTS

Operation and Distribution:
U.S. Geological Survey
Hydrologic Analysis Software Support Program
437 National Center
Reston, VA 20192

h2osoft@usgs.gov

Official versions of U.S. Geological Survey water-resources analysis software are available for electronic retrieval via the World Wide Web (WWW) at:

http://water.usgs.gov/software/

and via anonymous File Transfer Protocol (FTP) from:

```
        water.usgs.gov (path: /pub/software).

  The WWW page and anonymous FTP directory from which the SEDDISCH
  software can be retrieved are, respectively:

        http://water.usgs.gov/software/seddisch.html
                     --and--
        /pub/software/surface_water/seddisch
```

SEE ALSO

disdata(1) - Data entry program for seddisch
mepdata(1) - Data entry program for modein
modein(1) - Total sediment discharge program using modified Einstein procedure
sedsize(1) - Particle-size statistics of fluvial sediments
sizedata(1) - Data entry program for sedsize

The URL for this page is: http://water.usgs.gov/cgi-bin/man_wrdapp?seddisch
Send questions or comments to h2osoft@usgs.gov

APPENDIX F

SEQUENTIAL EXTRACTION REPORT

Attachment F1	Field Observation Photographs of 2009 Sequential Extraction Sampling
Attachment F2	ACZ Laboratories, Inc. Analytical Reports
Attachment F3	Data Validation Report

REPORT

REPORT ON PANTHER CREEK OVERBANK SAMPLING FOR SEQUENTIAL EXTRACTION ANALYSIS

Submitted To: Blackbird Mine Site Group

Submitted By: Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA

February 24, 2010

943-1595-004.1280

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1.0 INTRODUCTION

This report presents the results of the November 2009 field investigation and analysis of samples collected at overbank locations along Panther Creek in Lemhi County, Idaho. This investigation was conducted in accordance with the sampling and analysis plan (SAP) titled *Revised Sampling and Analysis Plan, Panther Creek Overbank Sampling For Sequential Extraction Analysis, Lemhi County, Idaho*, submitted by Golder Associates Inc. (Golder) on November 2, 2009 (Golder, 2009a).

The purpose of this investigation was to evaluate the abundance of floc (i.e., secondary iron oxyhydroxide precipitates) containing arsenic and cobalt in overbank deposits along Panther Creek. The Environmental Protection Agency (EPA) has expressed concern regarding the potential for iron oxyhydroxide floc formed from West Fork Tailings Impoundment seepage to be a continuing source of recontamination of arsenic and cobalt to overbank areas along Panther Creek (CH2M Hill, 2009a).

The investigation described in this report was based on the methodology proposed by the EPA in their memorandum tilted "*Determination of the Sources of Arsenic and Cobalt in Panther Creek Overbank Sediments*" (CH2M Hill, 2009b). In summary, the proposed methodology involves use of the Tessier extraction method as an approximation of the amount of arsenic and cobalt present in association with floc in an overbank sample. A liquid separation procedure performed prior to sequential extraction analysis is intended to remove primary sulfides from the sample.

2.0 FIELD INVESTIGATION - SAMPLE COLLECTION

Sampling was conducted by a representative of Golder on November 4, 2009 (sampling photographs provided in Attachment F1). As outlined in the SAP, three composite overbank samples were collected from along Panther Creek at the locations listed below (Figure F1):

- Cobalt Townsite area (Cobalt area's 1 – 3)
- Napias Creek near road bar area
- Bevan low bar area (far side of Panther Creek, northwest of the Bevan house and pasture)

Sample collection targeted areas containing new deposition material from the recent 2008 and 2009 flood events. At each sample location, six discrete samples (~ 0" – 2" depth) each weighing approximately 0.5 kg were collected from random locations within the overbank deposit area. A global positioning system (GPS) co-ordinate of the sampling location was recorded (see Table F1). After all discrete samples were collected, three composite samples were made (i.e., one for each of the three sample locations).

Samples were shipped to ACZ Laboratories, Inc. (ACZ) under chain of custody for preparation and analysis. The quality assurance/quality control (QA/QC) requirements described in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Golder, 1995) for sample collection, storage and shipping were followed.

3.0 SAMPLE ANALYSIS

ACZ was provided the following instructions from the SAP (Golder, 2009a):

- **Step 1** - Each sample will be air dried, disaggregated, homogenized, and sieved with a 10-mesh sieve (2 mm sieve).
- **Step 2** - Record the sieved sample weight.
- **Step 3** - Each sieved sample will be thoroughly homogenized and then a portion (a few hundred grams) removed for total metals analysis (arsenic, iron and cobalt). Total metals analysis will be by EPA method 3050 (digestion) followed by analysis using EPA method 6010 or 6020.
- **Step 4** - Place overbank sample (approximately 3 kg) in a clean five gallon plastic bucket. Add fifteen liters of distilled water. Using a large plastic spoon or spatula, stir and swirl the water-sediment mixture for five minutes.
- **Step 5** - Let the sample sit for 2.8 minutes to allow for settling of a portion of the sulfide tailings grains. This step is intended to allow for setting of a portion of the sulfide grains (that may have oxidized rims) while maintaining floc in suspension.
- **Step 6** - Decant the turbid water (assumed to include floc and other fine slow-settling particles) into a clean bucket. Avoid decanting any of the coarser-grained and denser solids that have settled to the bottom of the bucket.
- **Step 7** - Allow the suspended solids to settle out of the decanted water until the decanted water is visually clear (minimum of 12 hours).
- **Step 8** - Decant as much of the visually clear water as possible, retaining a small portion of the decant water (approximately 50 mL). Transfer all remaining solids and water mixture to a smaller clean beaker. Allow the suspended solids to settle out until the overlying water is visually clear. Decant the visually clear water, minimizing the loss of solids.
- **Step 9** - Allow the solids in the beaker to air dry.
- **Step 10** - Once dry, record the weight of the solids.
- **Step 11** - Perform sequential extraction following the Tessier method. The sample will be thoroughly homogenized before removing a portion for the Tessier extraction procedure. The laboratory will be instructed to follow the same procedure as that used during the Blackbird Remedial Investigation (RI). Step I (distilled water leach to extract readily dissolved) will be omitted from the procedure. Steps II (exchangeable and adsorbed), III (carbonate metal) and IV (easily reducible and iron oxides) will be performed. Leachate from Step IV will be analyzed for iron, cobalt and arsenic. The results from this leach step are assumed for purposes of this analysis to represent iron, cobalt and arsenic associated with floc. Leachates from Steps II and III will not be analyzed but will be preserved and retained for possible future analysis following review of the results. The solid residual following Step IV will also be retained.

ACZ made the following changes to the proposed protocol:

- **Step 4** – Only a portion of the <2 mm fraction sample (i.e., 300 g) was used in the separation procedure. Use of only a portion of the homogenized sample does not affect the results. The laboratory used a smaller amount to simplify material handling (i.e., to reduce the weight of the 5 gallon bucket containing the solids and water, specifically for the decanting step).

- **Step 7** – Settling of the suspended solids took longer than anticipated. Settling time was increased to a minimum of 8 days (actual times for each sample provided in Table F2). After this period of time, the water was still not clear. ACZ used pressure filtration to remove the remaining suspended solids, which were included with the sample following drying of the filters. The laboratory noted that the amount of solids retained by the filters was almost negligible when compared to the rest of the suspended solid mass.

The ACZ laboratory reports are provided in Attachment F2. Golder's data validation report is provided in Attachment F3.

Sample preparation results are shown in Table F2. Dry weights for the three samples ranged from 4.4 to 6.3 kg. Greater than 98% of all samples passed the 10 mesh sieve (2 mm). The suspended sediment portion of the <2 mm fraction of each sample ranged from approximately 40 to 80%. This fraction is assumed to contain any floc that is present.

Analytical results are shown in Table F3. The total arsenic concentration of the three samples (< 2 mm fraction) ranged from 270 to 683 mg/kg. Step IV[1] of the Tessier extraction reported arsenic concentrations of 30 to 74 mg/kg. For this study, this is the operationally defined concentration of arsenic in the suspended portion of the sample (suspended sample mass from Step 10) attributed to floc.

Total cobalt concentrations were consistently lower than arsenic concentrations. Total cobalt concentrations ranged from 122 to 209 mg/kg. Step IV of the Tessier extraction reported cobalt concentrations ranging from 44 to 72 mg/kg. The concentrations of cobalt in the suspended portions of the samples attributed to floc are similar (within 14 mg/kg, see Table F3) to the arsenic concentrations for the same samples.

The results of this study indicate similar concentrations for arsenic (30 to 74 mg/kg) and cobalt (44 to 72 mg/kg) within the suspended portion of the sample attributed to floc. The EPA made the following statement in their comments on the draft submission of this report (EPA, 2010):

> *"On a geochemical basis, the results of the sequential extraction indicating higher concentrations of cobalt than arsenic in the oxyhydroxide flocs are surprising. In general, cobalt is more soluble and mobile than arsenic, and would not adsorb to the oxyhydroxide flocs at higher concentrations than arsenic unless manganese were a significant component of the flocs. Existing sampling to date would not indicate that manganese should be a significant component of the flocs. Therefore, the text should include a discussion regarding the relative percentages of arsenic and cobalt in the flocs, and a discussion of the potential mechanisms contributing to the observed results."*

[1] Because step I was not performed, the leachate produced by this step is referenced as leachate 3 in the tables.

The floc chemical characterization data presented in the 2009 Blackbird Creek Iron Oxyhydroxide Solids Sampling Data Report (Golder, 2009b) indicate the following: (a) manganese is sometimes a significant component of the floc; and, (b) the relative proportion of arsenic and cobalt present in the floc varies spatially and in some samples, the concentrations of arsenic and cobalt are similar. The observed changes in the distribution of metals present in floc reflect the pH dependency of metal sorption onto iron oxyhydroxide. Sorption reactions are pH dependent, because this variable controls both the distribution of species in solution and the charge of mineral surfaces, factors that influence the affinity of a particular constituent for a sorbent. As conditions become more acidic, cationic trace metals, such as copper and cobalt, tend to desorb and sorption of anions, such as arsenic and sulfate, will increase. In general, floc samples collected close to the West Fork Tailings Impoundment yielded lower paste pH values and higher arsenic and sulfate concentrations, indicating preferential adsorption of these constituents under more acidic conditions. As pH increases with distance from the West Fork Tailings Impoundment, copper is adsorbed followed by cobalt and manganese. The concentrations of these metals demonstrate increasing trends as paste pH values increase (Figure F2). The results of the current study are therefore consistent with the concentration trends observed during the floc characterization study. In addition, chemical reactions that occur along Panther Creek (i.e., after the initial floc formation) may also affect the relative concentrations of arsenic and cobalt in Panther Creek overbank material floc. Dissolved cobalt concentrations are higher in Panther Creek than dissolved arsenic concentrations, which may result in increased adsorption of cobalt, relative to arsenic, along Panther Creek.

Based on the results of three samples, the percentage of total arsenic and total cobalt in overbank materials, assumed to be present in association with iron oxy-hydroxide floc, increases with distance down Panther Creek. In a typical, complex riverine system, overbank deposits are often segregated by size due to variations in settling velocity, differences in flow conditions and the tendency of sediment to move in waves through a transport reach. These characteristics tend to move smaller and lighter particles, like floc, further through the system, while coarser sand and gravel particles are left behind. This tendency for particle segregation may explain the observed trends in floc metal concentrations within Panther Creek overbank samples.

4.0 DATA EVALUATION

The objective of this study was to evaluate the abundance of floc (i.e., secondary iron oxyhydroxide precipitates) containing arsenic and cobalt in Panther Creek overbank samples. The SAP outlined the following data evaluation procedure to estimate the faction of arsenic and cobalt present in association with floc in overbank materials:

- **Step 1 - Total Overbank Metal Mass** - The total iron, arsenic and cobalt content of each overbank sample (minus 10-mesh) will be calculated as follows:
  - Total sample mass (kg) (laboratory step 2) x metal concentration (mg/kg) (laboratory step 3)
- **Step 2 - Floc Metal Mass** - The total iron, arsenic and cobalt content of each overbank sample (minus 10-mesh) assumed to be present as floc will be calculated as follows:
  - Sample mass (kg) (laboratory step 10) x Tessier extraction Step IV metal concentration (mg/kg) (laboratory step 11)
- **Step 3 - Floc Metal Fraction** – The fraction of the total iron, arsenic and cobalt concentration present as floc will be estimated as follows:
  - Metal fraction (%) = floc metal concentration (data evaluation step 2) / total metal concentration (data evaluation step 1)

Because ACZ used 300 grams of the total sample mass for the separation procedure, the total mass in Step 1 above is 0.3 kg for the purposes of these calculations.

Results from the above calculations are presented in Table F4. A sample calculation is provided at the bottom of this table. Based on these results, the floc is estimated to account for a small portion of the total arsenic concentration (i.e., ranging from 3.5 to 11%). The floc contributes a larger portion of the total cobalt concentration, estimated to range from 14 to 24%.

The SAP also outlined the following guidelines for EPA's intended evaluation of whether further floc is likely a continuing source of recontamination of arsenic and cobalt to overbank materials in Panther Creek and as a basis in the determination of whether further investigation is required:

- **Floc Metal Fraction <10% -** Floc contribution is likely insignificant and therefore further evaluation is not required
- **Floc Metal Fraction 10 to 50%** - Floc contribution is possibly significant. Further evaluation would be necessary
- **Floc Metal Fraction > 50%** - Floc contribution is likely significant

Based on average results, the floc contribution to total arsenic concentrations is "likely insignificant" and the floc contribution to total cobalt concentrations is "possibly significant". The arsenic concentrations (30 to 74 mg/kg) and cobalt concentrations (44 to 72 mg/kg) attributed to floc in the fine suspended fraction of the three overbank samples tested were all below the EPA's residential action level of 100 (As) and preliminary remediation goal (PRG) of 97 mg/kg (Co). This suggests that alone, the floc contribution to total arsenic and cobalt would not lead to exceedances of EPA's arsenic cleanup level or the cobalt PRG in the samples tested.

5.0 STUDY LIMITATIONS AND UNCERTAINTY

The investigation described in this report was based on the methodology proposed by the EPA (CH2M Hill, 2009b). The methodology did not follow any established or published protocols. It was recognized prior to implementation of the study that the proposed methodology would not provide definitive results regarding the differentiation among sources of arsenic and cobalt in Panther Creek overbank deposits; however, the EPA believed that the study would provide sufficient information in support of advancement of the Blackbird Creek Remedial Actions (CH2M Hill, 2009b). Study limitations and uncertainties are listed below:

- **Sample Representativeness** – The current study involved collection and analysis of three samples. This sample size is insufficient to provide a statistically defensible data set. Because all three samples reported similar results for the percentage of arsenic and cobalt attributed to floc, spatial variability in the contribution of floc to total metal concentrations may be low.
- **Separation Procedure** – The initial liquid separation procedure performed prior to sequential extraction analysis is intended to remove primary sulfides from the sample and retain all floc. This procedure may not be completely effective.
- **Tessier Extraction** – The Tessier extraction results provide an indirect measurement of the amount of metal present in each phase. Although each extraction step is intended to target a specific fraction of the sediment samples, undoubtedly some "overlap" between extraction steps may occur. This test may therefore underestimate or overestimate the amount of a metal that is present in the easily reducible phase.

6.0 REFERENCES

CH2M Hill, 2009a. Sequential Extraction of Panther Creek Overbank Sediments. Memorandum from John Lincoln of CH2M Hill to Fran Allans of the EPA, September 2, 2009.

CH2M Hill, 2009b. Determination of the Sources of Arsenic and Cobalt in Panther Creek Overbank Sediments. Memorandum from John Lincoln of CH2M Hill to Fran Allans of the EPA, September 22, 2009.

Environmental Protection Agency (EPA), 2010. Comment Letter for *Draft Report on Panther Creek Overbank Sampling for Sequential Extraction Analysis*. Letter from Fran Allans (EPA) to George Lusher (Noranda Mining Inc.) and Dave Jackson, January 25, 2010.

Golder Associates Inc. (Golder), 1995. Final Report – Focused Remedial Investigation and Feasibility Study Workplan, Blackbird Mine Site – Lemhi County, Idaho. Prepared for the Blackbird Mine Site Group, June 8, 1995.

Golder Associates Inc. (Golder), 2009a. Revised Sampling and Analysis Plan, Panther Creek Overbank Sampling For Sequential Extraction Analysis, Lemhi County, Idaho. Prepared for the Blackbird Mine Site Group, November 2, 2009.

Golder Associates Inc. (Golder), 2009b. Blackbird Creek Iron Oxyhydroxide Solids Sampling Data Report. Prepared for the Blackbird Mine Site Group, December 17, 2009.

TABLES

TABLE F1
2009 Panther Creek Overbank Composite Sample Locations

Field Sample Identification[1]	Panther Creek Sequential Extraction - Overbank Sample Location Description[2]	Sample Collection Date	GPS #	Geographic Location (NAD 83; DMS)[3]	
				Latitude	Longitude
PACrk_Seq_Cobalt1	Sample # Cobalt 1; discrete sample collected from Cobalt Area 1 from within the Cobalt Townsite.	11/4/2009	PACrk_Seq_Cobalt1a,b	114°14'12.257"W	45°5'25.314"N
PACrk_Seq_Cobalt2	Sample # Cobalt 2; discrete sample collected from Cobalt Area 2 from within the Cobalt Townsite.	11/4/2009	PACrk_Seq_Cobalt2a,b	114°14'7.008"W	45°5'31.214"N
PACrk_Seq_Cobalt3	Sample # Cobalt 3; discrete sample collected from Cobalt Area 2 from within the Cobalt Townsite.	11/4/2009	PACrk_Seq_Cobalt3a,b	114°14'5.46"W	45°5'31.822"N
PACrk_Seq_Cobalt4	Sample # Cobalt 4; discrete sample collected from Cobalt Area 2 from within the Cobalt Townsite.	11/4/2009	PACrk_Seq_Cobalt4a,b	114°14'3.51"W	45°5'32.349"N
PACrk_Seq_Cobalt5	Sample # Cobalt 5; discrete sample collected from Cobalt Area 3 from within the Cobalt Townsite.	11/4/2009	PACrk_Seq_Cobalt5a,b	114°13'58.71"W	45°5'37.327"N
PACrk_Seq_Cobalt6	Sample # Cobalt 6; discrete sample collected from Cobalt Area 3 from within the Cobalt Townsite.	11/4/2009	PACrk_Seq_Cobalt6a,b	114°13'57.594"W	45°5'37.372"N
PACrk_Seq_Napias1	Sample # Napias 1; discrete sample collected from Napias Near Bar Area.	11/4/2009	PACrk_Seq_Napias7a	114°13'0.72"W	45°8'11.645"N
PACrk_Seq_Napias2	Sample # Napias 2; discrete sample collected from Napias Near Bar Area.	11/4/2009	PACrk_Seq_Napias7a		
PACrk_Seq_Napias3	Sample # Napias 3; discrete sample collected from Napias Near Bar Area.	11/4/2009	PACrk_Seq_Napias9a&10a	114°13'0.679"W	45°8'11.888"N
PACrk_Seq_Napias4	Panther Creek Sequential extraction overbank sample # Napias 4; discrete sample collected from Napias Near Bar Area.	11/4/2009	PACrk_Seq_Napias9a&10a		
PACrk_Seq_Napias5	Sample # Napias 5; discrete sample collected from Napias Near Bar Area.	11/4/2009	PACrk_Seq_Napias11a&12a	114°13'0.812"W	45°8'12.115"N
PACrk_Seq_Napias6	Sample # Napias 6; discrete sample collected from Napias Near Bar Area.	11/4/2009	PACrk_Seq_Napias11a&12a		
PACrk_Seq_Bevan1	Sample # Bevan 1; discrete sample collected at the Bevan Property, from the low bar area of Panther Creek, NW of the house and pasture areas.	11/4/2009	PACrk_Seq_Bevan1a,1b	114°20'17.87"W	45°16'23.787"N
PACrk_Seq_Bevan2	Sample # Bevan 2; discrete sample collected at the Bevan Property, from the low bar area of Panther Creek, NW of the house and pasture areas.	11/4/2009	PACrk_Seq_Bevan2a,2b	114°20'18.439"W	45°16'23.801"N
PACrk_Seq_Bevan3	Sample # Bevan 3; discrete sample collected at the Bevan Property, from the low bar area of Panther Creek, NW of the house and pasture areas.	11/4/2009	PACrk_Seq_Bevan3a,3b	114°20'19.989"W	45°16'24.113"N
PACrk_Seq_Bevan4	Sample # Bevan 4; discrete sample collected at the Bevan Property, from the low bar area of Panther Creek, NW of the house and pasture areas.	11/4/2009	PACrk_Seq_Bevan4a,4b	114°20'21.1"W	45°16'26.223"N
PACrk_Seq_Bevan5	Sample # Bevan 5; discrete sample collected at the Bevan Property, from the low bar area of Panther Creek, NW of the house and pasture areas.	11/4/2009	PACrk_Seq_Bevan5a,5b	114°20'21.29"W	45°16'26.73"N
PACrk_Seq_Bevan6	Sample # Bevan 6; discrete sample collected at the Bevan Property, from the low bar area of Panther Creek, NW of the house and pasture areas.	11/4/2009	PACrk_Seq_Bevan6a,6b	114°20'21.311"W	45°16'27.032"N

Notes:

1 - Sample Identification naming scheme is the following: PACrk_Seq(Panther Creek_Sequential)- Cobalt#(unique sample ID & discrete sample #)

2 - Samples prepared for certified lab analysis represent a surface composite material of the 6 discrete samples (~6" wide by 6" long by 2" deep) from within each sample area (i.e. Cobalt). All samples were field homogenized and sent to Energy Laboratory, Inc. located in Billings, MT for analysis. Duplicates of the Cobalt and Bevan composite samples were sent to Golder Associates, Inc. laboratory located in Redmond, WA.

3- GPS Trimble Analyst™ Extension (ArcGIS®9) was used for GPS correction. Coordinates were transformed from *WGS-84* to *NAD_1983_StatePlane_Idaho_Central_FIPS_1102_Feet.* Base provider for GPS correction was CORS, National Geodetic Survey, NOAA based out of Grangeville, ID.

TABLE F2
Sample Preparation Results

Parameter	Units	Cobalt Townsite	Napias Creek	Bevan Bar
Laboratory ID		L79376	L79377	L79378
Sample Collection Date		4-Nov-09	4-Nov-09	4-Nov-09
Initial Sieve Analysis				
As received sample weight (including 2 large Ziplock bags)	g	8,062	6,264	7,218
Dry sample weight (> 10 mesh sieve)	g	46.2	75.4	36.3
Dry sample weight (< 10 mesh sieve)	g	6,292.5	4,367.3	5,741.3
Total dry sample weight	g	6,339	4,443	5,778
Separation Procedure				
Initial sample weight	g	300	300	300
Water volume	L	15	15	15
Settling time	min	2.8	2.8	2.8
Decant water settling time	hours	191.8	194.8	196.3
Dry suspended sample weight	g	116.2	240.4	123.5
Suspended sample fraction	%	39%	80%	41%

Golder Associates

TABLE F3
Total Metal and Sequential Extraction Analysis Results

Parameter	Units	Method	MDL	Cobalt Townsite	Napias Creek	Bevan Bar
Solid Phase Analysis						
Percent Solids	%	CLPSOW390, PART F, D-98	0.1	79.7	72.4	80.2
Arsenic (total)	mg/kg	6020 (ICP-MS)	1 or 0.5	555	683	270
Cobalt (total)	mg/kg	6010B (ICP)	1	156	209	122
Iron (total)	mg/kg	6010B (ICP)	2	29,500	41,100	30,000
Sequential Extraction (analysis of leachate 3 - easily reducible and iron oxides fraction)						
Arsenic, dissolved	mg/L	200.8 (ICP-MS)	0.005	3.06	1.48	3.71
Cobalt, dissolved	mg/L	200.7 (ICP)	0.02	2.72 J	2.2 J	3.6 J
Iron, dissolved	mg/L	200.7 (ICP)	0.04	277	207	360
Sequential Extraction (leachate 3 results converted to mg/kg) [(a)]						
Arsenic	mg/kg	-	-	61	30	74
Cobalt	mg/kg	-	-	54 J	44 J	72 J
Iron	mg/kg	-	-	5,540	4,140	7,200

Notes:
[(a)] Step 3 extraction uses 40 mL of solution and 2 g of sample. Leachate results multiplied by 20 to convert mg/L to mg/kg.
Solid phase analysis conducted using EPA method 3050.

J - Result qualified as an estimated value due to out of limit matrix spike recovery.

TABLE F4
Floc Metal Contribution Evaluation Results

Parameter	Units	Cobalt Townsite	Napias Creek	Bevan Bar	Average
Step 1 - Sample Total Metal Mass (<2 mm fraction)					
Arsenic	mg	167	205	81	-
Cobalt	mg	47	63	37	-
Iron	g	8.9	12.3	9.0	-
Step 2 - Sample Floc Metal Mass (<2 mm fraction)					
Arsenic	mg	7.1	7.1	9.2	-
Cobalt	mg	6.3	10.6	8.9	-
Iron	g	0.6	1.0	0.9	-
Step 3 - Floc Metal Proportion (<2 mm fraction)					
Arsenic	%	4.3%	3.5%	11%	6.4%
Cobalt	%	14%	17%	24%	18%
Iron	%	7.3%	8.1%	9.9%	8.4%

Sample Calculation - Cobalt Townsite:

Step 1 - Total Arsenic (mg)

As (mg) = 0.3 kg (Table F2) x 555 mg/kg (Table F3)
= 167 mg (Table F4)

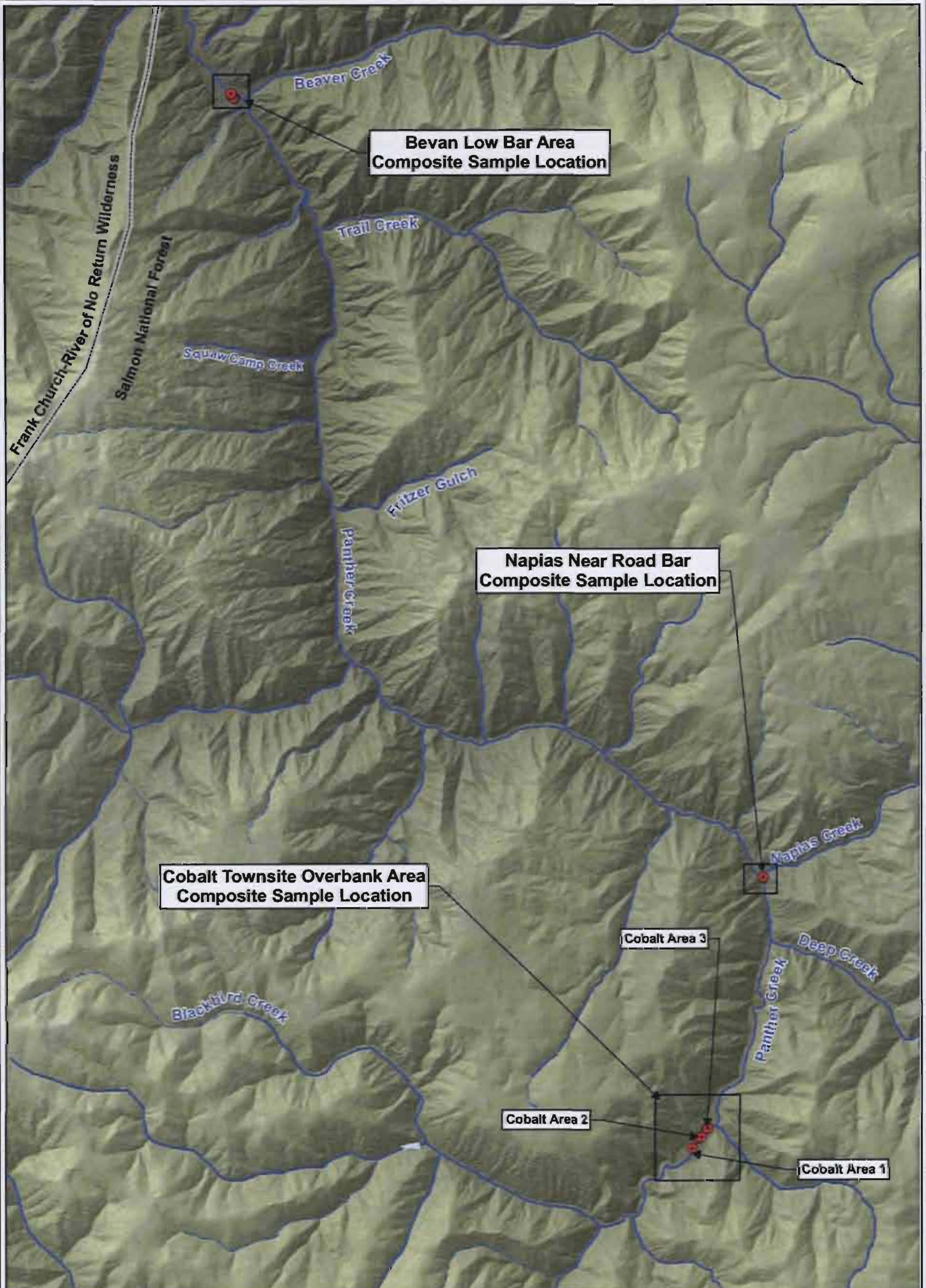
Step 2 - Floc Arsenic (mg)

As (mg) = 0.1162 kg (Table F2) x 61 mg/kg (Table F3)
= 7.1 mg (Table F4)

Step 3 - Floc Arsenic Proportion

As (%) = 7.1 mg (Table F4) / 167 mg (Table F4)
= 4.3% (Table F4)

FIGURES



LEGEND

- Panther Creek '09 Sequential Extraction Samples
- US National Forest Boundary

0 5700
Scale in Feet

Map Projection:
UTM Zone 11N NAD 1983

Source:
USGS (10m DEM), ESRI (base data),
Golder Associates, Inc.

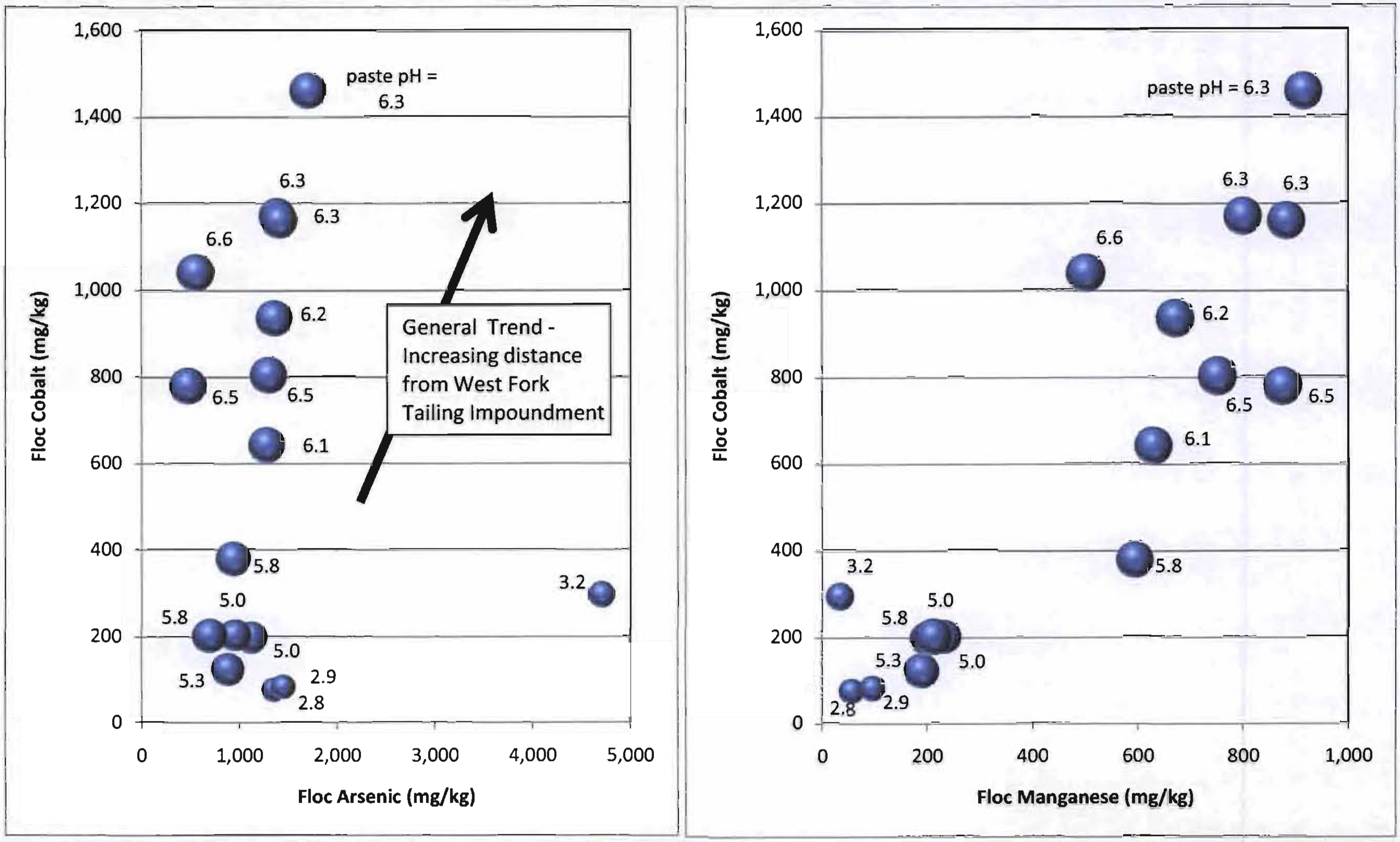
N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information

FIGURE **F1**
OVERVIEW MAP
BMSG/BLACK BIRD MINE/ID

9431595004_F01.mxd | 12/15/2009 | ARYDECKI

Golder Associates



Golder Associates	Title: Floc Arsenic, Cobalt and Manganese Concentrations (Golder, 2009b)		Drawn: CR / Checked: CS / Reviewed: CS
	Project Name: Blackbird Mine	Project No. 943-1595-004.1280	
	Client Name: Blackbird Mine Site Group	Date: February 2010	FIGURE F2

P:\PROJECTS\1994\9431595 Blackbird\Extender 004\Task 1280 - Evaluation Report\Geochem SAP\Sequential Extraction Report (Jan 2010)\Final to EPA (Feb 25 2010)\022510cr1_Pather Creek Overbank Report Tables.xlsx

ATTACHMENT F1

FIELD OBSERVATION PHOTOGRAPHS OF 2009 SEQUENTIAL EXTRACTION SAMPLING

PHOTOGRAPHS of COBALT TOWNSITE SAMPLE LOCATIONS

Discrete sample ID# PACrk_Seq_Cobalt1 collected from Cobalt Area 1 within Cobalt Townsite.

Discrete sample ID# PACrk_Seq_Cobalt4 collected from Cobalt Area 2 within Cobalt Townsite.

PHOTOGRAPHS of NAPIAS NEAR BAR SAMPLE LOCATIONS

Discrete sample locations collected from Napias near road bar adjacent to Panther Creek, looking north.

PHOTOGRAPHS of NAPIAS NEAR BAR SAMPLE LOCATIONS

Discrete sample locations at Napias near road bar near confluence of Napias Creek / Panther Creek.

PHOTOGRAPHS of BEVAN LOW BAR AREA SAMPLE LOCATIONS


Discrete sample ID# PACrk_Seq_Bevan3 collected from Bevan low bar area, looking N/NE.


Discrete sample locations at Bevan low bar area northwest of Bevan house and pasture, looking N/NE.

ATTACHMENT F2

ACZ LABORATORIES, INC. ANALYTICAL REPORTS

Partial Analytical Reports Included:

QA/QC Reporting on file at Golder Associates Inc., Redmond available upon request

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Revised Analytical Report

Tom Stapp
Golder Associates
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052-3333

January 11, 2010

Cc: Aaron Rydecki

Project ID:
ACZ Project ID: L79376

Tom Stapp:

Enclosed are revised analytical reports for sample(s) submitted to ACZ Laboratories, Inc. (ACZ) on November 11, 2009 and reported on December 16, 2009. Refer to the case narrative for an explanation of the changes. This project was assigned to ACZ's project number, L79376. Please reference this number in all future inquiries.

All analyses were performed according to ACZ's Quality Assurance Plan. The enclosed results relate only to the samples received under L79376. Each section of this report has been reviewed and approved by the appropriate Laboratory Supervisor, or a qualified substitute.

Except as noted, the test results for the methods and parameters listed on ACZ's current NELAC certificate letter (#ACZ) meet all the requirements of NELAC.

This report should be used or copied only in its entirety. ACZ is not responsible for the consequences arising from the use of a partial report.

All samples and sub-samples associated with this project will be disposed of after January 16, 2010. If the samples are determined to be hazardous, additional charges apply for disposal (typically less than $10/sample). If you would like the samples to be held longer than ACZ's stated policy or to be returned, please contact your Project Manager or Customer Service Representative for further details and associated costs. ACZ retains analytical reports for five years. Please notify your Project Manager if you have other needs.

If you have any questions, please contact your Project Manager or Customer Service Representative.

S. Habermehl

Scott Habermehl has reviewed
and approved this report.

ACCREDITED IN ACCORDANCE WITH nelac

ACIL

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Case Narrative

Golder Associates

January 11, 2010

Project ID:
ACZ Project ID: L79376

Sample Receipt

ACZ Laboratories, Inc. (ACZ) received 2 soil samples from Golder Associates on November 11, 2009. The samples were received in good condition. Upon receipt, the sample custodian removed the samples from the cooler, inspected the contents, and logged the samples into ACZ's computerized Laboratory Information Management System (LIMS). The samples were assigned ACZ LIMS project number L79376. The custodian verified the sample information entered into the computer against the chain of custody (COC) forms and sample bottle labels.

Holding Times

All analyses were performed within EPA recommended holding times.

Sample Analysis

These samples were analyzed for inorganic parameters. The individual methods are referenced on both, the ACZ invoice and the analytical reports. The extended qualifier reports may contain footnotes qualifying specific elements due to QC failures. In addition the following has been noted with this specific project:

1. This project is a client specified geochemical study. Sample -01 is a total (3050) analysis of the solid phase sample. Sample -02 is then an anlysis of the leachate using a portion of the tessier Sequential Extraction procedure. See the attachment for detailed instructions fofanalysis and a log of ACZ's activities and measurements.

2. This project has been revised to include a QC Summary.

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Golder Associates

Project ID:

Sample ID: PACRK_SEQ_COBALT TOW

ACZ Sample ID: ***L79376-01***

Date Sampled: *11/04/09 00:00*

Date Received: *11/11/09*

Sample Matrix: *Soil*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Arsenic, total (3050)	M6020 ICP-MS	555		*	mg/Kg	1	4	12/02/09 21:06	erf
Cobalt, total (3050)	M6010B ICP	156			mg/Kg	1	5	11/30/09 11:49	ear
Iron, total (3050)	M6010B ICP	29500		*	mg/Kg	2	5	11/30/09 11:49	ear

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	79.7		*	%	0.1	0.5	11/11/09 14:45	as

Soil Preparation

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Digestion - Hot Plate	M3050B ICP-MS							11/25/09 14:07	jjg
Serial Batch Extraction - 6 Step	M600/9-80-010							12/10/09 8:50	as/brd

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Golder Associates

Project ID:

Sample ID: PACRK_SEQ_COBALT TOW

ACZ Sample ID: ***L79376-02***

Date Sampled: *11/04/09 00:00*

Date Received: *11/11/09*

Sample Matrix: *Leachate*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Arsenic, dissolved	M200.8 ICP-MS	3.060		*	mg/L	0.005	0.02	12/14/09 14:29	msh
Cobalt, dissolved	M200.7 ICP	2.72		*	mg/L	0.02	0.1	12/14/09 10:39	ear
Iron, dissolved	M200.7 ICP	277		*	mg/L	0.04	0.1	12/14/09 10:39	ear

Report Header Explanations

Batch	A distinct set of samples analyzed at a specific time
Found	Value of the QC Type of interest
Limit	Upper limit for RPD, in %.
Lower	Lower Recovery Limit, in % (except for LCSS, mg/Kg)
MDL	Method Detection Limit. Same as Minimum Reporting Limit. Allows for instrument and annual fluctuations.
PCN/SCN	A number assigned to reagents/standards to trace to the manufacturer's certificate of analysis
PQL	Practical Quantitation Limit, typically 5 times the MDL.
QC	True Value of the Control Sample or the amount added to the Spike
Rec	Amount of the true value or spike added recovered, in % (except for LCSS, mg/Kg)
RPD	Relative Percent Difference, calculation used for Duplicate QC Types
Upper	Upper Recovery Limit, in % (except for LCSS, mg/Kg)
Sample	Value of the Sample of interest

QC Sample Types

AS	Analytical Spike (Post Digestion)
ASD	Analytical Spike (Post Digestion) Duplicate
CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification standard
DUP	Sample Duplicate
ICB	Initial Calibration Blank
ICV	Initial Calibration Verification standard
ICSAB	Inter-element Correction Standard - A plus B solutions
LCSS	Laboratory Control Sample - Soil
LCSSD	Laboratory Control Sample - Soil Duplicate
LCSW	Laboratory Control Sample - Water
LCSWD	Laboratory Control Sample - Water Duplicate
LFB	Laboratory Fortified Blank
LFM	Laboratory Fortified Matrix
LFMD	Laboratory Fortified Matrix Duplicate
LRB	Laboratory Reagent Blank
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PBS	Prep Blank - Soil
PBW	Prep Blank - Water
PQV	Practical Quantitation Verification standard
SDL	Serial Dilution

QC Sample Type Explanations

Blanks	Verifies that there is no or minimal contamination in the prep method or calibration procedure.
Control Samples	Verifies the accuracy of the method, including the prep procedure.
Duplicates	Verifies the precision of the instrument and/or method.
Spikes/Fortified Matrix	Determines sample matrix interferences, if any.
Standard	Verifies the validity of the calibration.

ACZ Qualifiers (Qual)

B	Analyte concentration detected at a value between MDL and PQL. The associated value is an estimated quantity.
H	Analysis exceeded method hold time. pH is a field test with an immediate hold time.
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

Method References

(1) EPA 600/4-83-020. Methods for Chemical Analysis of Water and Wastes, March 1983.

(2) EPA 600/R-93-100. Methods for the Determination of Inorganic Substances in Environmental Samples, August 1993.

(3) EPA 600/R-94-111. Methods for the Determination of Metals in Environmental Samples - Supplement I, May 1994.

(5) EPA SW-846. Test Methods for Evaluating Solid Waste, Third Edition with Update III, December 1996.

(6) Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995 & 20th edition (1998).

Comments

(1) QC results calculated from raw data. Results may vary slightly if the rounded values are used in the calculations.

(2) Soil, Sludge, and Plant matrices for Inorganic analyses are reported on a dry weight basis.

(3) Animal matrices for Inorganic analyses are reported on an "as received" basis.

(4) An asterisk in the "XQ" column indicates there is an extended qualifier and/or certification qualifier associated with the result.

For a complete list of ACZ's Extended Qualifiers, please click: http://www.acz.com/public/extquallist.pdf

Remainder of report on file at Golder Associates Inc., Redmond.
Available upon request.

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Revised Analytical Report

January 11, 2010

Tom Stapp
Golder Associates
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052-3333

Cc: Aaron Rydecki

Project ID:
ACZ Project ID: L79377

Tom Stapp:

Enclosed are revised analytical reports for sample(s) submitted to ACZ Laboratories, Inc. (ACZ) on November 11, 2009 and reported on December 16, 2009. Refer to the case narrative for an explanation of the changes. This project was assigned to ACZ's project number, L79377. Please reference this number in all future inquiries.

All analyses were performed according to ACZ's Quality Assurance Plan. The enclosed results relate only to the samples received under L79377. Each section of this report has been reviewed and approved by the appropriate Laboratory Supervisor, or a qualified substitute.

Except as noted, the test results for the methods and parameters listed on ACZ's current NELAC certificate letter (#ACZ) meet all the requirements of NELAC.

This report should be used or copied only in its entirety. ACZ is not responsible for the consequences arising from the use of a partial report.

All samples and sub-samples associated with this project will be disposed of after January 16, 2010. If the samples are determined to be hazardous, additional charges apply for disposal (typically less than $10/sample). If you would like the samples to be held longer than ACZ's stated policy or to be returned, please contact your Project Manager or Customer Service Representative for further details and associated costs. ACZ retains analytical reports for five years. Please notify your Project Manager if you have other needs.

If you have any questions, please contact your Project Manager or Customer Service Representative.

S. Habermehl

Scott Habermehl has reviewed
and approved this report.

ACCREDITED IN ACCORDANCE WITH nelac

ACIL

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Case Narrative

Golder Associates

January 11, 2010

Project ID:

ACZ Project ID: L79377

Sample Receipt

ACZ Laboratories, Inc. (ACZ) received 2 soil samples from Golder Associates on November 11, 2009. The samples were received in good condition. Upon receipt, the sample custodian removed the samples from the cooler, inspected the contents, and logged the samples into ACZ's computerized Laboratory Information Management System (LIMS). The samples were assigned ACZ LIMS project number L79377. The custodian verified the sample information entered into the computer against the chain of custody (COC) forms and sample bottle labels.

Holding Times

All analyses were performed within EPA recommended holding times.

Sample Analysis

These samples were analyzed for inorganic parameters. The individual methods are referenced on both, the ACZ invoice and the analytical reports. The extended qualifier reports may contain footnotes qualifying specific elements due to QC failures. In addition the following has been noted with this specific project:

1. This project is a client specified geochemical study. Sample -01 is a total (3050) analysis of the solid phase sample. Sample -02 is then an anlysis of the leachate using a portion of the tessier Sequential Extraction procedure. See the attachment for detailed instructions fofanalysis and a log of ACZ's activities and measurements.

2. This project has been revised to include a QC Summary.

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Golder Associates

Project ID:

Sample ID: PACRK_SEQ_NAPIAS CRE

ACZ Sample ID: ***L79377-01***

Date Sampled: *11/04/09 00:00*

Date Received: *11/11/09*

Sample Matrix: *Soil*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Arsenic, total (3050)	M6020 ICP-MS	683		*	mg/Kg	1	4	12/02/09 21:09	erf
Cobalt, total (3050)	M6010B ICP	209			mg/Kg	1	5	11/30/09 11:58	ear
Iron, total (3050)	M6010B ICP	41100		*	mg/Kg	2	5	11/30/09 11:58	ear

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	72.4		*	%	0.1	0.5	11/11/09 15:30	as

Soil Preparation

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Digestion - Hot Plate	M3050B ICP-MS							11/25/09 15:26	jjg
Serial Batch Extraction - 6 Step	M600/9-80-010							12/10/09 8:50	as/brd

* *Please refer to Qualifier Reports for details.*

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Golder Associates
Project ID:
Sample ID: PACRK_SEQ_NAPIAS CRE

ACZ Sample ID: ***L79377-02***
Date Sampled: *11/04/09 00:00*
Date Received: *11/11/09*
Sample Matrix: *Leachate*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Arsenic, dissolved	M200.8 ICP-MS	1.480		*	mg/L	0.005	0.02	12/14/09 14:31	msh
Cobalt, dissolved	M200.7 ICP	2.20		*	mg/L	0.02	0.1	12/14/09 10:48	ear
Iron, dissolved	M200.7 ICP	207		*	mg/L	0.04	0.1	12/14/09 10:48	ear

* *Please refer to Qualifier Reports for details.*

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Reference

Report Header Explanations

Batch	A distinct set of samples analyzed at a specific time
Found	Value of the QC Type of interest
Limit	Upper limit for RPD, in %.
Lower	Lower Recovery Limit, in % (except for LCSS, mg/Kg)
MDL	Method Detection Limit. Same as Minimum Reporting Limit. Allows for instrument and annual fluctuations.
PCN/SCN	A number assigned to reagents/standards to trace to the manufacturer's certificate of analysis
PQL	Practical Quantitation Limit, typically 5 times the MDL.
QC	True Value of the Control Sample or the amount added to the Spike
Rec	Amount of the true value or spike added recovered, in % (except for LCSS, mg/Kg)
RPD	Relative Percent Difference, calculation used for Duplicate QC Types
Upper	Upper Recovery Limit, in % (except for LCSS, mg/Kg)
Sample	Value of the Sample of interest

QC Sample Types

AS	Analytical Spike (Post Digestion)	LCSWD	Laboratory Control Sample - Water Duplicate
ASD	Analytical Spike (Post Digestion) Duplicate	LFB	Laboratory Fortified Blank
CCB	Continuing Calibration Blank	LFM	Laboratory Fortified Matrix
CCV	Continuing Calibration Verification standard	LFMD	Laboratory Fortified Matrix Duplicate
DUP	Sample Duplicate	LRB	Laboratory Reagent Blank
ICB	Initial Calibration Blank	MS	Matrix Spike
ICV	Initial Calibration Verification standard	MSD	Matrix Spike Duplicate
ICSAB	Inter-element Correction Standard - A plus B solutions	PBS	Prep Blank - Soil
LCSS	Laboratory Control Sample - Soil	PBW	Prep Blank - Water
LCSSD	Laboratory Control Sample - Soil Duplicate	PQV	Practical Quantitation Verification standard
LCSW	Laboratory Control Sample - Water	SDL	Serial Dilution

QC Sample Type Explanations

Blanks	Verifies that there is no or minimal contamination in the prep method or calibration procedure.
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(3) EPA 600/R-94-111. Methods for the Determination of Metals in Environmental Samples - Supplement I, May 1994.
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Comments

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(2) Soil, Sludge, and Plant matrices for Inorganic analyses are reported on a dry weight basis.
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Available upon request.

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Revised Analytical Report

Tom Stapp
Golder Associates
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052-3333

January 11, 2010

Cc: Aaron Rydecki

Project ID:
ACZ Project ID: L79378

Tom Stapp:

Enclosed are revised analytical reports for sample(s) submitted to ACZ Laboratories, Inc. (ACZ) on November 11, 2009 and reported on December 16, 2009. Refer to the case narrative for an explanation of the changes. This project was assigned to ACZ's project number, L79378. Please reference this number in all future inquiries.

All analyses were performed according to ACZ's Quality Assurance Plan. The enclosed results relate only to the samples received under L79378. Each section of this report has been reviewed and approved by the appropriate Laboratory Supervisor, or a qualified substitute.

Except as noted, the test results for the methods and parameters listed on ACZ's current NELAC certificate letter (#ACZ) meet all the requirements of NELAC.

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If you have any questions, please contact your Project Manager or Customer Service Representative.

S. Habermehl

Scott Habermehl has reviewed and approved this report.

ACCREDITED IN ACCORDANCE WITH nelac

ACIL

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Case Narrative

Golder Associates

January 11, 2010

Project ID:
ACZ Project ID: L79378

Sample Receipt

ACZ Laboratories, Inc. (ACZ) received 2 soil samples from Golder Associates on November 11, 2009. The samples were received in good condition. Upon receipt, the sample custodian removed the samples from the cooler, inspected the contents, and logged the samples into ACZ's computerized Laboratory Information Management System (LIMS). The samples were assigned ACZ LIMS project number L79378. The custodian verified the sample information entered into the computer against the chain of custody (COC) forms and sample bottle labels.

Holding Times

All analyses were performed within EPA recommended holding times.

Sample Analysis

These samples were analyzed for inorganic parameters. The individual methods are referenced on both, the ACZ invoice and the analytical reports. The extended qualifier reports may contain footnotes qualifying specific elements due to QC failures. In addition the following has been noted with this specific project:

1. This project is a client specified geochemical study. Sample -01 is a total (3050) analysis of the solid phase sample. Sample -02 is then an anlysis of the leachate using a portion of the tessier Sequential Extraction procedure. See the attachment for detailed instructions of analysis and a log of ACZ's activities and measurements.

2. This project has been revised to include a QC Summary.

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Golder Associates

Project ID:

Sample ID: PACRK_SEQ_BEVAN BAR

ACZ Sample ID: ***L79378-01***

Date Sampled: *11/04/09 00:00*

Date Received: *11/11/09*

Sample Matrix: *Soil*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Arsenic, total (3050)	M6020 ICP-MS	270		*	mg/Kg	0.5	2	12/02/09 21:26	erf
Cobalt, total (3050)	M6010B ICP	122			mg/Kg	1	5	11/30/09 12:07	ear
Iron, total (3050)	M6010B ICP	30000		*	mg/Kg	2	5	11/30/09 12:07	ear

Soil Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Solids, Percent	CLPSOW390, PART F, D-98	80.2		*	%	0.1	0.5	11/11/09 16:15	as

Soil Preparation

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Digestion - Hot Plate	M3050B ICP-MS							11/25/09 16:45	jjg
Serial Batch Extraction - 6 Step	M600/9-80-010							12/10/09 8:50	as/brd

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Golder Associates

Project ID:

Sample ID: PACRK_SEQ_BEVAN BAR

ACZ Sample ID: ***L79378-02***

Date Sampled: *11/04/09 00:00*

Date Received: *11/11/09*

Sample Matrix: *Leachate*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Arsenic, dissolved	M200.8 ICP-MS	3.710		*	mg/L	0.005	0.02	12/14/09 14:37	msh
Cobalt, dissolved	M200.7 ICP	3.60		*	mg/L	0.02	0.1	12/14/09 10:51	ear
Iron, dissolved	M200.7 ICP	360		*	mg/L	0.04	0.1	12/14/09 10:51	ear

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Reference

Report Header Explanations

Batch	A distinct set of samples analyzed at a specific time
Found	Value of the QC Type of interest
Limit	Upper limit for RPD, in %.
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Rec	Amount of the true value or spike added recovered, in % (except for LCSS, mg/Kg)
RPD	Relative Percent Difference, calculation used for Duplicate QC Types
Upper	Upper Recovery Limit, in % (except for LCSS, mg/Kg)
Sample	Value of the Sample of interest

QC Sample Types

AS	Analytical Spike (Post Digestion)	LCSWD	Laboratory Control Sample - Water Duplicate
ASD	Analytical Spike (Post Digestion) Duplicate	LFB	Laboratory Fortified Blank
CCB	Continuing Calibration Blank	LFM	Laboratory Fortified Matrix
CCV	Continuing Calibration Verification standard	LFMD	Laboratory Fortified Matrix Duplicate
DUP	Sample Duplicate	LRB	Laboratory Reagent Blank
ICB	Initial Calibration Blank	MS	Matrix Spike
ICV	Initial Calibration Verification standard	MSD	Matrix Spike Duplicate
ICSAB	Inter-element Correction Standard - A plus B solutions	PBS	Prep Blank - Soil
LCSS	Laboratory Control Sample - Soil	PBW	Prep Blank - Water
LCSSD	Laboratory Control Sample - Soil Duplicate	PQV	Practical Quantitation Verification standard
LCSW	Laboratory Control Sample - Water	SDL	Serial Dilution

QC Sample Type Explanations

Blanks	Verifies that there is no or minimal contamination in the prep method or calibration procedure.
Control Samples	Verifies the accuracy of the method, including the prep procedure.
Duplicates	Verifies the precision of the instrument and/or method.
Spikes/Fortified Matrix	Determines sample matrix interferences, if any.
Standard	Verifies the validity of the calibration.

ACZ Qualifiers (Qual)

B	Analyte concentration detected at a value between MDL and PQL. The associated value is an estimated quantity.
H	Analysis exceeded method hold time. pH is a field test with an immediate hold time.
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

Method References

(1) EPA 600/4-83-020. Methods for Chemical Analysis of Water and Wastes, March 1983.
(2) EPA 600/R-93-100. Methods for the Determination of Inorganic Substances in Environmental Samples, August 1993.
(3) EPA 600/R-94-111. Methods for the Determination of Metals in Environmental Samples - Supplement I, May 1994.
(5) EPA SW-846. Test Methods for Evaluating Solid Waste, Third Edition with Update III, December 1996.
(6) Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995 & 20th edition (1998).

Comments

(1) QC results calculated from raw data. Results may vary slightly if the rounded values are used in the calculations.
(2) Soil, Sludge, and Plant matrices for Inorganic analyses are reported on a dry weight basis.
(3) Animal matrices for Inorganic analyses are reported on an "as received" basis.
(4) An asterisk in the "XQ" column indicates there is an extended qualifier and/or certification qualifier associated with the result.

For a complete list of ACZ's Extended Qualifiers, please click: http://www.acz.com/public/extquallist.pdf

Remainder of report on file at Golder Associates Inc., Redmond.
Available upon request.

ATTACHMENT F3

DATA VALIDATION REPORT

METALS & INORGANIC / Tier I & II Data Validation Summary Checklist

GOLDER PROJECT #: 943-1595.004.1280	SITE: BLACKBIRD MINE SITE
LABORATORY: ACZ LABORATORIES	SDG: L79376, L79377, L79378
SAMPLES Extract Volume: SOIL SOURCE:	~~MATRIX~~
As ICP/MS 200.8	ICP/MS 6020/3050
Co ICP 200.7	ICP 6010 /
Fe " "	" " /

DATA ASSESSMENT SUMMARY

REVIEW ITEM	ICP/ AES	ICP/ MS	TDS/TSS	Alkalinity /Hardness	Anions	OTHER
1. Data Completeness	O	O				
2. Holding Times	O	O				
3. Calibration	O	O				
4. Blanks	O	O				
5. Field Duplicate RPD	—	—				
6. LCS, Blank Spike, MFS	O	O				
7. Matrix Spike, MSD (1)	X	O				
8. Detection Limits, Other QC	O	O				
9. Data Verification, Overall Summary	O	O				

O = Data had no problems Θ = Problems, but do not affect data
X = Data qualified due to minor problems [typically estimated data (J or UJ)].
M = Data qualified due to major problems [typically more than 50% qualified (J/UJ).
Z = Data unacceptable [typically data rejected (R).

Comments/Qualified Results: (1) Co results for Seq. Extract Liquid is qualif. (J) for all Samples due to out of limit MS/MSD.

Validated by: [signature] Date: Jan. 11, 2010
Reviewed by: [signature] Date: 01/11/2010

1. Date Package Completeness (Check if present) .... ☑ ☐

- ✓ Case narrative
- ✓ Chain of Custody
- ~~✓~~ ✓ Sample Results
- ✓ Blank Results
- ✓ Spike Recovery Results
- ✓ Instrument Det. Limits
- ✓ Duplicate Results
- ✓ LCS Results
- __Other__________

x Absent
o Not required for data package requested.
✓ Acceptable

TTB 1-11-10

Comments/Qualified Results: Cooler Rept 16°c ✓; Missing items to be requested from Lab. TTB ~~TTB~~ Rcvd. on 1-11-10 TTB

Acceptable: YES NO

2. Holding Times (Check all that apply) .... ☑ ☐

__ICP/GFAA metals completed in <6 months from collection

Collect 11-04-09 / END DATES:

Comments/Qualified Results: ~~16~~ Mois 11/11 ; Settling 12/08 ; DRYING 12/10 ; SEQ Ext 12/11

METALS: 7DAY 34DAY 36DAY 37DAY

DRY 11/30, 12/02 Extract 12/14 (40DAY).

1

METALS & INORGANIC / Tier I & II Data Validation Summary Checklist

3. Calibrations (Check all that apply).. ☑ ☐

* All Extract analytes Co & Fe

__ICV/CCV %R for ICP/AA, 90%-110%, acceptable
__ICV/CCV %R for ICP/AA, <75% or >125%, reject positive results (R).
__ICV/CCV %R for ICP/AA, 75%-89% or 111%-125%, results estimated (J/UJ)

Comments/Qualified Results: Soil Data ~~not provided~~ TMB ; Identified MS0912-02-1 & -2. 12/02 97% As, ICSAB 103%, CCV 96%, 96% ; EXTRACTS Data*: 11/30 CCV 99-106% CCV2 = 104 & 108%

4. Blanks (Check all that apply).. ☑ ☐

__Detects reported in ICB/CCB list:
__Detects in preparation blanks, list:
__Detects in field blanks, list

Qualified as undetected (U) all sample concentrations ≤10X any associated blank concentrations and less than the PQL or J+ for samples greater than the PQL.

Comments/Qualified Results: Soil Data ~~not provided~~ TMB ; 12/02 ICB As, Prep Blnk ND, CCB .002 U mg/L.
EXTRACTS DATA : 11/30 ICSAB 100-99%, CCB All ND.

5. Lab Duplicate / Field Duplicates (Check all that apply)........................ ☑ ☐

__Duplicate RPD ≤20% for waters (≤35% for soils) for results >5X CRDL
__Field dup RPD ≤20% (≤35% for soils)
__Duplicate range is within ±CRDL (± 2X CRDL for soils) for results <5X CRDL

Comments/Qualified Results DATA ~~not provided~~ TMB ; As 12/02 Soil ser dil. 8%. EXTRACTS DATA 11/30 Co 7.5% Fe 1.8%
Lab Duplicates not provided LCS/LCSD, MS/MSD
As Co Fe

6. Laboratory Control Samples, Blank Spikes (Check all that apply)... ☑ ☐

__LCS %R 80-120%, [50-150% for Ag, Sb]
__LCS %R 50-79% or >120%, results >IDL estimated (J)
__LCS %R 50-79% and results <IDL estimated (UJ)
__LCS %R <50% and all results rejected (R/UR)

Comments/Qualified Results: Narrative cites acceptable results; 12/02 As LCS/SD = 111%/113%. EXTRACTS DATA: 108/106% & 114/109

7. Spike Recovery (Check all that apply).. ☐ (X)

* Associated : L79377-02

__Spike %R with 75-125%
__Spike %R <30%, results <IDL rejected (UR)
__Spike %R 30-74%, >125%, results > IDL est. (J)
__Field blanks used for spike analysis
__Spike %R 30-74% results <IDL estimated (UJ)
__Post digest spk rcrd: %R 75-125%, excpt Ag

* L79376-02

Comments/Qualified Results: MS/MSD for Co ~~& Fe~~ out of limit for Extract portion. Assoc. Co results qualif. (J) all Samples: L79377-02, L79376-02, L79378-02. Note: recovery data not provided.
SOIL MS/MSD 12/02 As Soil Rec ↑ due to high initial sample conc. level - No Qual. Co recovery acceptable, Fe Rec ↑ due to high initial conc. No Qual.

METALS & INORGANIC / Tier I & II Data Validation Summary Checklist

Acceptable: YES NO

8. Detection Limits, Other QC .... ☑ ☐

Comments/Qualified Results:

SOLIDS: As 4. mg/L Extracts: As 0.02 mg/L
Co 5. Co 0.1
Fe 5. Fe 0.1

9. Data Verification and Overall Assessment .... ☐ ☐

Comments/Qualified Results: ~~Pending review of missing QC data~~, results and procedures appear correct and usable with Qualifiers applied. [initials]

Data Revd. / [initials] 1-11-10

APPENDIX G
ALTERNATIVE COST INFORMATION

TABLE G-1
Alternative Comparison Cost Summary

Alternative	Alternative Costs			Total Cost
	Capital Cost	Annual O&M	NPC O&M[1]	Total NPC
A - ROD Remedy - Baseline Alternative	$0	$407,000	$5,805,000	$5,805,000
B - In-Stream Stabilization and Removal	$6,061,000	$152,000	$2,633,000	$8,694,000
C - In-Stream Stabilization and Removal with PCI Settling Basins	$8,817,000	$219,000	$3,274,000	$12,091,000
D - Single Large Dam	$43,074,000	$394,000	$5,619,000	$48,693,000
E - In-Stream Stabilization and Removal with Single Moderate Sized Dam	$11,267,000	$485,000	$7,046,000	$18,313,000

Note:

[1]NPC O&M = Net Present Cost of Annual O&M plus two monitoring and overbank removal activities for Alt B and one monitoring and overbank removal activity for Alts C and E.

TABLE G-2
Alternative A Costs

Preliminary Cost Estimate - ROD Remedy

Item	Quantity	Units	Unit Rate	Cost	Total
No Action					
SUBTOTAL					$0
Subtotal Construction Cost:					**$0**
Mobilization at	10%			$0	
Subtotal				$0	
CQA	10%			$0	
Subtotal				$0	
Final Design Engineering	10%			$0	
Subtotal				$0	
Contingency at	15%			$0	
TOTAL CONSTRUCTION COST:					**$0**
O&M Costs					
No Action O&M	1	ls	$406,758		$406,758
Present Value of O&M	12.41	PV Factor			$5,047,482
Contingency (15% applied to total O&M cost)	15%	percent			$757,100
O&M Total Cost					**$5,804,600**
TOTAL ALTERNATIVE COST					**$5,804,600**

Note:

1. O&M Costs assume monitoring every 2-years, one major cleanup action every 2-years, and minor maintenance every year.

TABLE G-3
Alternative B Costs

Preliminary Cost Estimate - Blackbird Creek In-Stream Stabilization

Item	Quantity	Units	Unit Rate	Cost	Total
Excavation for Grade Controls	61,000	cy	$5	$305,000	
Riprap Grade Controls (In-Channel Stab., Areas 1-8)	30,500	cy	$50	$1,525,000	
Bank Stabilization Riprap (bank armoring)	7,000	cy	$50	$350,000	
Road Restoration/Grading	10,000	lf	$13	$130,000	
Additional Removals	50,000	cy	$15	$750,000	
Excavation for Additional Removal for Grade Controls	30,000	cy	$5	$150,000	
Riprap for Additional Grade Controls/Bendway Weirs	15,000	cy	$50	$750,000	
SUBTOTAL					$3,960,000
Subtotal Construction Cost:					**$3,960,000**
Mobilization at	10%			$396,000	
Subtotal				$4,356,000	
CQA	10%			$435,600	
Subtotal				$4,791,600	
Final Design Engineering	10%			$479,200	
Subtotal				$5,270,800	
Contingency at	15%			$790,600	
TOTAL CONSTRUCTION COST:					**$6,061,000**
O&M Costs					
O&M Activities, per year	1	ls	$151,525		$151,525
Two Monitoring Activities	1	ls	$81,817		$81,817
Two Overbank Removals	1	ls	$327,267		$327,267
Present Value of O&M	12.41	PV Factor			$2,289,363
Contingency (15% applied to total O&M cost)	15%	percent			$343,400
O&M Total Cost					**$2,632,800**
TOTAL ALTERNATIVE COST					**$8,693,800**

Notes and Assumptions:

1. O&M assumed based on a percentage of total capital cost, occuring once every 2 years, converted to NPV.
2. Two overbank removal activities were assumed to occur, one in year 2 and another in year 4, both converted to NPV
2. Two monitoring activities were assumed to occur, one in year 2 and another in year 4, both converted to NPV

TABLE G-4
Alternative C Costs

Preliminary Cost Estimate - In-Stream Stabilization and Diversion Structure and PCI Settling Basins

Item	Quantity	Units	Unit Rate	Cost	Total
In-Stream Stabilizaiton					
Excavation for Grade Controls	61,000	cy	$5	$305,000	
Riprap Grade Controls (In-Channel Stab., Areas 1-8)	30,500	cy	$50	$1,525,000	
Bank Stabilization Riprap (bank armoring)	7,000	cy	$50	$350,000	
Road Restoration/Grading	10,000	lf	$13	$130,000	
Additional Removals	50,000	cy	$15	$750,000	
Excavation for Additional Removal for Grade Controls	30,000	cy	$5	$150,000	
Riprap for Additional Grade Controls/Bendway Weirs	15,000	cy	$50	$750,000	
SUBTOTAL					$3,960,000
Diversion Structure Construction					
Clearing and Grubbing (Diversion Structure Footprint	861	cy	$15	$12,915	
Clearing and Grubbing (Reservoir Area)	4,391	cy	$15	$65,865	
Excavation	431	cy	$5	$2,155	
Grouted Riprap	485	cy	$320	$155,200	
Embankment Fill	2,300	cy	$14	$31,096	
Embankment Compaction	2,300	cy	$1	$1,150	
Road Surfacing for Crest	17	cy	$13	$224	
Low Flow Channel - Concrete Walls and Floor	122	cy	$800	$97,600	
Sluice Gate + Electronic Operator	1	ls	$50,000	$50,000	
Concrete Vault	14	cy	$800	$11,259	
Concrete Vault Sluice Gate (36" x 36")	1	ls	$15,100	$15,100	
Concrete Diversion Pipe Entrance Structure	27	cy	$800	$21,600	
Concrete Spillway Grade Control	24	cy	$800	$19,200	
48" Diameter Diversion Pipe	1,740	lf	$200	$348,000	
48" Diameter Sluice Gate	1	ls	$20,400	$20,400	
Instrumentation and Controls	1	ls	$50,000	$50,000	
Electric Power	1	ls	$50,000	$50,000	
Construction Diversion Ditch - Excavation	2,815	cy	$20	$56,296	
Construction Diversion Ditch - Installation	200	lf	$92	$18,364	
SUBTOTAL					$1,026,424
Access Road					
Clearing and Grubbing (under road fill prism)	633	cy	$15	$9,489	
Fill for Access Road	4,160	cy	$10	$41,600	
Road Surfacing	519	cy	$13	$6,741	
SUBTOTAL					$57,830
Settling Basin Construction					
Clearing and Grubbing	17,839	cy	$15	$267,580	
Excavation	7,300	cy	$5	$36,500	
Embankment Fill	11,100	cy	$14	$150,072	
Embankment Fill Compaction	11,100	cy	$1	$5,550	
Pond Rip-Rap Armoring	2,450	cy	$50	$122,500	
24" Diameter Pipe	1,800	lf	$50	$90,000	
SUBTOTAL					$672,202

TABLE G-4
Alternative C Costs

Preliminary Cost Estimate - In-Stream Stabilization and Diversion Structure and PCI Settling Basins

Item	Quantity	Units	Unit Rate	Cost	Total
Settling Basin Access Fence					
Chain link fence, 8 ft high	1,600	lf	$25	$40,320	
Tie in to creek	1	ls	$3,556	$3,556	
SUBTOTAL					$43,876
Subtotal Construction Cost:					**$5,760,331**
Mobilization at	10%			$576,000	
Subtotal				$6,336,331	
CQA	10%			$633,600	
Subtotal				$6,969,931	
Final Design Engineering	10%			$697,000	
Subtotal				$7,666,931	
Contingency at	15%			$1,150,000	
TOTAL CONSTRUCTION COST:					**$8,817,000**
O&M Costs					
One monitoring activity in year 2	1	ls	$43,672		$43,672
One overbank removal activity in year 2	1	ls	$87,344		$87,344
O&M Activities (In-Stream Stabilization), per year	1	ls	$151,525		$151,525
O&M Activities (Diversion Structure), per year	1	ls	$6,000		$6,000
O&M Activities (Fence), per year	1	ls	$7,334		$7,334
O&M Activities (Settling Basins), per year	1	ls	$54,000		$54,000
Present Value of O&M	12.41	PV Factor			$2,846,843
Contingency (15% applied to total O&M cost)	15%	percent			$427,000
O&M Total Cost					**$3,273,800**
TOTAL ALTERNATIVE COST					**$12,090,800**

Notes and Assumptions:

1. O&M assumed based on a percentage of total capital cost, applied every 2 years, and converted to NPV
2. One monitoring activity was assumed to occur in year 2, converted to NPV
3. One overbank removal activity was assumed to occur in year 2, converted to NPV

TABLE G-5
Alternative D Costs

Preliminary Cost Estimate - Single Large In-Stream Dam

Item	Quantity	Units	Unit Rate	Cost	Total
Dam Construction					
Clearing and Grubbing (Dam Footprint)	25,259	cy	$15	$385,709	
Clearing and Grubbing (Reservoir Area)	93,207	cy	$15	$1,398,111	
Excavation	26,431	cy	$5	$132,153	
Filter Layer (Chimney)	6,529	cy	$74	$486,248	
Filter Layer (Blanket)	3,667	cy	$74	$273,057	
Low permeability core	337,900	cy	$35	$11,894,080	
Embankment Fill	337,900	cy	$14	$4,568,408	
Embankment Compaction	337,900	cy	$1	$168,950	
Grout Curtain (foundation seepage)	2,200	sf	$57	$125,400	
Seepage Collection (toe of large dam)	1	ea	$75,600	$75,600	
Riprap on Dam Faces	34,822	cy	$50	$1,741,111	
Outlet Works	1	ls	$148,422	$148,422	
Outlet Energy Dissipater	1	ls	$93,600	$93,600	
Emergency Spillway (inc. energy dissipation)	650	cy	$800	$520,000	
Road Surfacing for Crest	459	cy	$13	$5,970	
SUBTOTAL					$22,016,819
Access Road					
Cut for Access Road	83,333	cy	$31	$2,583,333	
Fill for Access Road	59,259	cy	$10	$592,593	
Road Surfacing	5,704	cy	$13	$74,148	
SUBTOTAL					$3,250,074
Construction Diversion Ditch					
Ditch Excavation	108,370	cy	$20	$2,167,407	
Ditch Install (includes compaction, geotext, liner)	7,700	lf	$92	$706,999	
SUBTOTAL					$2,874,406
Subtotal Construction Cost:					**$28,141,299**
Mobilization at	10%			$2,814,100	
Subtotal				$30,955,399	
CQA	10%			$3,095,500	
Subtotal				$34,050,899	
Final Design Engineering	10%			$3,405,100	
Subtotal				$37,455,999	
Contingency at	15%			$5,618,400	
TOTAL CONSTRUCTION COST:					**$43,074,000**

TABLE G-5
Alternative D Costs

Preliminary Cost Estimate - Single Large In-Stream Dam

Item	Quantity	Units	Unit Rate	Cost	Total
O&M Costs					
Dam O&M Cost					
Dam O&M - NPV sed removal + operator	1	ls	$307,574		$307,574
Dam O&M - routine maintenance	1	ls	$86,148		$86,148
Present Value of O&M	12.41	PV Factor			$4,885,710
Contingency (15% applied to total O&M cost)	15%	percent			$732,900
O&M Dam Total Cost					**$5,618,600**
TOTAL O&M COSTS					**$5,618,600**
TOTAL ALTERNATIVE COST					**$48,692,600**

Notes and Assumptions:

1. Assume low permeability fill (clay core) is 50% of total dam volume.
2. O&M costs include operator and general maintenance and disposal. Sediment removal based on sediment volume and assumed cleanout intervals. New structures or improvements not included. Routine maintenance assumed to be a percentage of total capital cost.
3. Some dam construction unit costs pulled from Sup 2 AOA (7100 Dam) costs, and increased for inflation.
4. Quantities calculated for quantity-based unit costs and applied for dam volumes. However, lump sum values (outlet works)were applied a factor of 3 to account for larger dam size.
5. Outlet works energy dissipator based on a Type 10 USBR Baffled Outlet.
6. Assume no monitoring necessary

TABLE G-6
Alternative E Costs

Preliminary Cost Estimate - In-Stream Stabilization and Removal and Single Moderate Sized Dam

Item	Quantity	Units	Unit Rate	Cost	Total
Targeted Stabilization					
Excavation for Grade Controls	61,000	cy	$5	$305,000	
Riprap Grade Controls (In-Channel Stab., Areas 1-8)	30,500	cy	$50	$1,525,000	
Bank Stabilization Riprap (bank armoring)	7,000	cy	$50	$350,000	
Road Restoration/Grading	10,000	lf	$13	$130,000	
Additional Removals	50,000	cy	$15	$750,000	
Excavation for Additional Removal for Grade Controls	30,000	cy	$5	$150,000	
Riprap for Additional Grade Controls/Bendway Weirs	15,000	cy	$50	$750,000	
SUBTOTAL					$3,960,000
Dam Construction					
Clearing and Grubbing (Dam Footprint)	2,778	cy	$15	$42,417	
Clearing and Grubbing (Reservoir Area)	13,704	cy	$15	$205,556	
Excavation	6,417	cy	$5	$32,083	
Filter Layer (Chimney)	676	cy	$74	$50,309	
Filter Layer (Blanket)	875	cy	$74	$65,161	
Low permeability core	12,500	cy	$35	$440,000	
Embankment Fill	12,500	cy	$14	$169,000	
Embankment Compaction	12,500	cy	$1	$6,250	
Grout Curtain (foundation seepage)	2,100	sf	$57	$119,700	
Seepage Collection (toe of dam)	1	ea	$31,500	$31,500	
Riprap on Dam Faces	4,000	cy	$50	$200,000	
Outlet Works	1	ls	$61,843	$61,843	
Outlet Energy Dissipater	1	ls	$31,200	$31,200	
Emergency Spillway (inc. energy dissipation)	540	cy	$800	$432,000	
Road Surfacing for Crest	159	cy	$13	$2,070	
SUBTOTAL					$1,889,088
Access Road					
Cut for Access Road	24,630	cy	$31	$763,519	
Fill for Access Road	13,148	cy	$10	$131,481	
Road Surfacing	1,511	cy	$13	$19,644	
SUBTOTAL					$914,644
Construction Diversion Ditch					
Ditch Excavation	22,519	cy	$20	$450,370	
Ditch Install (includes compaction, geotext, liner)	1,600	lf	$92	$146,909	
SUBTOTAL					$597,279

TABLE G-6
Alternative E Costs

Preliminary Cost Estimate - In-Stream Stabilization and Removal and Single Moderate Sized Dam

Item	Quantity	Units	Unit Rate	Cost	Total
Subtotal Construction Cost:					**$7,361,012**
Mobilization at	10%			$736,100	
Subtotal				$8,097,112	
CQA	10%			$809,700	
Subtotal				$8,906,812	
Final Design Engineering	10%			$890,700	
Subtotal				$9,797,512	
Contingency at	15%			$1,469,600	
TOTAL CONSTRUCTION COST:					**$11,267,000**
O&M Costs					
One monitoring activity at year 2 (NPV)	1	ls	$43,672		$43,672
One overbank removal activitiy at year 2 (NPV)	1	ls	$69,875		$69,875
Dam O&M Costs					
Dam O&M - NPV sediment removal + operator	1	ls	$310,564		$310,564
Dam O&M - routine maintenance	1	ls	$22,534		$22,534
Present Value of O&M	12.41	PV Factor			$4,246,978
Contingency (15% applied to total O&M cost)	15%	percent			$637,000
Total Dam O&M Cost					**$4,883,978**
In-Stream Stabilization O&M Activities, per year	1	ls	$151,525		$151,525
Present Value of O&M	12.41	PV Factor			$1,880,280
Contingency (15% applied to total cost)	15%	percent			$282,000
Total In-Stream Stabilization O&M Cost					**$2,162,300**
O&M Total Cost					**$7,046,278**
TOTAL ALTERNATIVE COST					**$18,313,278**

Notes and Assumptions:

1. Assume low permeability fill (clay core) is 50% of total dam volume.
2. O&M costs include operator and general maintenance and disposal. Sediment removal based on sediment volume and required cleanout intervals. New structures or improvements not included. Routine maintenance assumed to be a percentage of total capital cost.
3. Some dam construction unit costs pulled from Sup 2 AOA (7100 Dam) costs, and increased for inflation.
4. Quantities calculated for quantity-based unit costs and applied for dam volumes. However, lump sum values (outlet works) were applied a factor of 1.25 to account for larger dam size.
5. Outlet works energy dissipator based on a Type 10 USBR Baffled Outlet.
6. One overbank removal activity in year 2
7. One monitoring activity in year 2

TABLE G-7
New Unit Costs

Note: These are new unit costs specifically developed for this costing exercise. Unit costs developed specifically for Blackbird based on previous construction costs.

Item	Units	Unit Cost	Notes
			Assume 2% per year for 13 years
Clear and Grub (includes haul and disposal)	cy	$300	Updated per Dahle, 2/2009
Clearing and Grubbing (Diversion Structure Footprint)	cy	$15	
Clearing and Grubbing (Reservoir Area)	cy	$15	
Clearing and Grubbing (under road fill prism)	cy	$15	
Clearing and Grubbing (Dam Footprint)	cy	$15	
Finish Grading	sf	$0.20	
Excavation - General (inc. 1 machine, 1 labor)	cy	$5	Updated per Dahle, 2/2009
Excavation - Trench	cy	$20	
Remove and Haul Contaminated Material to Disposal	cy	$15	Updated per Dahle, 2/2009
Backfill - includes haul and place, no compaction	cy	$14	Updated per Dahle, 2/2009
Compaction - dam fill	cy	$1	Estimate per experience
Gravel - backfill/bedding	cy	$60	for bucktail creek
Clay (from Forney) includes hauling, placing, compacting	cy	$35	Updated per Dahle, 2/2009
Riprap (from Napias to PCI)	cy	$46	Updated per Dahle, 2/2009
Riprap (from Napias to West Fork)	cy	$55	Updated per Dahle, 2/2009
Riprap (average cost)	ct	$50	
Road Construction (haul, & place)	cy	$10	Estimate based on site experience
Road Surfacing (production and placement)	cy	$13	Updated per Dahle, 2/2009
Sand, Hauled to site and material cost. Placement cost a	cy	$74	Updated per Dahle, 2/2009
HDPE pipe, 6"	lf	$20	Placed in already-excavated trench
24-inch culvert, installed	lf	$50	Estimate, and checked w/ Dahle 6/2009
Concrete, Hauled to site, rebar, formed and finished.	cy	$800	Updated per Dahle, 2/2009
Overbank Removal for In-stream Stabilization	cy	$15	per Dave Jackson, 2/19/2010, based on Alan Macleod analysis of 2009 costs
48-inch HDPE pipe, installed	lf	$200	Estimated, Means 2007 cost = $89/ft (page 304)
Grouted riprap	cy	$320	assumed rip-rap volume + concrete volume = 1/3 of rip-rap volume
Sediment Removal	cy	$15	
Monitoring Activities	ls	$50,000	total cost of monitoring activies (per occurrence)
Dam Construction			
Slurry Cutoff or Grout Curtain (foundation seepage)	sf	$57.00	See Note 1
Seepage Collection (toe of dam)	ea	$75,600.00	Alternative D - Large Dam
Seepage Collection (toe of dam)	ea	$25,200.00	Alternative E - Medium Dam; See Note 1
Outlet Works	ls	$18,900.00	See Note 1
Outlet Works Trash Rack	ls	$5,040.00	See Note 1
Outlet Works Piping	lf	$252.00	See Note 1
Overflow Spillway	ls	$25,200.00	See Note 1
Overflow Spillway Pipe	lf	$82.00	See Note 1
Outlet works baffled basin (energy dissipater)			
Assume Type 10 baffled outlet			
Concrete	cy	39	
Concrete Cost per cy		$800.00	
TOTAL		$31,200.00	
New Road Construction (in rock/steep slope)			
Excavation (removal, haul and place)	cy	$20.00	From Blackbird Unit Cost
Blasting (can vary greatly)	cy	$11.00	From RSMeans, 2007 (rock blasting)
Total Road Excavation Cost	cy	$31.00	
Dam Diversion Ditch Install			
Determine cost of ditch install (not incl.			
excavation) per LF. Ditch Area = 32.3 sf/lf of ditch length			
Includes: compaction, geotextile, geomembrane.			
Geotextile and Geomembrane include 3' overlap each side.			
Costs:			
Compaction	sf	$1.00	
Geotextile	sf	$0.35	
Geomembrane	sf	$1.20	
Cost per LF:	LF	$91.82	
Instrumentation and Controls	ls	$50,000.00	Costs from M. Brown
Electric Power	ls	$50,000.00	Costs from M. Brown to bring power to the site
Sluice Gate & Electronic Operator	ea	$50,000.00	Costs from M.Brown: $30 K for sluice gate, and $20K for operator
48" Diameter Sluice Gate	ea	$20,400.00	Assumed 48" square sluice gate cost from Means 2007, p. 336 item 35 20 16.26 0150
Concrete Vault Sluice Gate (36" x 36")	ea	$15,100.00	Cost from Means (2007) p. 336 35 20 16.26 0130
Concrete Vault 10' x 18' x 8'	ea	$9.630	From Amcor Precast. Includes entire vault (access, foundation, etc.) plus freight.

Notes:

1 From 7100 Dam Cost Estimate (sheet "Costs to Compare"); AOA 96

2. Unit costs increased for inflation and include installation costs (labor and materials).

TABLE G-8
Quantities

Item	Units	Measurement
Relocated Blackbird Creek Road		
Assumed cut and fill cross-sectional area	ft3/lf	500.0
Upstream Cut Volume		
Alt E Dam		
Total estimated length of road	ft	1330.0
Total Cut Volume	cy	24629.6
Road Surfacing - 20' width, 1ft deep, at length	cy	985.2
Alt D Dam		
Total estimated length of road	ft	4500.0
Total Cut Volume	cy	83333.3
Road Surfacing - 20' width, 1ft deep, at length	cy	3333.3
Diversion Structure C		
Road clear and grub area (assume 2 ft deep)	cy	481
Total estimated length of road	ft	500.0
Total Fill Volume	cy	2920.0
Road Surfacing - 20' width, 1ft deep, at length	cy	370.4
Downstream Fill Volume		
Alt E Dam		
Total estimated length of road	ft	710.0
Total Fill Volume	cy	13148.1
Road Surfacing - 20' width, 1ft deep, at length	cy	525.9
Alt D Dam		
Total estimated length of road	ft	3200.0
Total Fill Volume	cy	59259.3
Road Surfacing - 20' width, 1ft deep, at length	cy	2370.4
Diversion Structure C		
Road clear and grub area (assume 2 ft deep)	cy	151
Total estimated length of road	ft	200.0
Total Fill Volume	cy	1240.0
Road Surfacing - 20' width, 1ft deep, at length	cy	148.1
Dam Diversion Ditches		
Ditch geometry: assume 10' wide, 5' deep.		
Based on side slope topography, excavation		
is approx. 380 ft3/LF.	ft3/LF	380
Alt C Construction Diversion Ditch	lf	200
Alt E Cosntruction Diversion Ditch	lf	1600
Alt D Construction Diversion Ditch	lf	7700

TABLE G-9
Operations and Maintenance Costs

Item	Quantity	Units	Unit Rate	Cost
O&M Costs				
Present Value of O&M	12.41	PV Factor		
(I=7%, n=30 years - PV Factor =12.41)				
Contingency (15% applied to total O&M cost)	15%	percent		
costs for PV and Contingency are included in each alternative cost estaimte				
ALT A: No Action, on-going O&M in Blackbird Creek				
Monitoring every 2 years	1	ls	$50,000	
Split into per year for NPV				**$25,000**
Assume one major cleanup action once every 2 years.				
Assume minor O&M every year.				
Major Cleanup: $750,000 every 2 years.	1	ls	$750,000	
Split into per year for NPV				**$375,000**
Assume a crew of 2 for 1 week for minor maintenance.				
Crew includes 1 equiment operator and 1 laborer.				
Labor:	90	hr		$3,557
Equipment:	45	hr		$3,202
TOTAL Annual O&M ALT A				**$406,758**
ALT B: In-Stream Stabilization				
One monitoring activity at year 2 and year 4	1	ls	$50,000	
NPV= Cost*((1+.07)^-2 + (1+.07)^-4)				**$81,817**
Assume 5% of total capital cost, every 2-years.		2 yr	$303,050	
Total Annual O&M Cost ALT B, 1-yr increments:		1 yr		**$151,525**
one overbank removal activity at year 2 and year 4	1	ls	$200,000	
NPV= Cost*((1+.07)^-2 + (1+.07)^-4)				**$327,267**
ALT C: In-Stream Stabilization and Settling Basins				
Monitoring at year 2	1	ls	$50,000	
NPV= Cost*((1+.07)^-2				**$43,672**
One overbank removal, 2-yrs after construction	1	ls	$100,000	
NPV = Cost*(1+.07)^-2				**$87,344**
ALT C: In-Stream Stabilization O&M				
Assume 5% of total capital cost, every 2-years.		2 yr	$303,050	
Annual O&M (In-stream stabilization):		1 yr		**$151,525**
ALT C: Settling Basins O&M				
Assumed sediment cleanup = 4000 cy - 400 cy				
Annual Sediment Removal costs	3600	cy	$15	$54,000
Annual O&M (Settling Basins):				**$54,000**
ALT C: Diversion Structure O&M				
Assumed diversion structure sediment removal once per year	400	cy	$15	$6,000
Assume no additional cost for sluice gate operator				
Annual O&M (Diversion Structure)				**$6,000**
ALT C: Fence Maintenance				
Assume entire fence needs to be replaced every 10 yrs.				
Total Fence Construction Cost		ls	$67,000	
Every 10 year total replacement		per yr	$6,700	
Assume yearly maintenance (cleanup of debris).				
Assume 2 laborers, 1 day		ls	$634	
Annual O&M (Fence)				**$7,334**

TABLE G-9
Operations and Maintenance Costs

Item	Quantity	Units	Unit Rate	Cost
ALT D: Dam Operation & Maintenance Costs:				
Assume 1 operator, year round, part-time	520	hr	$60.00	$31,200
ALT D: Dam				
For 4000 cy sed/year, assumed cleanout every 25 years				
Sediment Removal	100,000	cy	$15	$1,500,000
NPV of Cost (1+.07)^-25				**$276,374**
Total Annual O&M ALT D				**$307,574**
ALT E: Dam w/ In-Stream Stabilization				
Monitoring at year 2	1	ls	$50,000	
NPV= Cost*((1+.07)^-2	1	ls		**$43,672**
Assumes 1 overbank removal activity 2-yrs after constructio	1	ls	$80,000	
NPV (1+.07)^-2	1	ls		**$69,875**
Assume 32,000 cy sediment removal once every 8 years:	32,000	cy	$15	$480,000
NPV of Cost (1+.07)^-8				**$279,364**
Total Dam Annual O&M				**$310,564**

O&M Activity Assumptions

ALT A
Monitoring every 2 years
One major clean-up every 2 years

ALT B
Monitoring at 2 years and 4 years
Overbank removal activities at 2 years and 4 years after construction
Minor annual O&M of in-stream stabilization structures as a function of capital cost

ALT C
Monitoring at 2 years
One overbank removal activity 2 years after construction
Minor annual O&M of in-stream stabilization structures as a function of capital cost
Settling basin clean out once every 5 years
Diversion structure cleanout once per year
Replace fence every 10 years

ALT D
No additional monitoring
Part time dam operator
Cleanout/sediment removal once every 25 years

ALT E
Monitoring at 2 years
One overbank removal activity 2 years after construction
Minor annual O&M of in-stream stabilization structures as a function of capital cost
Part time dam operator
Cleanout/sediment removal every 8 years

APPENDIX H

SEDIMENT SAMPLING, TESTING AND ANALYSES

Appendix H1 – Technical Memorandum Suspended Sediment Sampling and Testing

Appendix H2 – Results of 2009 Panther Creek Overbank Sediment Sampling and Testing

Appendix H3 – Panther Creek Settling Basin Effectiveness

APPENDIX H1

TECHNICAL MEMORANDUM
SUSPENDED SEDIMENT SAMPLING AND TESTING

Golder Associates

TECHNICAL MEMORANDUM

Date: February 22, 2010 **Project No.:** 943-1595-004.1280

To: Blackbird Mine Site Group **Company:** Golder Associates

From: Rachel Hanson, Paul Pigeon

cc: Cathy Smith, Colby Caywood, Mike Brown

RE: RESULTS OF BLACKBIRD CREEK SUSPENDED SEDIMENT SAMPLING AND TESTING

1.0 INTRODUCTION

Twenty four samples were collected at six different locations along Blackbird Creek, over a six day period in May 2009. The sample identification numbers and sample locations (Figure H1-1) are as follows:

BBSW-01	At the outfall of the lower PCI pond just above the bridge.
BBSW-01A	Downstream of Targeted Stabilization Area (TSA) #5 at Station 60+00, which is 100 feet upstream of the weir.
BBSW-01.5	Upstream of TSA #5 at Station 72+00.
BBSW-02	250 yards below the West Fork Pond Outlet at the main gate.
BBSW-03	Approximately 200 yards above the confluence of West Fork and Blackbird Creeks.
WFPONDINLET	Combined flows of West Fork and Blackbird Creek entering the West Fork Pond.

The Total Suspended Solids (TSS) and Volatile Suspended Solids (VSS) were measured in the initial Blackbird Creek samples. Following these measurements, settling tests were performed on composite samples to evaluate the solids settling rate in the water. Samples were collected throughout the experiment to measure the concentrations of TSS and Total Volitile Solids (TVS) remaining. Additionally, a particles size analysis was performed on the blended water and settled solids after the settling tests to better characterize the solids present in the samples. The results of these tests can be used to aid in the design of sediment controls for Blackbird Creek runoff.

2.0 TESTING PROCEDURES

Settling tests were performed according to the procedures outlined in the Technical Memorandum *Draft Modified Static Clarification Test Method, Blackbird Creek Runoff Water Testing, Blackbird Creek Evaluation Report (BCER)*. Upon receipt at the Golder Water Treatment Laboratory (WTL), TSS and VSS samples were collected from the raw waters after shaking vigorously to re-suspend any settled solids. After re-suspending the solids, the raw waters were combined according to Table H1-1, and the composite water samples were used for the settling tests. The samples were mixed vigorously and an initial sample was collected during mixing using a peristaltic pump. Immediately after mixing, the composite samples were poured into graduated cylinders, and the timed settling tests began five minutes

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later. Samples were collected using a peristaltic pump at 1, 2, and 4 hours after the testing began. When sufficient water volume was available, two depths were sampled. Sample volumes were maximized to achieve low detection limits during solids analysis. Sample times and locations are detailed in Table H1-1. Solids analyses were performed at Energy Laboratories, and the particle size analysis was performed by Hazen Research.

The settling test for B was modified to a 1 L volume as there wasn't sufficient water after raw water sampling for TSS and VSS analysis to perform a 2 L test. During settling test D, the 1 L graduated cylinder leaked. The water in the 1 L cylinder was mixed to re-suspend settled solids and then transferred to a new graduated cylinder. This resulted in variation of sampling time for the 1 L sample.

3.0 RESULTS AND DISCUSSION

3.1 Initial TSS and VSS Sampling

Initial observation of the raw water suggested that suspended solids and turbidity of the samples decreased with time. Samples collected in the beginning of the sampling period were darkly colored and contained many visible solids, whereas samples collected at the end of the period were clearer with very little visible solids.

These physical observations were confirmed by TSS analysis. Results of the TSS and Volatile Suspend Solids (VSS) analysis from the 6-day sampling are presented in Table H1-2. TSS values ranged from 2110 mg/L (BB-3) to 28 mg/L (BB-22). At each sampling location, the TSS decreased over time, suggesting TSS is highest early in the run-off event and then decreases (Figure H1-2). Additionally, as the sampling location moved downstream, TSS typically increased for the same sampling time. Locations BBSW-01A and BBSE-01.5, downstream and upstream of TSA #5, respectively, had similar TSS profiles.

Observed VSS concentrations were much lower than TSS concentrations, ranging from 267 mg/L (BB-3) to less than 10 mg/L. VSS was found to compose between 5% and 20% of the TSS. The VSS profile (Figure H1-3) exhibited trends similar to the TSS profile. VSS decreased over time at each sampling location, and VSS was not detected for BBSW-01, BBSW-01.5, and BBSW-01A at the last sampling time. As the sampling location moved downstream the VSS increased for the same sampling time.

3.2 Settling Tests

Settling tests were performed on six composite water samples, grouped according to the sampling date and time. Visual observations of the composite samples showed the samples collected the earliest (A) were the darkest in color and the most turbid, while the samples collected the latest (F) were the lightest in color and the least turbid. Samples B, C, D, and E fell between the two extremes. For all samples, a small portion of solids settled immediately after pouring into the graduated cylinder.

Results of the settling test, presented in Table H1-3 and Figure H1-4, indicate greater than 80% of the TSS for each composite sample were removed by settling. Most of this removal occurred within the first hour of settling: After 1 hour, the TSS fell to within 10% of the removal efficiency obtained at 4 hours for C and D (Figures H1-5 and H1-6), and to about 15% of the removal efficiency for E (Figure H1-7). TSS continued to settle in E at a much lower rate, until at 5 hours, no TSS was detected.

TVS was measured for all samples, and the initial VSS was estimated using averages based on the initial VSS data. In addition, final VSS concentrations were measured for C and D on the 4 hour samples. VSS was not measured for E and F because TVS was not detected in the composite water, indicating no VSS was present. It was estimated that C contained 26 mg/L VSS and D contained 16 mg/L VSS. VSS removal efficiencies of 9% and 76% were calculated for C and D, respectively. However, because the TSS measurement for C was significantly higher in the duplicate analysis, it is possible the removal efficiency was artificially low. If the ratio of VSS to TSS in the duplicate analysis is used to estimate the VSS in the original TSS analysis, a removal efficiency of 69% is obtained. This suggests that a slightly smaller proportion of VSS than TSS settled during the two tests. The ratio of VSS to TSS remained constant for D during settling at about 11%. The ratio of VSS to TSS for C tripled, from 9% to 27%, suggesting that VSS settled at a slower rate than TSS in C.

3.3 Particle Size Analysis

A particle size analysis was performed on the combined, residual water from the settling tests. The water contained particles ranging in size from 1 to 301 µm. The average particle size was 41.7 µm and 95% of the particles were 151.3 µm or smaller. A summary of the results are shown in Table H1-4.

4.0 SUMMARY

Samples collected from Blackbird Creek over a six day period were analyzed for TSS and VSS. The samples were then combined based on collection date and time and subjected to settling tests. TSS and VSS analysis on the initial water indicated that while TSS and VSS decreased over time at any given sampling location, the TSS and VSS generally increased as sampling locations moved downstream for the same sample time. VSS composed between 5% and 20% of the TSS.

Settling tests showed greater than 80% of the TSS and about 70% of the VSS were removed from the water by settling. The majority of this removal occurred within the first hour of the settling tests. It was also found that the average particle size was 41.7 µm.

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TABLE H1-1
Sample Identification and Schedule for Settling Tests

Sample Location	Sample Date	Sample Time	Sample ID	Composite ID	Experiment Volume (L)	Sampling Depth (in)	Sampling Time (hr)
BBSW-01	05/18/09	21:30	BB-1	--	--	--	--
BBSW-01	05/19/09	16:30	BB-2	A	1	11.7	2
BBSW-01	05/19/09	21:48	BB-3				
BBSW-01	05/20/09	10:30	BB-4	B	1	11.7	2
BBSW-03	05/20/09	13:45	BB-5				
BBSW-01	05/20/09	15:40	BB-6				
BBSW-01	05/21/09	5:55	BB-7	C	1	11.7	4
BBSW-01A	05/21/09	6:10	BB-8				
BBSW-01.5	05/21/09	6:15	BB-9		2	9.4	1 & 2
BBSW-02	05/21/09	6:20	BB-10			11.7	1 & 2
BBSW-03	05/21/09	6:25	BB-11				
BBSW-03	05/21/09	16:45	BB-12	D	1	11.7	4
BBSW-02	05/21/09	16:50	BB-13				
BBSW-01.5	05/21/09	16:55	BB-14		2	9.4	1 & 2
BBSW-01A	05/21/09	17:00	BB-15			11.7	1 & 2
BBSW-01	05/21/09	17:10	BB-16				
WFPONDINLET	05/22/09	15:15	BB-17	E	1	11.7	4
BBSW-02	05/22/09	15:20	BB-18				
BBSW-01.5	05/22/09	15:25	BB-19		2	9.4	1 & 2
BBSW-01A	05/22/09	15:30	BB-20			11.7	1 & 2
BBSW-01	05/22/09	15:35	BB-21				
BBSW-01.5	05/23/09	12:15	BB-22	F	2	9.4	1 & 2
BBSW-01A	05/23/09	12:20	BB-23			11.7	1 & 2
BBSW-01	05/23/09	12:25	BB-24				

TABLE H1-2
Initial TSS and VSS Concentrations in Blackbird Creek Samples

Sample ID	Sample Name	Date and Time	TSS mg/L	VSS mg/L	% VSS of TSS
BB-1	BBSW-01	5/18/09 21:30	2090	168	8.0
BB-2	BBSW-01	5/19/09 16:30	1870	160	8.6
BB-3	BBSW-01	5/19/09 21:48	2110	267	12.7
BB-4	BBSW-01	5/20/09 10:30	1400	112	8.0
BB-6	BBSW-01	5/20/09 15:40	1060	84	7.9
BB-7	BBSW-01	5/21/09 5:55	514	46	8.9
BB-16	BBSW-01	5/21/09 17:10	309	24	7.8
BB-21	BBSW-01	5/22/09 15:33	78	10	12.8
BB-24	BBSW-01	5/23/09 12:25	84	*5*	6.0
BB-8	BBSW-01A	5/21/09 6:10	296	27	9.1
BB-15	BBSW-01A	5/21/09 17:00	163	14	8.6
BB-20	BBSW-01A	5/22/09 15:30	50	*5*	10.0
BB-23	BBSW-01A	5/23/09 12:20	32	*5*	15.6
BB-9	BBSW-01.5	5/21/09 6:15	307	23	7.5
BB-14	BBSW-01.5	5/21/09 16:55	152	13	8.6
BB-19	BBSW-01.5	5/22/09 15:25	40	*5*	12.5
BB-22	BBSW-01.5	5/23/09 12:55	28	*5*	17.9
BB-10	BBSW-02	5/21/09 6:20	220	19	8.6
BB-13	BBSW-02	5/21/09 16:50	54	*5*	9.3
BB-18	BBSW-02	5/22/09 15:20	77	12	15.6
BB-5	BBSW-03	5/20/09 13:45	1660	88	5.3
BB-11	BBSW-03	5/21/09 6:25	146	14	9.6
BB-12	BBSW-03	5/21/09 16:45	56	11	19.6
BB-17	WFPONDINLET	5/22/09 15:15	84	12	14.3

TABLE H1-3
Settling Experiment Results for Blackbird Creek Composite Water

Sample ID	Time	ΔT hours	Depth inches	TS mg/L	TDS mg/L	TSS mg/L	TVS mg/L	VSS mg/L	% TVS of TSS[1]	% TSS Removed	% VSS Removed
Composite A											
Average of Raw - A	--	--	--	--	--	1990	--	214	10.8	--	
BB-A T=0	13:33	0	--	3380	1100	2280	203	--	8.9	0.0	
BB-A T=2hr	15:45	2.12	11.7	297	97	200	39	--	19.3	91.2	--
Composite B											
Average of Raw - B	--	--	--	--	--	1373	--	95	6.9	--	
BB-B T=0	13:33	0	--	2640	1380	1260	132	--	10.5	0.0	
BB-B T=2hr	15:48	2.17	11.7	454	299	155	168	--	108.4	87.7	--
Composite C											
Average of Raw - C	--	--	--	--	--	297	--	26	8.8	--	
BB-C T=0	13:48	0	--	496	236	260	45	--	17.2	0.0	
BB-C T=1hr 800mL	14:53	1	9.4	112	42	70	20	--	28.8	73.1	
BB-C T=1hr 500mL	14:53	1	11.7	121	81	40	25	--	63.5	84.6	
BB-C T=2hr 800mL	15:53	2	9.4	94	44	50	26	--	52.6	80.8	
BB-C T=2hr 500mL	15:53	2	11.7	98	62	36	41	--	114.3	86.2	
BB-C T=4hr	17:53	4	11.7	95	67	28	27	--	95.0	89.2	
BB-C T=4hr	17:53	4	11.7	95	7	88	27	24	30.7	66.2	8.6
Composite D											
Average of Raw - D	--	--	--	--	--	147	--	16	10.9	--	
BB-D T=0	13:48	0	--	308	138	170	40	--	23.6	0.0	
BB-D T=1hr 800mL	14:56	1.05	9.4	109	69	40	23	--	57.2	76.5	
BB-D T=1hr 500mL	14:56	1.05	11.7	98	54	44	25	--	55.7	74.1	
BB-D T=2hr 800mL	15:56	2.05	9.4	81	53	28	24	--	86.8	83.5	
BB-D T=2hr 500mL	15:56	2.05	11.7	98	70	28	28	--	101.5	83.5	
BB-D T=4hr[2]	18:09	2.52	11.7	101	73	28	15	--	54.1	83.5	
BB-D T=4hr[2]	18:09	2.52	11.7	101	69	32	15	4	47.3	81.2	76.0
Composite E											
Average of Raw - E	--	--	--	--	--	66	--	11	16.7	--	
BB-E T=0	14:04	0	--	143	58	85	*0.5*	--	0.6	0.0	
BB-E T=1hr 800mL	15:09	1	9.4	23	9	14	*0.5*	--	3.6	83.5	
BB-E T=1hr 500mL	15:09	1	11.7	43	27	16	6	--	37.6	81.2	
BB-E T=2hr 800mL	16:09	2	9.4	24	4	20	*0.5*	--	2.5	76.5	
BB-E T=2hr 500mL	16:09	2	11.7	25	15	10	*0.5*	--	5.0	88.2	
BB-E T=4hr	19:09	5	11.7	132	130	2	5	--	264.0	97.6	--
Composite F											
Average of Raw - F	--	--	--	--	--	48	--	*0.5*	1.0	--	
BB-F T=0	14:04	0	--	83	38	45	*0.5*	--	1.1	0.0	
BB-F T=1hr 800mL	15:12	1.05	9.4	68	48	20	*0.5*	--	2.5	55.6	
BB-F T=1hr 500mL	15:12	1.05	11.7	47	41	6	*0.5*	--	8.3	86.7	
BB-F T=2hr 800mL	16:12	2.05	9.4	79	77	*2*	*0.5*	--	25.0	95.6	
BB-F T=2hr 500mL	16:12	2.05	11.7	76	74	2	*0.5*	--	25.0	95.6	--

1. For the average value of the raw water, the value recorded is the percent VSS of TSS.
2. The start time for the BB-D 4 hour time point was 15:33.

TABLE H1-4
Particle Size Analysis on Settling Test Residual Water

Cumulative Distribution %	Diameter µm
5	5.6324
10	8.1397
20	11.7806
30	15.0518
40	18.6865
60	30.1232
70	41.1091
80	59.5188
90	98.3602
95	151.2622

FIGURES

LEGEND

WFPONDINLET — TSS SAMPLING LOCATION AND ID

0 2000 4000
SCALE IN FEET

FIGURE **H1-1**
TSS SAMPLING LOCATIONS
NORANDA/BLACKBIRD MINE/ID

Golder Associates

K:\CAD\Projects\1994\9431595\x004\1280\943-1595-004_1152_FH-1_1.dwg | F-H1_1 | Mod: 02/10/2010, 12:32 | Plotted: 02/18/2010, 13:28 | SSimmons

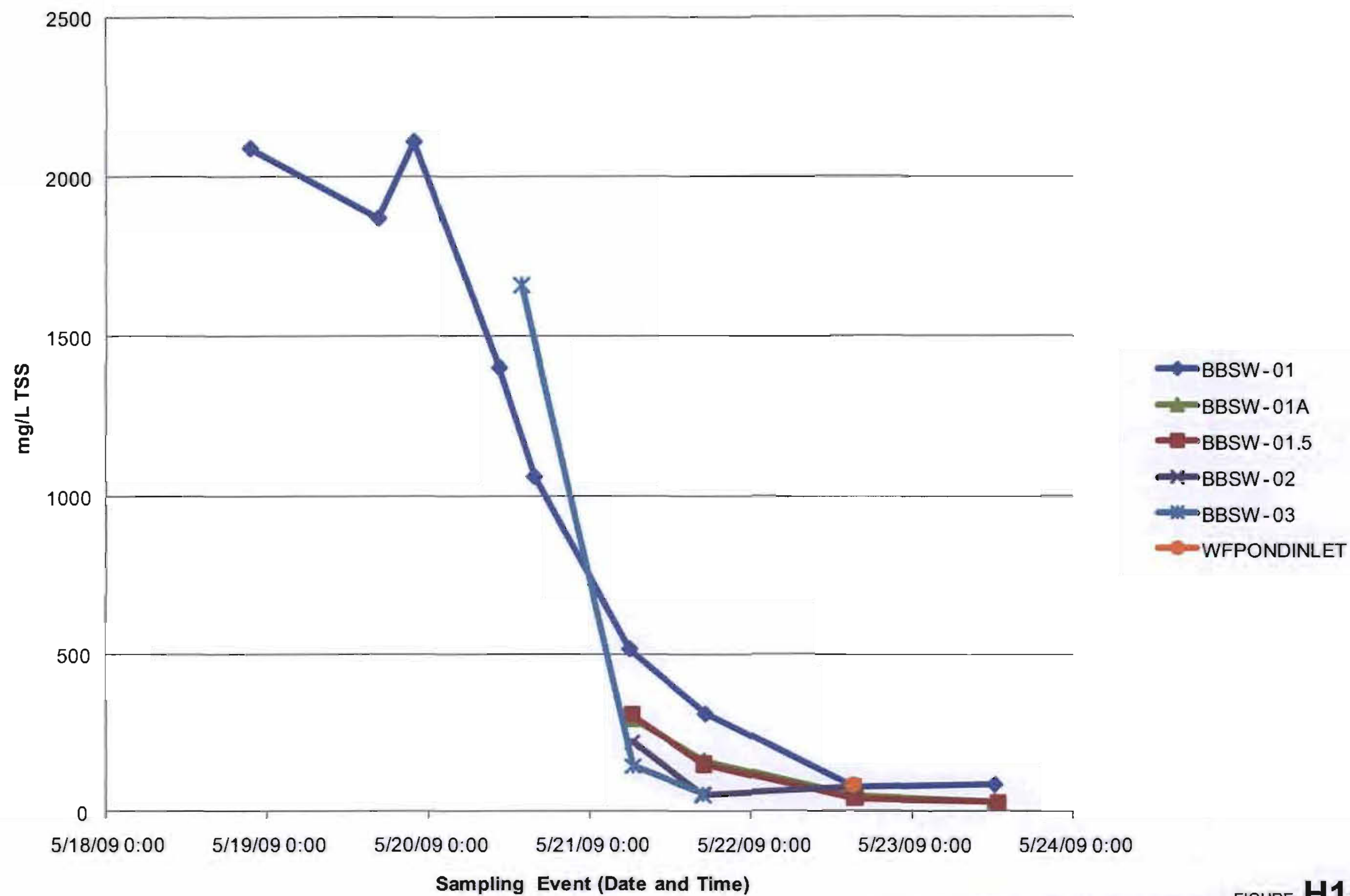

FIGURE **H1-2**

INITIAL TSS IN BLACKBIRD CREEK SAMPLES

BMSG/BLACK BIRD MINE/ID

94315950041280figH1-2.ai | Mod: 02/22/10 | AMP

Golder Associates

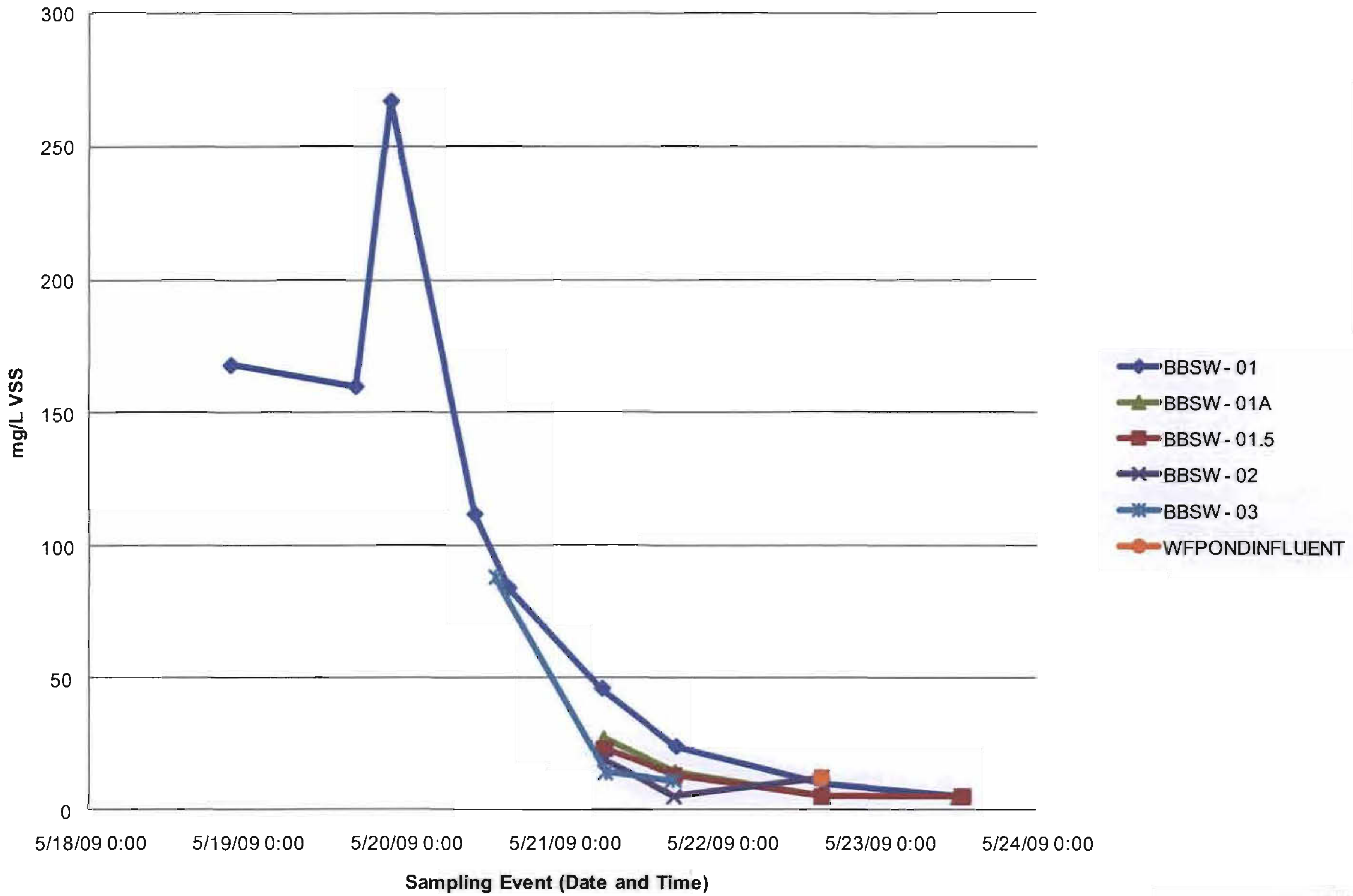

FIGURE **H1-3**

INITIAL VSS IN BLACKBIRD CREEK SAMPLES

BMSG/BLACK BIRD MINE/ID

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Golder Associates

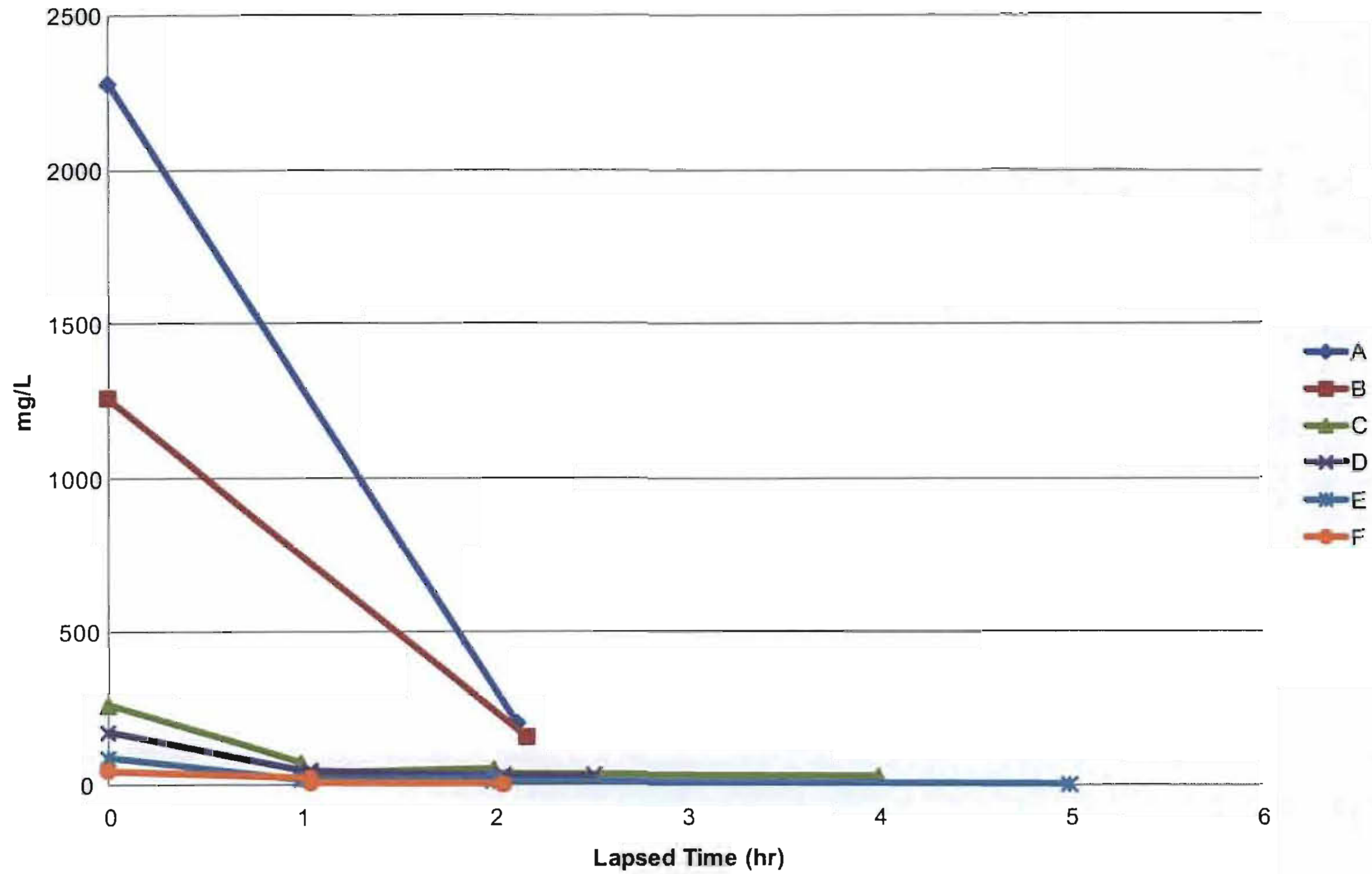

FIGURE **H1-4**

TSS CONCENTRATION DURING SETTLING OF BLACKBIRD COMPOSITE SAMPLES

BMSG/BLACK BIRD MINE/ID

Golder Associates

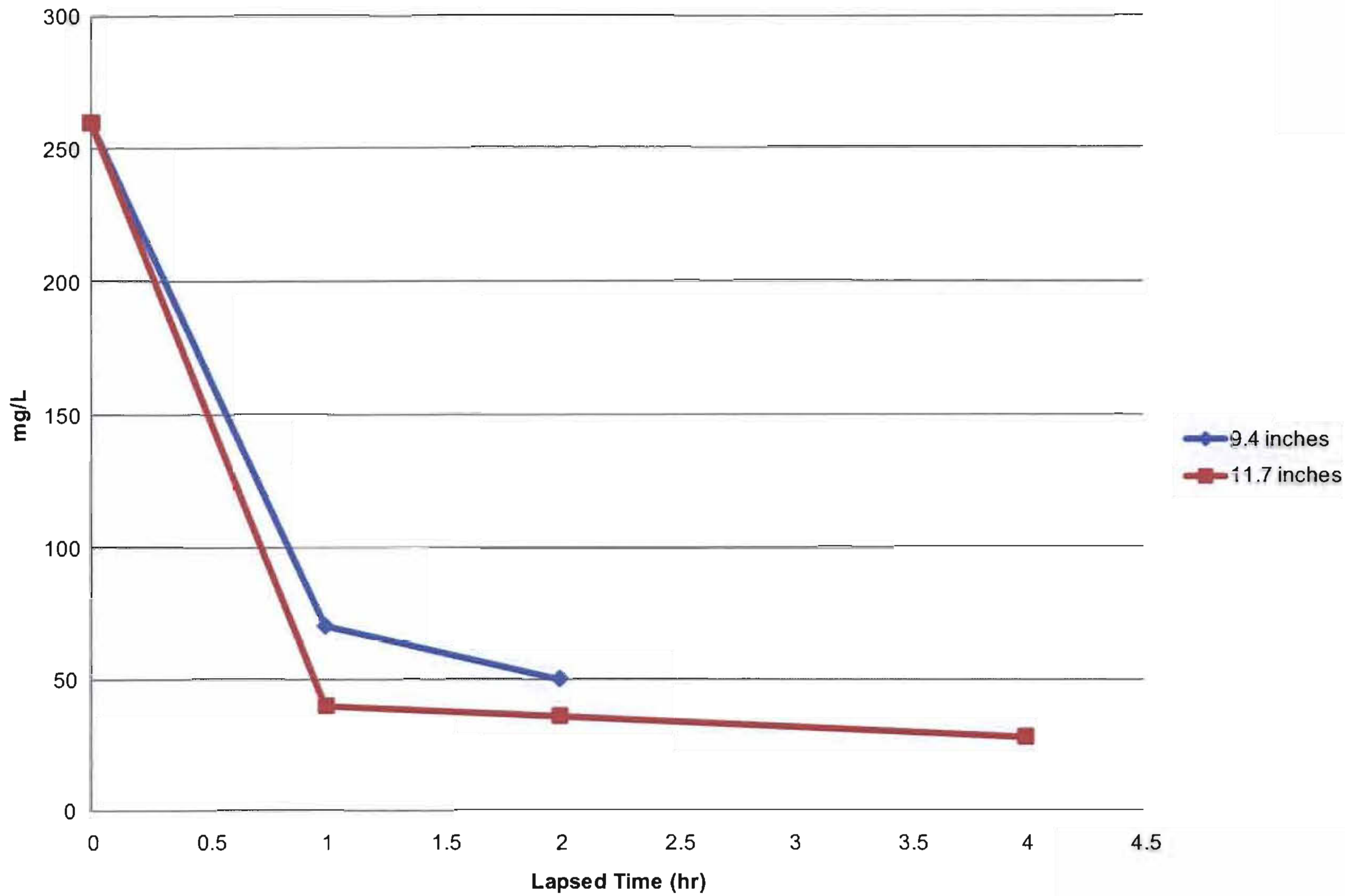

FIGURE **H1-5**
TSS CONCENTRATION DURING SETTLING IN COMPOSITE C
BMSG/BLACK BIRD MINE/ID

943159500041280figH1-5.ai | Mod: 02/22/10 | AMP

Golder Associates

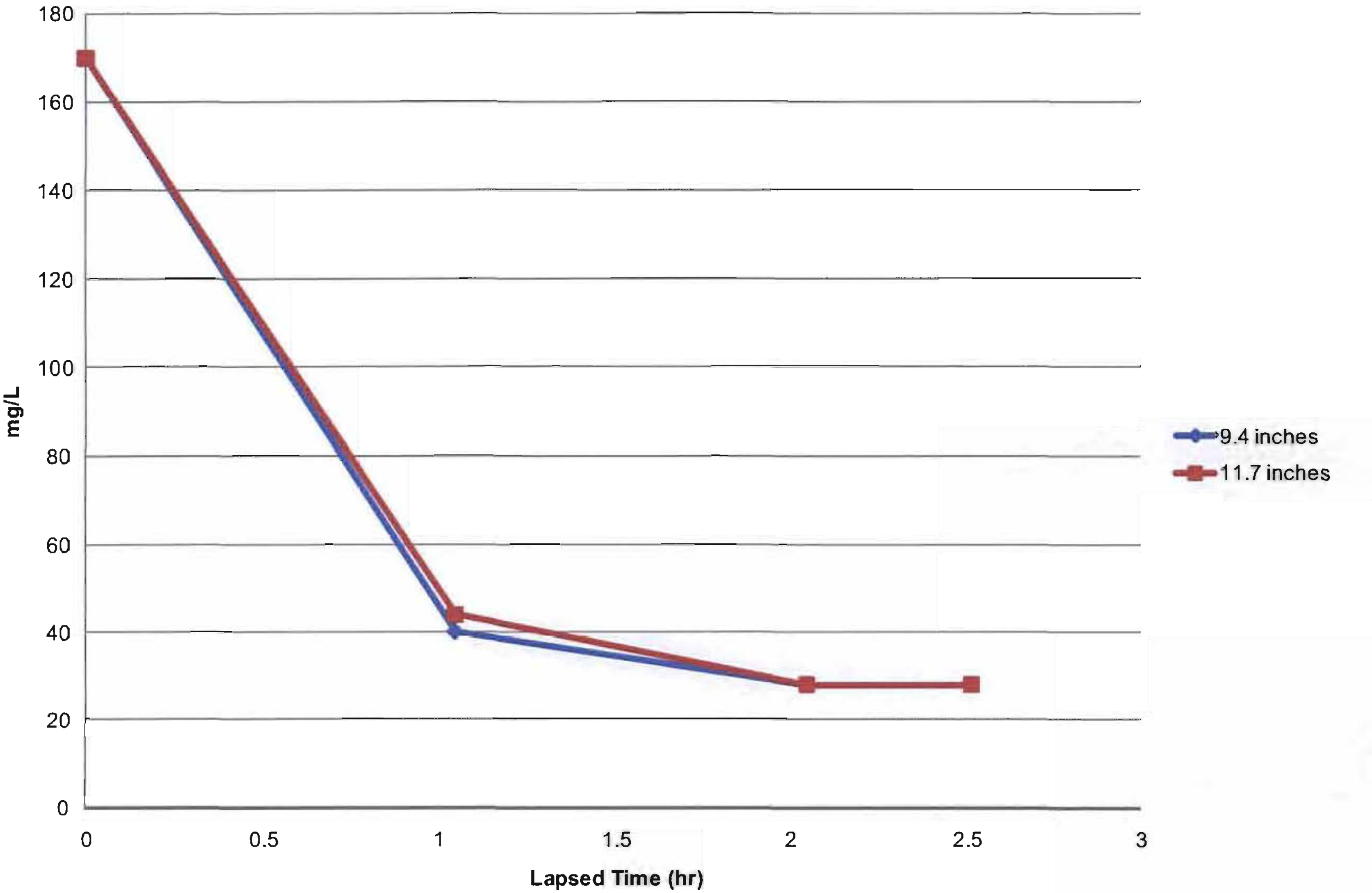

FIGURE **H1-6**
TSS CONCENTRATION DURING SETTLING IN COMPOSITE D
BMSG/BLACK BIRD MINE/ID

94315950041280figH1-6.ai | Mod: 02/22/10 | AMP

Golder Associates

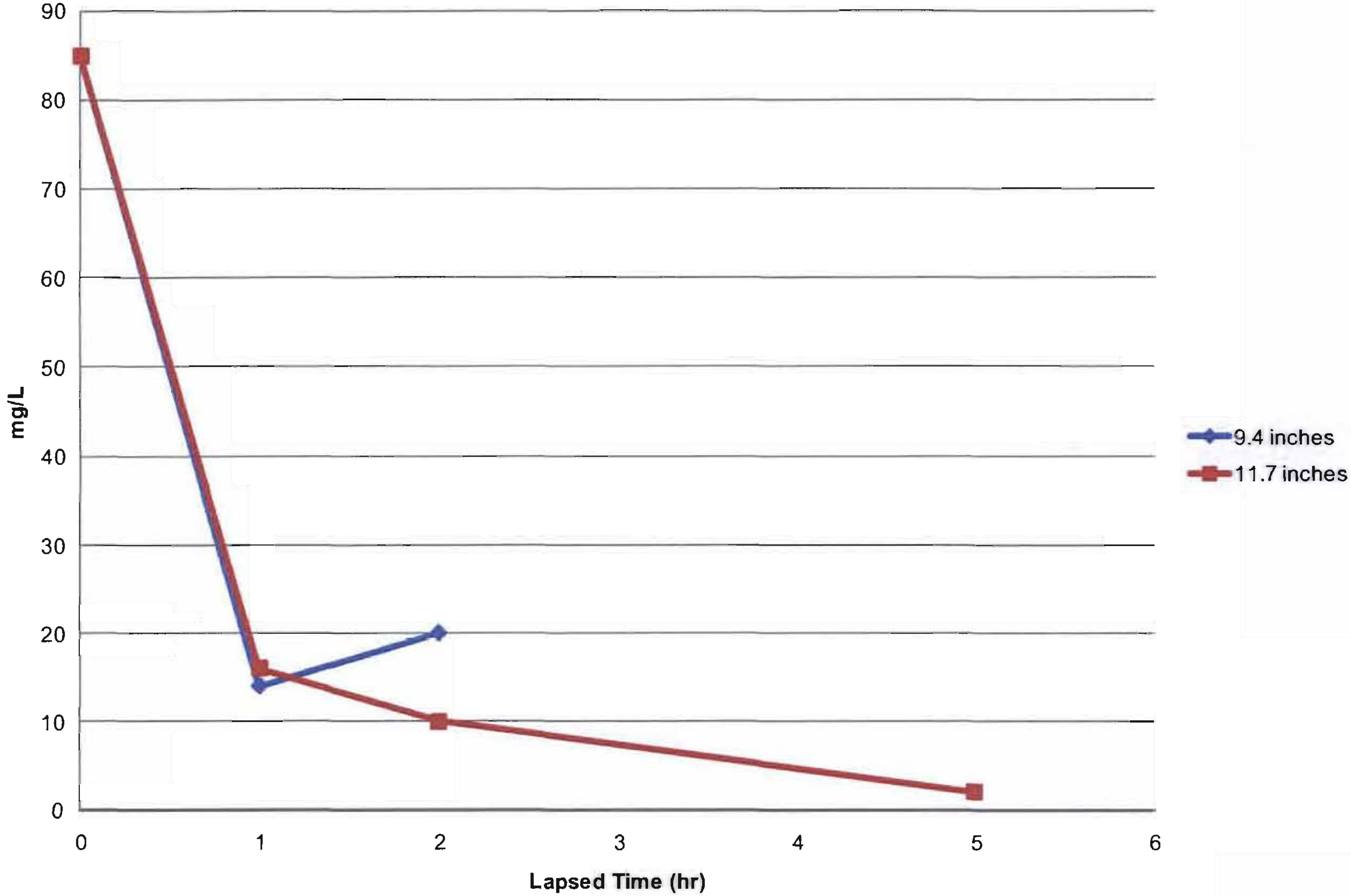

FIGURE **H1-7**
TSS CONCENTRATION DURING SETTLING IN COMPOSITE E
BMSG/BLACK BIRD MINE/ID

APPENDIX H2

RESULTS OF 2009 PANTHER CREEK OVERBANK SEDIMENT SAMPLING AND TESTING

RESULTS – 2009 PANTHER CREEK OVERBANK SOIL/SEDIMENT SAMPLING AND TESTING

Submitted To: Blackbird Mine Site Group

Submitted By: Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052 USA

February 2010

Project No.: 943-1595-004.1280

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1.0 INTRODUCTION

This technical memorandum presents a summary of the results of 2009 supplemental investigative sampling of sediments to further characterize overbank sediments deposited along Panther Creek during the 2008 and 2009 snowmelt runoff event. The investigative sampling was conducted by Golder Associates Inc. (Golder) on September 16, 2009 and was completed in accordance with techniques and procedures described in the *2009 Panther Creek Overbank Sediment Sampling Plan For Supporting Data for the Blackbird Creek Evaluation Report, Lemhi County, Idaho* (Golder, 2009a).

The data obtained from the sampling provides information on the grain size distribution of the overbank sediments that were deposited along the banks of Panther Creek during the spring runoff of 2009, as well as concentrations of arsenic and cobalt in those sediments by grain size fraction. T he objective of collecting this data is to provide information for evaluation of particle settling within settling basin(s) that are being evaluated near the Panther Creek Inn (PCI). The sampling activities are in support of the *Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments* (Golder, 2009b) for the Blackbird Mine Site located near Cobalt, Idaho.

Materials presented include a summary of the supplemental sampling, certified laboratory analytical results, laboratory quality assurance, and an interpretation of the analytical results in support of the Blackbird Creek Evaluation Report.

2.0 SAMPLING

2.1 Sampling Locations

The sample locations are shown on Figure H2-1, which is an overview of the site along Panther Creek. A total of eight locations were sampled in Panther Creek overbank areas between the PCI and the Bevan property. The eight sample locations were selected by a Golder scientist with assistance from CH2M Hill representative Jeff Franklin. Sample locations were spaced along Panther Creek and were selected based on observations of newly deposited (2009) overbank materials. These locations are listed below:

- Along Blackbird Creek near the PCI
- Upstream end of the PCI campground area
- Downstream end of the PCI campground area
- Cobalt Townsite 2
- Noranda Pasture 2
- Rip Rap Bar
- Napias Near Bar
- Bevan Bar Area

2.2 Sampling Methods

From each of the identified sample locations, a total of three grab samples of the observed newly deposited material were collected. Samples were collected to the full depth of recently deposited 2008 and 2009 depositional materials, ranging from less than one inch to four inches thick. The three grab samples collected at each of the sample locations were composited into a single representative sample for each respective sample location. Sample locations were identified in the field by recording on a map and collection of GPS coordinate data to document the sampling point. All composited samples were labeled and sent to the commercial and certified laboratory (Energy Laboratory, Inc. of Billings, Montana) for analysis. The laboratory data are shown in Tables H2-1 and H2-2. An additional summary of the sample locations by GPS waypoint locations is shown Table H2-3.

3.0 LABORATORY TESTING RESULTS - TABULATIONS

The data obtained from the sampling provide information on the grain size distribution of the overbank sediments that were deposited along the banks of Panther Creek during the spring runoff of 2009, as well as concentrations of arsenic and cobalt in those sediments by grain size fraction.

A grain size analysis was performed on each sample consisting of sieves #10, #40, #100, and #200. If more than 5% of the sample was observed to pass the #200 sieve, and that fraction of the sample weighed more than 150 grams, a hydrometer test was run on the minus #200 sieve fraction. Procedures requested by Golder for the laboratory included ASTM D421, D2217, C117, D422, and C136. Certified laboratory analytical methods included ASA-15-2 method (sieve analysis), and ASA-15-5 method (hydrometer). Additionally, each of the eight composited samples collected were selected for laboratory testing of each of the screened fractions for arsenic and cobalt.

The laboratory analysis was performed by Energy Laboratory in Billings, Montana. Analysis for arsenic and cobalt was completed using inductively coupled plasma (ICP) by EPA Method 6010. QA/QC requirements in the RI/FS Work Plan (Golder, 1995) for sample collection, storage, and shipping were applicable to this sampling effort, with the exception of equipment blanks, which were not performed.

4.0 SAMPLE ANALYSIS AND LABORATORY QUALITY ASSURANCE

Laboratory data quality was reviewed for data packages provided by Energy Laboratory, Inc. (ELI) of Billings, Montana. ELI data package #B09091883 represents the September 16, 2009 sample collection task. Quality control data is unique to each data set and an individual assessment was performed in accordance with data validation guidelines (EPA, 2004).

Standard quality control (QC) information includes quality control standard recovery, interference check samples, method blanks, serial dilutions, laboratory control samples, matrix spike, and matrix spike duplicates (MS/MSD), and relative percent difference calculations.

The serial dilution result for sample 'PCI near/@ BB Crk & Panther Creek confluence composite' was observed with an out of limit relative percent difference (RPD) calculation for arsenic. The arsenic value at 12% indicates chemical or physical interferences could exist in the matrix tested and the arsenic value for this sample was qualified as estimated (J qualifier). The serial dilution RPD calculated result for cobalt was within acceptance limits (+/- 10%) and no qualification was applied.

In conclusion, the serial dilution RPD outlier for arsenic indicate chemical or physical interferences could exist in the matrix tested; however qualification of results was limited to those samples tested and found out of limit. The data validator can cite justification for this to include the fact that soils found to be out of limit may be significantly different from the bulk of materials collected from the similar deposited sediments at the PCI near/at the confluence of Blackbird Creek and Panther Creek. Additionally, other associated QC criteria (matrix spikes, and matrix spike duplicates, and other serial dilutions) were found to be within acceptance limits, over multiple days of analysis, and with varying matrices. Therefore, the qualifications were applied to the specific samples that were outside of the acceptance limits.

5.0 DATA INTERPRETATION

The patterns of concentrations of COCs by grain size are presented in Figure H2-2. Analytical chemical testing results indicate that arsenic and cobalt concentrations at each of the eight sample locations generally decrease from upstream to downstream (Table H2-1). However, the results are quite variable and a significant exception exists near the PCI. Samples from the downstream end of the PCI campground have COC concentrations that are low and inconsistent with the declining trend. See Figure H2-3. The samples from locations both upstream and downstream have concentrations that are much higher. This inconsistency may be the result of the incomplete blending of waters and their overbank sediment deposits from both Blackbird Creek and Panther Creek. This may cause the overbank sediments to be segregated due to hydraulic differences during depositions.

Figure H2-3 shows that COCs in the samples are generally 10%-30% from the minus #200 sieve fraction, although variability and an exception is observed. As observed in two samples collected at the PCI Campground, one at the upstream extent and another at the downstream extent, a high proportion (+70%) of the COCs are within the minus #200 sieve fraction when the total COC concentrations are respectively very high and very low. These variations likely resulted from the depositional variability.

A generally decreasing trend was observed for both the overall contaminant concentration and the percent of total COC within the minus #200 sieve fraction in overbank samples (Figure H2-3). This decreasing trend also shows that as sediment progresses downstream from Blackbird Creek, inputs of cleaner, more uniformly distributed grain sized materials are added to the system by side drainages, lowering the contaminant concentrations in associated depositional areas (Figures H2-2 and H2-3). In Figure H2-3, it appears that the percent of total arsenic contained within the minus #200 sieve fraction is increasing from 5.6 miles downstream of PCI to approximately 19 miles downstream of PCI. Conversely, the arsenic load percentage within the same screened fraction is decreasing during this same extent (Figure H2-2).

The soil texture classification assigned by ELI was determined by the associated percent compositions of sand, silt, and clay for each sample location. Physical results, as percent composition of sand, silt, and clay, are presented within Table H2-2. Soil texture classifications were also assigned to each sample collected. The percent composition of sand by sample location was observed to increase from upstream to downstream. Conversely, both percent compositions of silt and clay decreased. A silt(y) texture (Si) was assigned to the samples collected from the three most upstream locations (PCI near/@ BB Crk Confluence, PCI Campground U.S., and PCI Campground D.S.). A silt(y) loam texture (SiL) was assigned to the remaining samples collected from Cobalt Townsite 02 sample location downstream to the Bevan Bar Area sample location.

6.0 REFERENCES

Golder Associates Inc., 1995. Final Report Focused Remedial Investigation and Feasibility Study Work Plan – Blackbird Mine Site, Lemhi County, Idaho. Prepared for Blackbird Mine Site Group, June 1995.

Golder Associates Inc., 2009a. 2009 Panther Creek Overbank Sediment Sampling Plan for Supporting Data for the Blackbird Creek Evaluation Report, Lemhi County, Idaho. Prepared for Blackbird Mine Site Group, August 18, 2009.

Golder Associates Inc., 2009b. Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments. Prepared for the BMSG by Golder Associates Inc. August 21, 2009.

TABLES

TABLE H2-1
2009 Panther Creek Overbank Sediment Samples
Laboratory Results - Sieve Analysis and As & Co Results on Screened Fractions

Sample Location	Along Blackbird Creek near the PCI - Composite							
Sieve Analyis (Sieve Size)	wt % retained[3]	wt (g) retained[2]	As (mg/kg)[1]	As Load (mg)[4]	As Load (%)[5]	Co (mg/kg)[1]	Co Load (mg)[4]	Co Load (%)[5]
No. 10 Sieve (>2.00 mm)	1	0.5	348 J	0.17	0.9	134	0.07	1.1
No. 40 Sieve (>0.425 mm)	10.4	5.2	847 J	4.40	23.8	215	1.12	18.7
No. 100 Sieve (>0.15 mm)	17.4	8.7	694 J	6.04	32.6	217	1.89	31.6
No. 200 Sieve (>0.075 mm)	33.9	16.95	451 J	7.64	41.2	157	2.66	44.5
Pan - Passing No. 200 (<0.075 mm)	37.3	18.65	15 J	0.28	1.5	13	0.24	4.1
Total (Weighted Average in italics)	100.0	50.0	*370.8* J	18.5	100.0	*119.5*	6.0	100.0
Sample Location	PCI Campground U.S. (Upstream Area) - Composite							
No. 10 Sieve (>2.00 mm)	3.5	1.8	21	0.04	0.1	8	0.01	0.1
No. 40 Sieve (>0.425 mm)	0.7	0.4	54	0.02	0.1	30	0.01	0.1
No. 100 Sieve (>0.15 mm)	2.9	1.5	574	0.83	2.5	336	0.49	5.0
No. 200 Sieve (>0.075 mm)	15.8	7.9	1070	8.45	25.2	294	2.32	23.7
Pan - Passing No. 200 (<0.075 mm)	77	38.5	630	24.26	72.2	181	6.97	71.1
Total (Weighted Average in italics)	99.9	50.0	*672.6*	33.6	100.0	*196.3*	9.8	100.0
Sample Location	PCI Campground D.S. (Downstream Area) - Composite							
No. 10 Sieve (>2.00 mm)	42.7	21.4	ND	0.00	0.0	ND	n/a	n/a
No. 40 Sieve (>0.425 mm)	9.2	4.6	15	0.07	7.5	8	0.04	5.1
No. 100 Sieve (>0.15 mm)	4.3	2.2	32	0.07	7.4	25	0.05	7.4
No. 200 Sieve (>0.075 mm)	4.6	2.3	35	0.08	8.7	29	0.07	9.2
Pan - Passing No. 200 (<0.075 mm)	39.3	19.7	36	0.71	76.4	29	0.57	78.4
Total (Weighted Average in italics)	99.9	50.1	*18.5*	0.9	100.0	*14.5*	0.7	100.0
Sample Location	Cobalt Townsite 2 - Composite							
No. 10 Sieve (>2.00 mm)	0	0.0	ISS	0.00	0.0	ISS	n/a	n/a
No. 40 Sieve (>0.425 mm)	4.8	2.4	357	0.86	2.8	174	0.42	5.9
No. 100 Sieve (>0.15 mm)	42.2	21.1	774	16.33	52.9	154	3.25	45.8
No. 200 Sieve (>0.075 mm)	33.4	16.7	572	9.55	31.0	134	2.24	31.6
Pan - Passing No. 200 (<0.075 mm)	19.6	9.8	420	4.12	13.3	121	1.19	16.7
Total (Weighted Average in italics)	99.9	50.0	*617.1*	30.9	100.0	*141.8*	7.1	100.0

Notes:
J - Qualifier applied to value as an estimated value based on a quality control out of limit RPD calculation.
ND - non detection by laboratory analysis; n/a - not available
ISS - Insufficient sample for analysis
1 - Certified Laboratory Reporting Limits (RL): Arsenic = 5 mg/kg, and Cobalt = 5 mg/kg.
2 - Percentage of weight retained for sample by sieve fraction.
3- Weight (g) of sample by sieve fraction, calculated by total weight of sample by weighted percentages of each sieve fraction.
4 - mg/kgT = mg of analyte in this fraction per kg of Total Sample
5 - Load is the percentage of the sieve fraction analyte concentration (mg/kg) per total analyte concentration (mg/kg).

Table H2-1
2009 Panther Creek Overbank Sediment Samples
Laboratory Results - Sieve Analysis and As & Co Results on Screened Fractions

Sample Location	Noranda Pasture 1 - Composite							
Sieve Analyis (Sieve Size)	wt % retained[3]	wt (g) retained[2]	As (mg/kg)[1]	As Load (mg)[4]	As Load (%)[5]	Co (mg/kg)[1]	Co Load (mg)[4]	Co Load (%)[5]
No. 10 Sieve (>2.00 mm)	0	0.0	ISS	0.00	0.0	ISS	n/a	n/a
No. 40 Sieve (>0.425 mm)	1	0.5	190	0.10	0.4	106	0.05	0.9
No. 100 Sieve (>0.15 mm)	62.7	31.4	543	17.02	68.6	120	3.76	61.6
No. 200 Sieve (>0.075 mm)	28.3	14.2	441	6.24	25.1	128	1.81	29.7
Pan - Passing No. 200 (<0.075 mm)	7.9	4.0	373	1.47	5.9	122	0.48	7.9
Total (Weighted Average in italics)	99.9	50.0	*497.1*	24.8	100.0	*122.3*	6.1	100.0
Sample Location	Rip Rap Bar - Composite							
No. 10 Sieve (>2.00 mm)	0	0.0	ISS	0.00	0.0	ISS	n/a	n/a
No. 40 Sieve (>0.425 mm)	0.1	0.1	833	0.04	0.1	189	0.01	0.1
No. 100 Sieve (>0.15 mm)	27.9	14.0	1000	13.95	39.3	146	2.04	26.2
No. 200 Sieve (>0.075 mm)	44.6	22.3	576	12.84	36.2	151	3.37	43.3
Pan - Passing No. 200 (<0.075 mm)	27.4	13.7	632	8.66	24.4	172	2.36	30.3
Total (Weighted Average in italics)	99.9	50.0	*709.9*	35.5	100.0	*155.4*	7.8	100.0
Sample Location	Napias Near Bar - Composite							
No. 10 Sieve (>2.00 mm)	2.8	1.4	606	0.85	5.8	327	0.46	7.7
No. 40 Sieve (>0.425 mm)	4.4	2.2	931	2.05	13.9	304	0.67	11.3
No. 100 Sieve (>0.15 mm)	9.9	4.95	658	3.26	22.1	191	0.95	15.9
No. 200 Sieve (>0.075 mm)	28.1	14.05	491	6.90	46.8	160	2.25	37.8
Pan - Passing No. 200 (<0.075 mm)	54.9	27.45	62	1.70	11.5	59	1.62	27.3
Total (Weighted Average in italics)	100.1	50.1	*294.8*	14.8	100.0	*118.7*	5.9	100.0
Sample Location	Bevan Bar Area - Composite							
No. 10 Sieve (>2.00 mm)	13.1	6.6	6	0.04	1.2	28	0.18	5.8
No. 40 Sieve (>0.425 mm)	47.2	23.6	19	0.45	13.3	52	1.23	38.5
No. 100 Sieve (>0.15 mm)	20.9	10.5	88	0.92	27.2	78	0.82	25.6
No. 200 Sieve (>0.075 mm)	10.4	5.2	195	1.01	30.0	88	0.46	14.4
Pan - Passing No. 200 (<0.075 mm)	8.3	4.2	230	0.95	28.3	121	0.50	15.8
Total (Weighted Average in italics)	99.9	50.0	*67.6*	3.4	100.0	*63.8*	3.2	100.0

Notes:
ND - non detection by laboratory analysis; n/a - not available
ISS - Insufficient sample for analysis
1 - Certified Laboratory Reporting Limits (RL): Arsenic = 5 mg/kg, and Cobalt = 5 mg/kg.
2 - Percentage of weight retained for sample by sieve fraction.
3- Weight (g) of sample by sieve fraction, calculated by total weight of sample by weighted percentages of each sieve fraction.
4 - mg/kgT = mg of analyte in this fraction per kg of Total Sample
5 - Load is the percentage of the sieve fraction analyte concentration (mg/kg) per total analyte concentration (mg/kg).

TABLE H2-2
2009 Panther Creek Overbank Sediment Samples
Laboratory Testing Results - Physical Characteristics

Sample ID #	PCI near/@BB Crk Confluence - Comp (Lab ID # 008)	PCI Campground U.S. - Comp (Lab ID# 005)	PCI Campground D.S. - Comp (Lab ID# 006)	Cobalt Townsite 02 - Comp (Lab ID# 007)	Noranda Pasture 01 - Comp (Lab ID# 003)	Rip Rap Bar - Comp (Lab ID# 004)	Napias Near Bar - Comp (Lab ID# 002)	Bevan - Comp (Lab ID# 001)
Physical Characteristics	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Sand	8	8	ND	16	24	17	16	26
Silt	81	85	91	79	71	76	77	66
Clay	11	6	9	5	5	7	7	8
Texture[1]	Si	Si	Si	SiL	SiL	SiL	SiL	SiL

1 - Energy Laboratory, Inc. Abbreviations - C = Clay, S = Sand(y), Si = Silt(y), L = Loam(y)

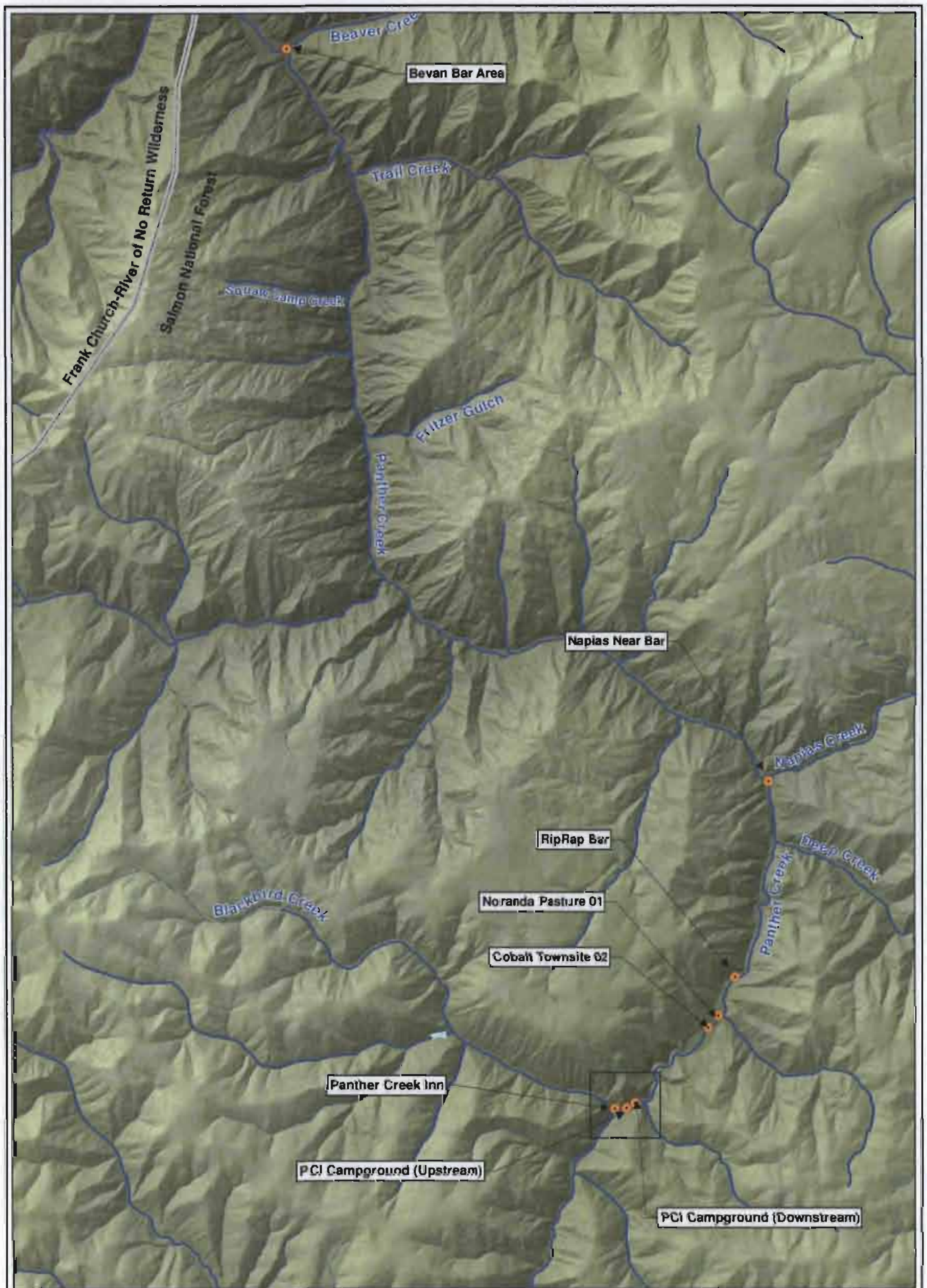
Golder Associates

TABLE H2-3
2009 Panther Creek Overbank Sediment Samples - GPS Waypoint Locations

Location/Sample ID#	Sample Location Description	Longitude (DMS)[1]	Latitude (DMS)[1]
PCI near BB Crk & PA Crk confluence - Composite	PA Crk SED SAMPLE	114°15'35.124"W	45°4'40.974"N
PCI Campground Upstream Location - Composite	PA Crk SED SAMPLE	114°15'24.288"W	45°4'40.999"N
PCI Campground Downstream Location - Composite	PA Crk SED SAMPLE	114°15'15.842"W	45°4'44.113"N
Cobalt Townsite 02 - Composite	PA Crk SED SAMPLE	114°14'5.491"W	45°5'31.813"N
Noranda Pasture 01 - Composite	PA Crk SED SAMPLE	114°13'55.255"W	45°5'39.376"N
Riprap Bar Area - Composite	PA Crk SED SAMPLE	114°13'38.373"W	45°6'4.331"N
Napias Near Bar - Composite	PA Crk SED SAMPLE	114°13'0.586"W	45°8'11.863"N
Bevan - Composite	PA Crk SED SAMPLE	114°20'6.779"W	45°16'25.405"N

1 - DMS = degrees, minutes, seconds

FIGURES



This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

LEGEND

- 2009 Panther Creek Overbank Deposit Sample Locations
- **US National Forest Boundary**

0 — 6000
Scale in Feet

Map Projection:
UTM Zone 11N NAD 1983

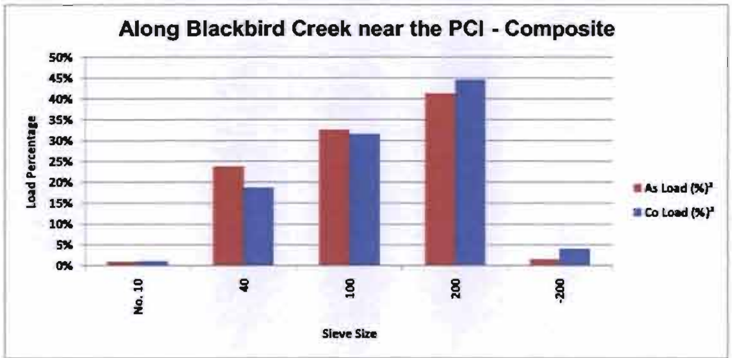
Source:
USGS (10m DEM), ESRI (base data), Golder Associates, Inc.

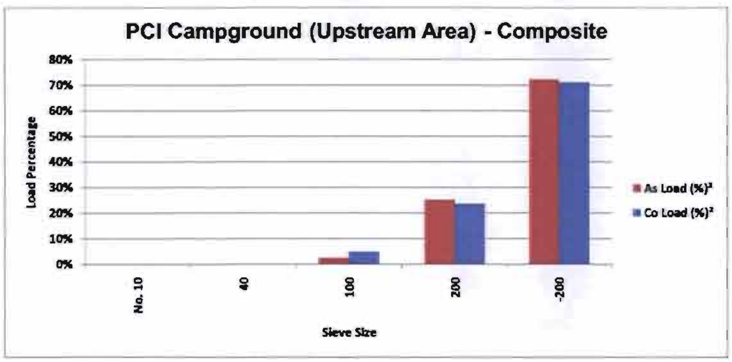
N

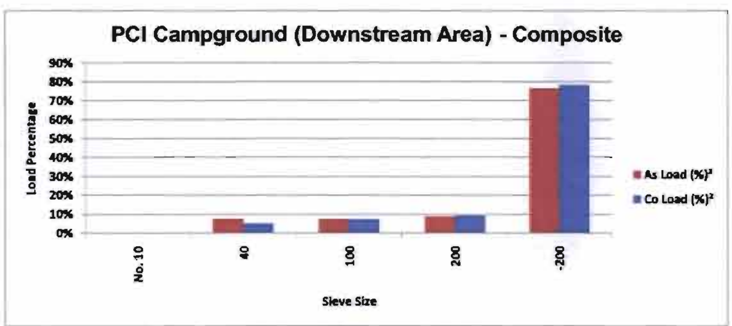
FIGURE **H2-1**
OVERVIEW MAP
BMSG/BLACK BIRD MINE/ID

Golder Associates

Figure H2-2
2009 Panther Creek Overbank Sediment Samples
As & Co Percent Load Results on Screened Fractions







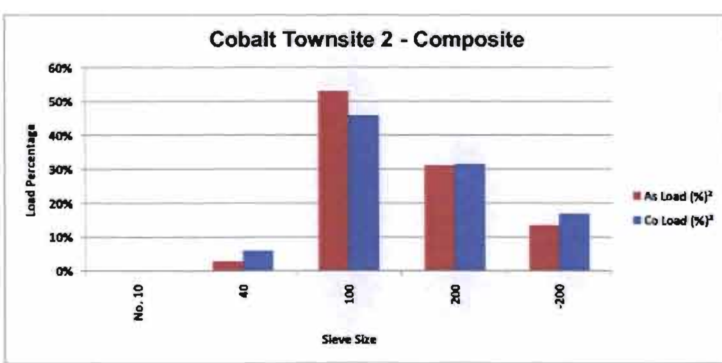


Figure H2-2
2009 Panther Creek Overbank Sediment Samples
As & Co Percent Load Results on Screened Fractions

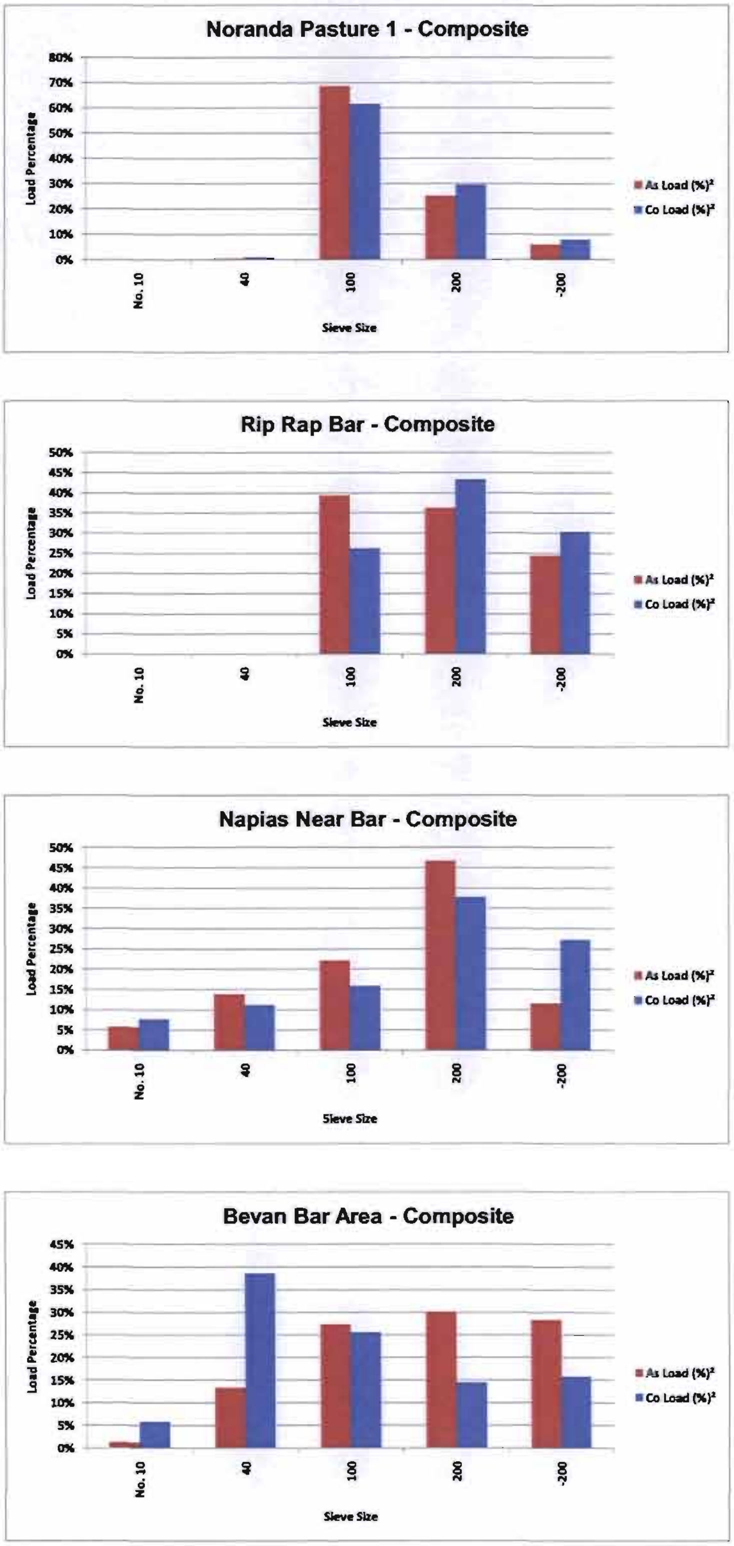
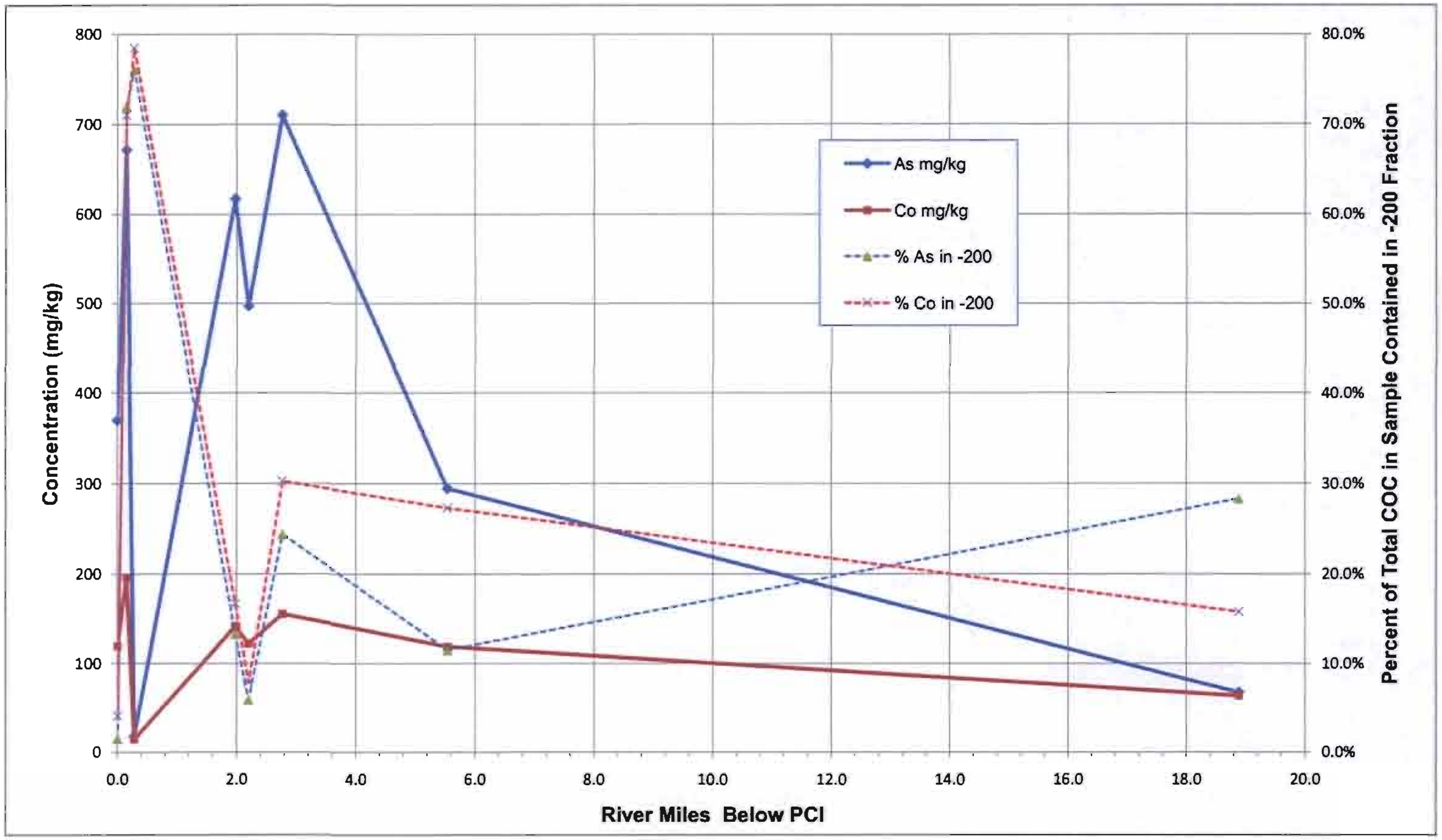


Figure H2-3
Panther Creek Overbank Contaminant Concentration and Percent of Total COC in Sample within the minus #200 Sieve Fraction By River Mile



APPENDIX H3
PANTHER CREEK SETTLING BASIN EFFECTIVENESS

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943-1595-004.1280

Proposed PCI Settling Basins

Suspended Sediment Settlement Estimates

Objectives

Evaluate the ability of the proposed PCI settling ponds to capture suspended sediments

Methods:

Four methods were used to evaluate the ability of the proposed PCI ponds to capture suspended sediments:

1) Shear Stress: Computation of grain size experiencing incipient movement on the pond bottom
2) Standard Tank Capture Calculation: Using settling velocity computed by Stokes Law
3) Observation of Settlement of Floc: The original method based on observed settlement velocity of 4 in./3 min
4) Time to Settlement: Curves based on the Denver Settlement Tests

Assumptions:

Proposed Pond

- Construct diversion on lower BB Creek, convey diversion thru pipe to ponds in the RV park below the old PCI.

Peak Flow =	200	cfs
Area =	174,000	sq ft
Depth =	3	ft

Summary of Results:

Method 1: Shear Stress

- Diameter of particle at incipient movement = 0.0031mm (much smaller than #325 sieve)
- These particles must first get to the bottom of the pond
- These results represent the limit of the particle size that will stay on the bottom without moving

Method 2: Standard Tank Capture Calculation

- Using basic tank theory and Stokes Law
- Diameter of smallest particle captured = 0.025mm (extrapolated from data; ~#500 sieve)
- Corresponding settling velocity = 0.0003 m/sec

Method 3: Observation of Floc Settlement

- Observed velocity = 1.3 in/ min, which equals 0.0003 m/s
- Corresponds to ~#500 sieve

Method 4: Time to Settlement

- Retention Time = ~0.72 hours, based on Denver Settlement Tests
- Percent Solids Removed = ~54%, using the synthesized curve based on data from several tests
- Using the PCI sample only, as a reference, this removes all particles larger than ~#150 sieve
    and 80% of the Arsenic load in the sample
    and 70% of the Cobalt load in the sample

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Proposed PCI Settling Basins | Chk'd by: SLH

Suspended Sediment Settlement Estimates | Date: 2/3/10

Method 1: Shear Stress

- Computing the Particle size that is at incipient motion
- Compute Shear stress for conditions at bottom of pond

Assumptions

- Design flow for ponds is 200 cfs across two ponds, with a total width of 800 ft
- Flow per foot is then 0.25 cfs/ft, n=0.015

Using **Manning's Equation** on a wide rectangular channel, compute Slope for a given depth:

Manning's Equation: $V = k/n\ (A/P)^{2/3} S^{1/2}$

Depth (ft) =	3	ft	
Depth (m) =	0.91	meters	
Velocity =	0.083	fps	[V = Q/A]
Slope =	**1.6651E-07**	ft/ft	[Solved using Manning's equation]
Angle =	1.665E-07	radians	
sine of angle =	1.665E-07	<= note that sine of the angle is approximately equal to slope	
Water Density =	9,807	N/m^3	
Shear stress = τ_o =	0.00149353	N/m^2	$= \gamma DS$ = shear stress on bottom of the pond.

Using **Shields Equation,** estimate the particle size that would be mobilized by this shear stress:

$\tau_c = s(\gamma_s - \gamma_w) d_{50}$ N/m^2 (critical shear stress, causing incipient particle motion)

Shields Parameter (S) =	0.03
γ_w =	9,807
γ_s =	25,989

if $\tau_c = \tau_o$, shear stress on the pond bottom is equal to the critical stress

d_{50} = 3.0766E-06 m

d_{50} = 0.00308 mm

Conclusion:

Diameter of particle at incipient motion is ~0.0031mm (<< #325 sieve)

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Method 2: Standard Tank Capture Calculation

Basic Tank Theory says:

Vs = Settling Velocity of smallest particle removed
Q = Inflow to Clarifier/Tank/Pond
A = Surface area of Pond
Vs = Q/A

Q		A		Vs	
cfs	cms	sq ft	sq m	ft/sec	m/sec
200	5.67	174,000	16,173	1.15E-03	3.50E-04

Stokes Law | **Values**

Fd is the frictional force (in N),
μ is the fluid's dynamic viscosity (in Pa s), = 1.79E-03 at 0 deg C
R is the radius of the spherical object (in m), and
V is the particle's velocity (in m/s)

- If the particles are falling in the viscous fluid by their own weight due to gravity, then a terminal velocity (also known as the settling velocity) is reached when this frictional force combined with the buoyant force exactly balances the gravitational force. The resulting settling velocity (or terminal velocity) is given by:[2]

$$V_s = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} g\, R^2$$

where:

V_s is the particles' settling velocity (m/s) (vertically downwards if $\rho_p > \rho_f$, upwards if $\rho_p < \rho_f$),
g is the gravitational acceleration (m/s^2), = 9.81
ρp is the mass density of the particles (kg/m^3), and = 2650
ρ_f is the mass density of the fluid (kg/m^3) = 1000

Results

- Assuming all particles are spheres:
- Assuming Opening Size is twice the sphere radius.

R =	3.75E-05	m	#200 Sieve = 0.075mm
Vs =	2.83E-03	m/s	<= Computed Settling Velocity of the smallest captured particle.

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Suspended Sediment Settlement Estimates — Date: 2/3/10

Method 2: Standard Tank Capture Calculation

Results

Sieve Number	Opening Size	Radius	Settling Velocity, Vs	Pond Area	Treatable Flow	
#	mm	m	m/sec	sq ft	cms	cfs
4	4.75	2.38E-03	11.35	174,000	183,630	6,479,869
6	3.35	1.68E-03	5.65	174,000	91,337	3,223,062
8	2.36	1.18E-03	2.80	174,000	45,330	1,599,569
12	1.68	8.40E-04	1.42	174,000	22,971	810,583
16	1.18	5.90E-04	0.701	174,000	11,332	399,892
20	0.85	4.25E-04	0.364	174,000	5,880	207,499
30	0.6	3.00E-04	0.181	174,000	2,930	103,391
40	0.425	2.13E-04	0.0909	174,000	1,470	51,875
50	0.3	1.50E-04	0.0453	174,000	732	25,848
60	0.25	1.25E-04	0.0315	174,000	509	17,950
80	0.18	9.00E-05	0.0163	174,000	264	9,305
100	0.15	7.50E-05	0.0113	174,000	183	6,462
140	0.106	5.30E-05	0.00565	174,000	91	3,227
200	0.075	3.75E-05	0.00283	174,000	46	1,615
270	0.053	2.65E-05	0.00141	174,000	23	807
325	0.045	2.25E-05	0.001019	174,000	16	582
400	0.038	1.90E-05	0.000727	174,000	12	415
500	0.025	1.25E-05	0.000315	174,000	5	179

Conclusion:

At 200cfs, the smallest particle captured is ~0.025mm (#500 sieve), with a settling velocity of ~0.0003 m/sec

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Method 3: Observation of Floc Settlement

- Observed Floc settling rate:
  1.3 inches/min = 0.00056444 m/sec

- From Stokes Law Calculations:

Sieve Number	Opening Size		Radius	Settling Velocity Vs
#	mm	m	m	m/sec
4	4.75	0.00475	0.002375	11.4
6	3.35	0.00335	0.001675	5.65
8	2.36	0.00236	0.00118	2.80
12	1.68	0.00168	0.00084	1.42
16	1.18	0.00118	0.00059	0.701
20	0.85	0.00085	0.000425	0.364
30	0.6	0.0006	0.0003	0.181
40	0.425	0.000425	0.0002125	0.0909
50	0.3	0.0003	0.00015	0.0453
60	0.25	0.00025	0.000125	0.0315
80	0.18	0.00018	0.00009	0.0163
100	0.15	0.00015	0.000075	0.0113
140	0.106	0.000106	0.000053	0.00565
200	0.075	0.000075	0.0000375	0.00283
270	0.053	0.000053	0.0000265	0.00141
325	0.045	0.000045	0.0000225	0.00102
400	0.038	0.000038	0.000019	0.00073
500	**0.025**	**0.000025**	**0.0000125**	**0.000315**

Conclusion:

The observed floc settling rate (1.3"/ min, 0.00056 m/s) approximately corresponds to sieve #500 (0.025mm)

1. The observed floc settlement rate was developed based on the procedure outlined in the Sampling and analysis Plan for Blackbird Creek Iron Oxyhydroxide Solids, Golder, 2008. The settleability analysis of the floc was conducted, generally in accordance with the approved SAP. Three samples were placed in 1 liter beakers and stirred. The level of the interface was then measured at varying intervals of time. The first measurement was taken 3 minutes after stirring. At that time the interface levels were at or below the mid-point of the beaker in all cases, and the supernatant was beginning to clear. Further measurements revealed that the interface continued to fall, suggesting consolidation of the solids on the bottom of the beaker with very little further settlement from the supernatant. Assuming the beaker is 8 inches high, we concluded that the settlement velocity of nearly all of the floc was 4 inches in 3 minutes, or greater.

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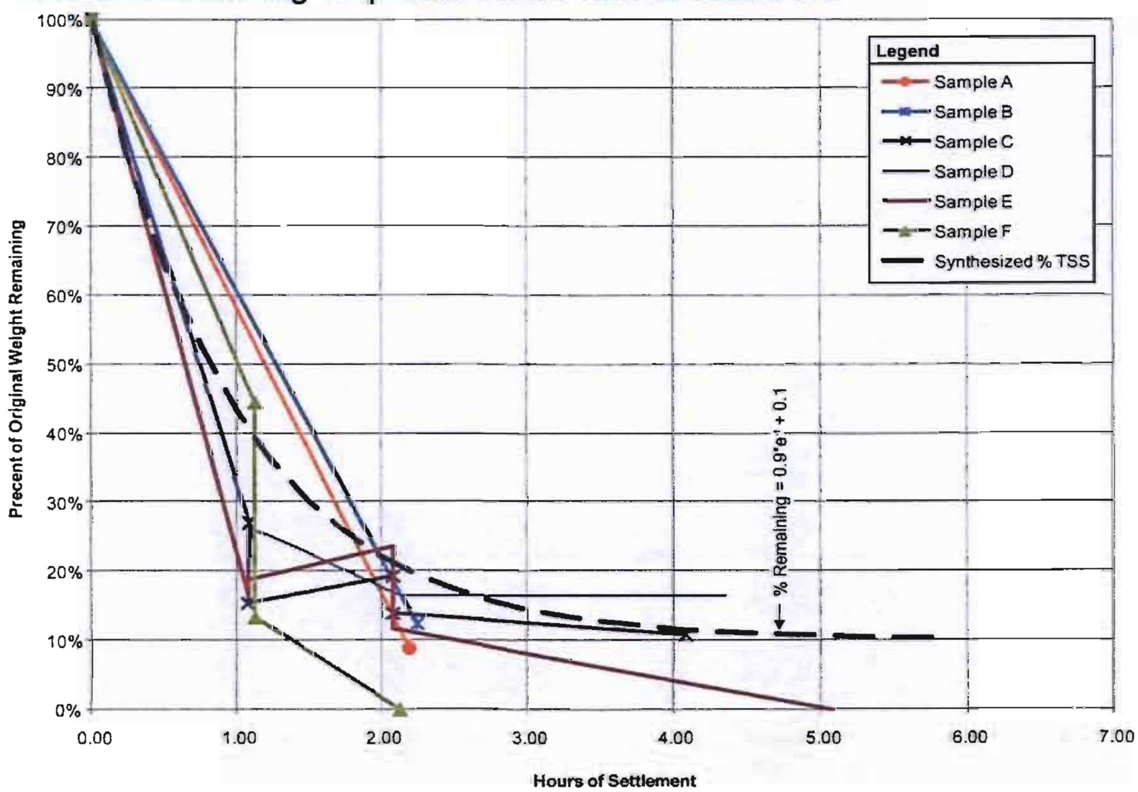
Method 4: Time to Settlement

Area =	174,000	ft^2		
Depth =	3		1	
Volume =	522,000	ft^3		
Qin =	200	cfs		
Retention Time =	2610	sec		
Retention Time =	43.5	min		<= Time that water spends in the settling pond
Retention Time =	**0.725**	**hours**		

- See Settlement chart (Figure 3-4B from the main body of the text)
- Synthesized curve results in the following equation:

% Remaining = 0.9e-t + 0.1
% Remaining = 54%

Total Solids Remaining Suspended versus Time of Settlement



APPENDIX I

TECHNICAL MEMORANDUM
WEST FORK TAILINGS FACILITY GROUNDWATER CALCULATION

TECHNICAL MEMORANDUM

Date: February 22, 2010 **Project No.:** 943-1595-004.1280

To: Blackbird Mine Site Group

From: Cheryl Ross and Cathy Smith – Golder Associates Inc.

RE: SUPPORTING INFORMATION FOR BLACKBIRD CREEK EVALUATION REPORT TO ADDRESS MIGRATION OF BLACKBIRD CREEK SEDIMENTS - ESTIMATE OF WEST FORK GROUNDWATER DISCHARGE

1.0 INTRODUCTION

This Technical Memorandum is an Appendix to the report titled *Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments* prepared by Golder Associates Inc. (Golder) (Golder, 2009). Treatment of West Fork Tailings Impoundment seepage is being considered as a remedial alternative; therefore, an estimate of groundwater discharge from the West Fork Tailings Impoundment to Blackbird Creek was required. To evaluate methods of seepage collection, as well as the effectiveness of seepage collection, the allocation between surface seepage (i.e., shallow groundwater seepage that discharges to the West Fork Interceptor Ditch or the tailings impoundment under drain) and underflow was required.

Based on information presented in the Feasibility Study (Golder, 2002), this evaluation assumed that West Fork Tailings Impoundment seepage discharges to Blackbird Creek at a rate of 100 to 200 gpm. Surface seepage (i.e., shallow groundwater seepage that discharges to the West Fork Interceptor Ditch or the tailings impoundment under drain) was assumed to account for most of this flow, with the contribution from groundwater underflow estimated at less than 10 gpm.

This Technical Memorandum summarizes the evaluations conducted as part of the Feasibility Study to derive the estimate of groundwater seepage/discharge.

2.0 FEASIBILITY STUDY GROUNDWATER FLOW ESTIMATE

The 100 to 200 gpm estimate of total groundwater discharge from the West Fork Tailings Impoundment to Blackbird Creek was presented in the Feasibility Study (Golder, 2002). Three methods were used in this study to estimate groundwater discharge as follows: (1) estimation of total recharge; (2) estimation of groundwater discharge based on the increase in cobalt loading to Blackbird Creek; and, (3) estimation of groundwater discharge from a Darcy calculation (i.e., Q=KiA). The first two methods provide an estimate of total groundwater discharge including both discharge from surface seeps and subsurface discharge. The third method provides an estimate of subsurface groundwater discharge. Each of these methods is described in more detail below.

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2.1 Recharge Estimation

The calculation of total recharge to the West Fork Tailings Impoundment area was presented in Appendix D of the Feasibility Study (Golder, 2002). The maximum total annual recharge to the footprint of the surface of the tailings and the adjacent hillslopes was estimated at 90 gpm, with approximately 17% infiltrating through the tailings and the remainder infiltrating though the hillslopes (supporting calculation shown in Table I-1). This calculation assumed that annual recharge was equal to mean annual precipitation (i.e., the upper bound for infiltration from direct precipitation assuming no runoff or evaporation). The results from this calculation estimate a total of approximately 89 gpm of total recharge to the West Fork Tailings Impoundment area.

2.2 Cobalt Loading Estimate

The approach used to estimate total groundwater seepage from the West Fork Tailings Impoundment to Blackbird Creek based on the increase in cobalt loading between BBSW-03A and BBSW-01A is presented in Appendix F of the Feasibility Study (Golder, 2002). The increase in loading between these stations was attributed entirely to groundwater discharge. Using varying flow rates (1 to 200 gpm), the average cobalt concentration at each flow rate required to result in the observed load difference was calculated. The calculated concentrations were then compared with the average cobalt concentration of the West Fork Tailings Impoundment seepage, 11.5 mg/L, to determine the flow of the seepage. The Feasibility Study estimated groundwater seepage to range from 100 to 200 gpm. This estimate includes both surface and subsurface seepage.

Evaluation of cobalt and sulfate loading data from recent synoptic events indicates that the surface expression of groundwater seepage (i.e., WFTTSW-01 and WFINTDITH) accounts for the majority of the observed loading. Since 2005, there are two synoptic events (i.e., Spring 2006 and 2007) for which flow and concentration data are available for all of the following sites: BBSW-03/03A, West Fork of Blackbird Creek (WFSW-03), WFINTDITCH, WFTTSW-01 and BBSW-02. For these sampling events, the combined sulfate and cobalt load calculated for the upstream stations exceeds the load calculated for the downstream station (Table I-2). The mass loading attributable to groundwater underflow would therefore be zero. Based on these data, it is assumed that the contribution of groundwater underflow is small relative to the amount of seepage that discharges at the surface.

2.3 Darcy Calculation

Darcy's law estimates the groundwater flux across a vertical section using the hydraulic gradient (i), aquifer hydraulic conductivity (K) and cross sectional area (A) (Q=KiA). Based on a Darcy calculation, the report titled *Technical Memorandum Evaluation of West Fork Tailings Impoundment* (Golder, 1998) estimated that the combined groundwater flux within the alluvial and bedrock aquifers at the West Fork Tailings Impoundment ranged from 9 to 15 gpm. A Darcy calculation was performed at each of the wells sited in the vicinity of the West Fork Tailings Impoundment for which adequate information were available. The following data were used in this calculation:

- **Hydraulic Conductivity** – The hydraulic conductivity (K) of the alluvial and bedrock aquifers was estimated based on the results of clean water injection tests conducted by Knight Piésold at WFMW-1S (alluvium), WFMW-1D (bedrock), WFMW-13S (alluvium) and WFMW-13D (bedrock). Hydraulic conductivity estimates are shown in Table I-3. The hydraulic conductivity of the bedrock is estimated to be greater than the hydraulic conductivity of the alluvium. The hydraulic conductivity measured at WFMW-1S was assumed representative of conditions at WFMW-2. The hydraulic conductivity measured at WFMW-13S was assumed representative of conditions at the following wells: WFMW-3, WFMW-4, WFWM-6, WFMW-9 and WFMW-11.
- **Hydraulic Gradient** – The hydraulic gradient was calculated using water level data from the nearest upgradient well. For example, the gradient between WFMW-4 and WFMW-1S was calculated to represent conditions at WFMW-1S.
- **Aquifer Cross Sectional Area** - The width of the valley was assumed to range from 300 feet at WFMW-13S/D to 600 feet at WFMW-1S/1D. For the alluvium wells, the saturated thickness of the aquifer was calculated by subtracting the bottom of screen elevation from the static groundwater elevation. The saturated thickness of the bedrock aquifer at wells WFMW-1D and WFMW-13D was estimated by subtracting the bottom elevation of the bedrock well screen from the bottom elevation of the alluvial well screen and adding 50 feet to acknowledge that groundwater flow is possible below the bottom elevation of the bedrock well screen.

The results of a Darcy flux calculation based on October 1996 water level data are shown in Table I-4. The groundwater flux in the alluvial aquifer is estimated to range from 0.2 to 0.6 gpm. The contribution from the bedrock aquifer is estimated to range from 8.8 to 13.8 gpm. The higher hydraulic conductivity of the bedrock aquifer and greater saturated thickness result in a higher estimate of groundwater flux in the bedrock than in the alluvial aquifer.

The calculation presented in Table I-4 was repeated using June 1995 and September 1995 data. The results for these time periods were similar to those presented in Table I-4.

3.0 SUMMARY

In summary, three methods have been used to estimate groundwater discharge from the West Fork Tailings Impoundment to Blackbird Creek. Estimates based on surficial recharge to the area and observed cobalt loading between BBSW-03 and BBSW-02 indicate that total groundwater discharge is on the order of 100 to 200 gpm. Based on sulfate and cobalt loading evaluations using recent synoptic data (Spring 2006 and 2007), the majority of groundwater seepage discharges to surface prior to discharge into Blackbird Creek. Darcy estimates of groundwater flow also support the conclusion that the majority of groundwater discharges to surface prior to discharge into Blackbird Creek.

4.0 REFERENCES

Golder Associates Inc., 1998. Technical Memorandum – Evaluation of West Fork Tailings Impoundment Blackbird Mine Site, Idaho. Prepared for Blackbird Mine Site Group. March 6, 1998.

Golder Associates Inc., 2002. Focused Feasibility Study for the Blackbird Mine Site, Lemhi County, Idaho. Prepared for the Blackbird Mine Site Group. June 21, 2002.

Golder Associates Inc., 2009. Blackbird Creek Evaluation Report to Address Migration of Blackbird Creek Sediments. Prepared for the BMSG by Golder Associates Inc. August 21, 2009.

List of Tables

TABLES

TABLE I-1
West Fork Tailing Impoundment Recharge Calculation

Contributing Area	Assumptions	Area (ha)	Recharge (inches)	Flow (gpm)
Tailings Impoundment	Surface area includes the West Fork channel Recharge equal to mean annual precipitation	14.4	21.2	15.8
North Hillslope	Recharge equal to mean annual precipitation	25.3	21.2	27.7
South Hillslope	Recharge equal to mean annual precipitation	41.4	21.2	45.3
			Total	**88.7**

Notes:
Source: Golder (2002) - Appendix D
Mean annual precipitation = 21.2 inches/year

TABLE I-2
West Fork Tailing Impoundment Loading Calculation

	Spring 2007 (May 2, 2007)				
	SO_4	Co (D)	Flow	SO_4	Co (D)
	mg/L	mg/L	cfs	kg/day	kg/day
BBSW-03	22	0.073	29.61	1,594	5.3
WFSW-03	3	0.005	35.52	261	0.4
WFTTSW-01	380	3.26	0.13	121	1.0
WFINTDITCH	210	1.63	0.22	113	0.9
BBSW-02	14	0.052	59.67	2,044	7.6
Upstream Load (kg/day)				2,088	7.64
Downstream Load (kg/day)				2,044	7.59
Groundwater Load (by difference) (kg/day)				-45	-0.05

	Spring 2006 (May 16, 2006)				
	SO_4	Co (D)	Flow	SO_4	Co (D)
	mg/L	mg/L	cfs	kg/day	kg/day
BBSW-03A	17	0.055	36.45	1,516	4.9
WFSW-03	2	0.006	46.77	229	0.7
WFINTDITCH	417	3.1	0.18	184	1.4
WFTTSW-01	552	4.06	0.13	176	1.3
BBSW-02	10	0.042	79.32	1,941	8.2
Upstream Load (kg/day)				2,104	8.25
Downstream Load (kg/day)				1,941	8.15
Groundwater Load (by difference) (kg/day)				-163	-0.10

Notes:
Source: Golder (2002) - Appendix F

TABLE I-3
Hydraulic Conductivity of Aquifers

Aquifer Type	WFMW-1S/1D		WFMW-13S/13D	
	Low Estimate (ft/s)	High Estimate (ft/s)	Low Estimate (ft/s)	High Estimate (ft/s)
Alluvium	3.28E-06	1.10E-04	7.87E-07	3.20E-05
Bedrock	9.19E-06	4.40E-04	7.22E-06	7.60E-04

Source: Knight Piesold

TABLE I-4
West Fork Tailings Impoundment Darcy Calculation

Well	Stratigraphic Layer	Northing	Easting	Approx. Valley Width	Top of Casing Elevation	Approx. Ground Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Low Estimate Hydraulic Conductivity	High Estimate Hydraulic Conductivity	Waterlevel Measurement Date	Depth to Water	Static Water Elevation	Nearest Upgradient Well	Distance to Nearest Upgradient Well	Hydraulic Gradient	Layer Saturated Thickness	Area	Low Estimate Groundwater Flux	High Estimate Groundwater Flux
		feet	feet	feet	famsl	famsl	famsl	famsl	ft/s	ft/s		fbtoc	famsl		feet	ft/ft	feet	ft^2	gpm	gpm
WFMW-1S	Alluvium	1,248,933.51	422,548.72	600	5,577.61	5,576.46	5,573.09	5,548.09	3.28E-06	3.61E-06	10/25/1996	1.99	5,575.62	WFMW-4	78	0.018	27.5	16,518	0.4	0.5
WFMW-ID	Fractured Rock	1,248,933.51	422,548.72	600	5,577.97	5,576.46	5,539.63	5,519.63	9.19E-06	1.44E-05	10/25/1996	4.25	5,573.72	WFMW-13D	2,022	0.045	78.5	47,076	8.8	13.8
WFMW-2	Alluvium	1,248,854.64	422,585.60	600	5,589.24	5,584.85	5,568.20	5,548.20	3.28E-06	3.61E-06	10/24/1996	14.9	5,574.34	WFMW-IS	87	0.015	26.1	15,684	0.3	0.4
WFMW-3	Alluvium	1,248,960.39	422,322.27	600	5,654.65	5,651.50	5,583.70	5,548.70	7.87E-07	1.05E-06	10/24/1996	dry	-		-	-	-	-	-	-
WFMW-4	Alluvium	1,248,935.47	422,470.92	600	5,597.60	5,595.10	5,559.58	5,539.58	7.87E-07	1.05E-06	10/25/1996	20.55	5,577.05	WFMW-6	339	0.053	37.5	22,482	0.4	0.6
WFMW-6	Alluvium	1,248,960.02	422,132.43	600	5,711.18	5,709.25	5,589.16	5,564.16	7.87E-07	1.05E-06	10/24/1996	116.04	5,595.14	WFMW-9	475	0.044	31.0	18,588	0.3	0.4
WFMW-9	Alluvium	1,248,889.67	421,662.62	500	5,706.06	5,703.75	5,611.80	5,586.80	7.87E-07	1.05E-06	10/24/1996	90.02	5,616.04	WFMW-11	643	0.054	29.2	14,620	0.3	0.4
WFMW-II	Alluvium	1,248,716.96	421,043.21	400	5,711.73	5,707.64	5,649.62	5,619.62	7.87E-07	1.05E-06	10/24/1996	60.68	5,651.05	WFMW-13S	518	0.041	31.4	12,572	0.2	0.2
WFMW-13S	Alluvium	1,248,496.22	420,574.61	300	5,713.25	5,708.41	5,671.96	5,656.96	7.87E-07	1.15E-06	10/24/1996	40.82	5,672.43		-	-	15.5	4,641	-	-
WFMW-13D	Fractured Rock	1,248,496.22	420,574.61	300	5,713.25	5,708.41	5,649.46	5,629.46	7.22E-06	2.49E-05	10/24/1996	48.08	5,665.17		-	-	77.5	23,250	-	-

Notes:
Source: Golder (1998) - Table 2A
famsl - feet above mean sea level
fbtoc - feet below top of casing
gpm - gallons per minute

APPENDIX J

TECHNICAL MEMORANDUM WATER TREATMENT ALTERNATIVE AT THE WEST FORK

Attachment J1-1 – Costs Tables

Golder Associates

TECHNICAL MEMORANDUM

Date: February 24, 2010 **Project No.:** 943-1595-004.1280

To: Blackbird Mine Site Group

From: Pete Lemke

cc: Cathy Smith, Mike Brown

RE: WATER TREATMENT ALTERNATIVES AT THE WEST FORK

1.0 BACKGROUND AND INTRODUCTION

1.1 Objectives

The objective of this technical memorandum is to identify and evaluate passive and active water treatment alternatives to collect or control the floc deposits that form in Blackbird Creek downstream of the West Fork Tailings Impoundment. The primary objective of the conceptualized alternatives would be to reduce the formation of iron oxy-hydroxide precipitate (floc) downstream of the location where the flow of groundwater from West Fork joins Blackbird Creek. In quantifiable terms, the water treatment objective would be to reduce the dissolved iron concentration in West Fork groundwater by approximately 90 percent, from 200 mg/L influent to 20 mg/L effluent in a flow of 200 gallons per minute before the water would be discharged to Blackbird Creek. Some of the dissolved cobalt and arsenic within the West Fork ground water and Blackbird Creek surface water co-precipitates with the floc and is carried downstream as suspended sediment. So controlling floc (by treating effectively for iron removal) would also control the cobalt and arsenic that is transported by floc.

1.2 West Fork Water Quality Evaluation Basis

The influent evaluation basis for the West Fork Impoundment seepage treatment system is as follows:

- Flow: 100 to 200 gpm
- pH: 4.5 to 6.5 (standard units)
- Iron: 50 to 200 mg/L
- Sulfate: 500 mg/L
- Dissolved Arsenic: 0.150 mg/L

Because alkalinity and total dissolved solids (TDS) can increase the chemical demand in metals removal treatment processes, the concentrations of these constituents were also evaluated; however, these constituents were determined to not have a significant impact on development of conceptual treatment alternatives with respect to chemical demand. The primary parameters for development of conceptual alternatives are flow rate and iron concentration. Conceptual treatment alternatives were developed for the high end of both flow and iron concentrations ranges (200 gpm with 200 mg/L iron).

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1.3 Alternatives Evaluation Process

Evaluation of water treatment alternatives went through several steps as follows:

- **An initial screening of potentially applicable treatment technologies to "retain" or "reject".** Retained technologies were considered technically viable for treatment of an "evaluation basis" flow rate and water quality characterization. Rejected technologies were considered either incapable of handling the flow or of treating water to adequate quality to meet the treatment targets.
- **Development of treatment process trains utilizing the retained technologies.** Treatment alternatives were developed using the retained technologies. Pretreatment steps needed to maximize the efficiency of the retained technologies were added. Post-treatment polishing steps and/or handling of secondary wastes were also added to the process trains as needed.
- **Effectiveness, Implementability and Cost Evaluation of Treatment Alternatives.** The conceptual treatment alternatives were evaluated for effectiveness, implementability and comparison of estimated capital and operations costs.

2.0 PASSIVE TREATMENT TECHNOLOGIES

Several passive treatment technologies were screened for potential applicability to treat the collected West Fork Tailings Impoundment seepage. The passive technologies include: biochemical reactors (BCRs), zero valent iron (ZVI) reactors, iron terraces, aerobic wetlands, and open and anoxic limestone channels (OLCs and ALCs).

Biochemical Reactors. A BCR is a passive treatment technology which typically functions using gravity flow, with minimal O&M. BCRs do not require routine operator attention or chemical addition and may not require electrical power if the site is conducive to a gravity flow-through process. Typical full-scale BCRs resemble bermed ponds and operate as vertical-flow reactors. BCRs employ geochemical and biological processes to reduce metals concentrations and perform pH adjustment of mining influenced waters (MIW). Key processes occurring in BCRs include:

- Biological reduction from sulfate to sulfide
- Precipitation of metal sulfide compounds
- Dissolution of limestone (in the treatment medium)
- Precipitation of metal hydroxides
- Complexation/precipitation of metals with organic material present in the BCR

BCRs typically use locally available, ecologically friendly materials such as limestone, cow manure, wood chips, and hay; are simple to construct, and are designed to operate virtually unattended for decades (Gusek, 2002). BCR effluent water is usually reducing water which contains elevated concentrations of biochemical oxygen demand and total suspended solids. Typically, an aerobic wetland system is used to reduce biological oxygen demand (BOD) and total suspended solids (TSS) concentrations from the BCR prior to discharge.

A BCR could potentially be implemented to reduce iron and arsenic concentrations in the West Fork Tailings Impoundment seepage water. The BCR would likely co-precipitate iron and arsenic on the surface of the reactor, and may precipitate arsenic anaerobically as arsenopyrite within the BCR. This alternative was rejected from further consideration for this site for the following reasons:

- As long as iron and arsenic are the only constituents of concern, a BCR does not provide significant cost or operations advantages over other methods of passive oxidation/precipitation and may produce an effluent that would require further treatment for BOD or TSS.
- The BCR space requirement would be about 5 acres, which exceeds available space near the tailings impoundment.

Zero Valent Iron. ZVI is an adsorption technology that has been used to reduce concentrations of arsenic from MIW. ZVI systems are notorious for clogging issues as the cell matures. Frequently, ZVI cells become clogged within a few months of implementation. A ZVI system would require significant treatability studies prior to implementation, and may provide a limited benefit by removing arsenic but not iron. Since iron is one of the COCs, a ZVI cell is not recommended for the site.

Iron Terraces. Iron terraces are essentially terraces of MIW pools, whose floors and sidewalls are coated in iron precipitation. Microbial populations living in the MIW pools are believed to be responsible for precipitating iron on the pool walls. Volunteer iron terraces have been observed at the Summitville Superfund Site near Alamosa, Colorado. Iron terraces have been shown to have the capability to sequester iron and arsenic from MIW (Leblanc, 1996). The arsenic and iron sequestration mechanisms are understood to be biologically facilitated by microbial populations in the MIW. An iron terrace system could potentially be implemented in the steep hillsides near the West Fork Tailings Facility. An engineered iron terrace treatment system could be based on the observed volunteer systems. However, this technology is considered conceptual at best. Implementation of this concept would require treatability testing to determine the feasibility of this concept and to collect data which could be used to size a system to treat the design flow rate of 200 gpm. Accordingly, there is significant risk associated with this technology and it will not be considered further in this assessment.

Aerobic Wetlands. Passive biological treatment has long been observed and documented in natural wetlands that receive MIW. Constructed wetlands treatment systems can be installed in-situ and require minimal operations or maintenance attention. Wastewater constituent removal is accomplished by three mechanisms: consumption by a microbial population; conversion (oxidation or reduction) of constituents by microbial processes to cause dissolved species to form solid precipitates; and/or sorption on to the organic substrate material. Removal by microbial action can be both anaerobic in the depth of the substrate and aerobic through surface flow. The relatively low velocity flows through a passive treatment system also allow for removal of suspended solids if present. Constructed wetlands treatment is a relatively new technology and is generally applicable to lower flow rate waste streams at remote locations where power and operations personnel are not readily available. The key design parameters are surface area and contact time required to achieve the desired constituent removal level. Passive systems for constituent removal to very low levels may be prohibitively land intensive. The properly designed and constructed wetlands system may operate for up to 20 years with minimal attention, assuming that the influent water quality does not vary significantly over time. Routine maintenance activities may be limited to occasional monitoring of the microbial populations, and addition of micronutrients. Long term maintenance activity may include periodic sludge or solids removal.

Open Limestone Channel - Open limestone channels (OLC) are a proven physical/chemical passive treatment technology. Limestone is used to line a surface water channel which contains MIW flows. When the MIW contacts the limestone in the channel, the pH of the MIW is increased, resulting in precipitating iron (and coprecipitating arsenic) from the MIW. Potential maintenance issues associated with OLCs include the potential for armoring the limestone with iron deposits, which would decrease the rate of limestone dissolution. OLCs typically need to be "recharged" with fresh limestone on at least an annual basis. The length and required slope for adequate dissolution in an OLC for a treatment flow rate of 200 gpm would also be prohibitive, and is therefore not considered further for this assessment.

Anoxic Limestone Channel – An ALC is a limestone channel designed for MIW flows in which ferrous iron is the dominant form of iron present in solution. ALCs are designed to maintain reducing conditions while the MIW contacts the limestone, resulting in less limestone armoring than would be experienced in an OLC. ALCs are typically used in conjunction with a settling pond or aerobic wetland located downstream of the ALC, where the MIW is oxidized to precipitate metal hydroxides. The applicability of ALCs to the West Fork seepage is limited in that additional treatment steps (settling pond or wetland) would be required, and the footprint of the additional pond or wetland would exceed the available land area.

2.1 Passive Treatment Technology Selected For Evaluation

Of the technologies described above, only the aerobic wetlands provide a solution with a realistic probability of success. To assess the potential implementability, effectiveness and cost of passive treatment using an aerobic wetland, conceptual designs were developed for the project site. Dikes that could provide passive treatment ponds were laid out along Blackbird Creek, downstream of West Fork. The resulting series of twelve ponds are shown on Figure J1. The ponds are arranged in two general groups, Ponds 1-7 and Ponds 8-12. The groups are separated by a long reach of Blackbird Creek that is too steep and narrow to allow pond construction. These groups of ponds form the basis for two passive treatment systems that were considered. P1: Ponds 1-7 and P2: Ponds 1-12.

Design and analysis of the performance of the passive treatment system alternatives was done using EPA's modeling tool AMDTreat. Several assumptions were made in the analyses. It was assumed that the winter water temperature starts at approximately 3 degrees Celsius in Pond #1 and is 0.5 degrees Celsius for Ponds #2 through 12. Temperature estimates were made based on review of historical field measurements and 3 degrees Celsius was the lowest temperature recorded. For Ponds 2 through 12, it was assumed that flow would have dwelled in the first pond at a quiescent flow rate and that the water temperature would be reduced to just above freezing (0.5 degrees Celsius). We also expect that the ponds will be covered with an ice layer in the winter. Influent flow would be 200 gpm in all ponds and flow can be maintained through winter with a water temperature of 0.5 degrees Celsius. It was also assumed that the hydraulics would be improved by using several smaller ponds rather than one large pond, and that the chemical portion of iron removal (ferric hydroxide precipitation) efficiency would not be impacted by several smaller ponds. Similarly it was assumed that the biological portion of iron removal (iron sulfide precipitation) efficiency would be slightly increased by several smaller ponds (mimics batch flow).

The results are summarized as follows:

P1: Ponds 1 through 7

- Surface Area: 2.0 acres
- Volume: 4.9 acre-feet
- Iron: 200 mg/L down to ~80 mg/L (~60 percent removal)
- Capital cost: $1,195,000
- Annual O&M Cost: $217,000

P2: Ponds 1 through 12

- Surface Area: 3.5 acres
- Volume: 8.7 acre-feet
- Iron: 200 mg/L down to ~25 mg/L (~87 percent removal)
- Capital cost: $2,234,000
- Annual O&M Cost: $334,000

2.2 Evaluation of Effectiveness, Implementability and Cost

The aerobic wetlands treatment system described above was evaluated against criteria of effectiveness, implementability and cost. Evaluation of effectiveness was focused on the projected contaminant removal efficiency. Consideration of implementability was focused on the constraint of available land area. Cost evaluation included development of order-of-magnitude estimates for capital and long term operations and maintenance (O&M) costs. These evaluation criteria are discussed in more detail in the following sections.

2.2.1 Aerobic Wetlands Effectiveness & Implementability

The influent flow rate from West Fork of 200 gpm produces a required wetland footprint of over 4 acres for complete removal of the iron in the influent. This area is not available, as shown on Figure J1. The largest possible pond system would be less than fully effective in removing iron. As discussed previously, an estimated 10 percent of the West Fork seepage flow would bypass the collection system and enter Blackbird Creek untreated. The best possible passive treatment design would not be fully effective because of the insufficient available pond area and the uncollectable fraction of groundwater/seepage flow. Therefore, at best, the effectiveness would be on the order of 77 percent effective (87 percent minus 10 percent).

Since the passive treatment ponds unavoidably encroach on the Blackbird Creek flood plain, they also increase the risk of inundation of the Blackbird Creek road, due to backwater effects from the encroachment. The inundation of the road increases the risk of road damage. The increased water levels would also result in an increased likelihood of inundating the treatment ponds in areas. This would increase maintenance costs.

2.2.2 Aerobic Wetlands Capital and O&M Cost Estimates

As shown above the cost of implementing passive treatment would include between $1.2 million and $2.2 million, depending on the extent of the ponds constructed, plus an annual O&M cost of approximately $217,000 to $334,000. There is substantial uncertainty in these cost estimates. Estimates for the capital and operation costs are included in Attachment J-1.

3.0 ACTIVE TREATMENT TECHNOLOGIES

Active treatment methodologies considered for seepage from the West Fork Tailings Impoundment include chemical precipitation either in a treatment facility or in a pond.

Active treatment alternatives include collection and conveyance of surface seepage to the active treatment system. Based on work completed as a part of the site Feasibility Study (Golder, 2002a), the groundwater seepage is estimated to represent only a small fraction of the total discharge to Blackbird Creek (i.e., up to 10 gpm), and it is assumed that this water would not be treated. The current evaluation assumes collection and treatment of shallow groundwater flow that currently discharges to surface and flows to Blackbird Creek.

A portion of the arsenic transport in Blackbird Creek is believed to result from coprecipitation with iron and/or adsorption onto iron oxyhydroxide surfaces. Therefore, arsenic and iron are the primary target constituents of concern and other constituents of concern were not considered as part of the water treatment evaluation. Controlled formation of iron floc coupled with isolation or removal of floc from the treated flow is expected to prevent the formation of iron floc and transport of arsenic containing floc in Blackbird Creek. It was assumed that high iron removal efficiency would be required to prevent the formation of floc in Blackbird Creek. The treatment alternatives were developed with assumed capability to reduce the dissolved iron concentration from an influent concentration of 200 mg/L to a projected effluent concentration of 20 mg/L. Given the ratio of iron to arsenic as described above, arsenic is expected to be removed to a trace level. Additional evaluation of water chemistry should be undertaken before definitively projecting the capability of treatment alternatives to reach an effluent target.

The following site constraints and logistical factors were considered in the selection and evaluation of water treatment alternatives:

- **Available Land Area** – Land area available for siting a treatment system is limited. Available area and run length for a sloped inlet channel for pond treatment alternatives must also be taken into account.
- **Excavation Depth** – Treatment alternatives utilizing ponds are limited to an excavation depth of six to eight feet. The excavation depth coupled with the available land area limits the pond volume to approximately 2 million gallons.
- **Extreme precipitation events** – Pond treatment options must account for excess capacity for a design basis storm event. Extreme precipitation has not been accounted for in the current conceptualization of the pond treatment alternatives, and should be considered further if a pond treatment alternative is carried forward.
- **Remote Location** – Location would affect construction, chemical deliveries and waste disposal hauling costs. The treatment alternatives with minimal chemical needs and minimal waste for offsite disposal will be favored in consideration of location. Cost estimates for construction and hauling have been adjusted for remote location.
- **West Fork Tailings Water Collection System** – The location of the treatment process relative to the collection system would affect power consumption (pumping distance and head). The quality of the water provided by the collection system would also have to be relatively consistent. If collected water quality is subject to seasonal variations, the treatment alternatives may need to be more robust to consistently hit the treatment goal.
- **Winter Conditions** – The operability of pond treatment systems would be affected by cold weather. There would be some loss of available pond detention volume to formation of ice in winter. Further loss of operational efficiency in winter would occur due to the increase in floc settling time. A 30 percent reduction in settling efficiency is expected as the water temperature falls from about 50° F to 35 ° F. Consideration of climate will favor the treatment facility alternatives. Existing water chemistry and natural aeration in Blackbird Creek provide the conditions necessary for precipitation of iron floc. The waters of Blackbird Creek, combined with the effluent of the existing WTP and waters from West Fork, provide sufficient iron, alkalinity (while the WTP is operating) and hydroxyl ion concentrations to precipitate iron in hydroxide form in the West Fork seepage when coupled with the natural aeration in Blackbird Creek. In an active treatment system involving West Fork seepage alone, alkalinity and hydroxyl ion concentrations are insufficient for precipitation of iron. Thus, all treatment processes used in the active treatment alternatives include addition of alkalinity in the form of calcium hydroxide (hydrated lime). These processes are developed and discussed in more detail below.

Alkalinity and hydroxyl ion concentration needed for metal-hydroxide precipitation can also be added in the form of sodium hydroxide (caustic). Use of caustic presents several disadvantages in comparison to hydrated lime including the following:

- Caustic is more hazardous to handle and store than hydrated lime. Caustic presents additional storage cost for secondary containment, and presents much greater personnel safety risk when compared with hydrated lime.
- As a 50 percent solution, caustic crystallizes at a temperature of about 55°F. Caustic delivered as 50 percent solution would have to be made down to 25 percent to avoid the risk of crystallizing at relatively mild temperature conditions, or would have to be stored in a heated tank. Making down caustic to 25 percent increases storage volume and

pumping requirements, and storing as 50 percent requires increased utility consumption to prevent crystallization.

- Caustic pricing is quite volatile. Suppliers are unlikely to provide a long-term pricing agreement except at "higher than market" prices. In cases where caustic is a significant part of the annual operating cost, fluctuations in price can result in annual operating budget issues, unless a higher price is paid for long-term cost certainty.
- Because caustic is not used at the existing WTP, delivery of this additional chemical would be required along with safety training for site workers. Hydrated lime is already in use at the existing WTP and site workers are familiar with ordering, delivery and handling.

Due to the relative disadvantages of caustic use in comparison to hydrated lime, active treatment alternatives that would utilize caustic have not been developed. Addition of alkalinity and hydroxyl ion concentration for treatment processes is provided through use of hydrated lime only.

Water treatment alternatives were developed to a conceptual level, using the influent data summarized above. This level of development is appropriate for qualitative comparative evaluation and "order-of-magnitude" cost estimation. The current level of alternatives development should not be considered for any other purpose beyond comparison of alternatives, and recommendation of representative alternative(s) for further evaluation prior to design. The two active treatment alternatives are described below.

3.1 Active Treatment Alternative I - Chemical Precipitation in a Treatment Facility

Chemical precipitation is broadly applicable to treatment of metals that form insoluble hydroxides. Multiple pH steps may be used if multiple metals must be removed. In the case of seepage from the West Fork Tailings Impoundment, the primary constituents of concern are iron and arsenic. A single stage lime addition at pH 9 should remove iron at about 90 to 95 percent efficiency, and arsenic is expected to co-precipitate with iron. It is important to note that removal efficiency is dependent on influent concentration with higher removal efficiencies being generally achievable with higher influent concentrations. The effects of the "complete" water quality matrix must be confirmed prior to making a definitive prediction of treatment efficiency. A chemical precipitation process would consist of:

- Hydrated lime addition in a stirred and aerated tank to form metal hydroxide precipitates
- Clarification to separate a clear (treated water) overflow from a sludge underflow
- Polishing filtration for the treated stream
- Dewatering of the clarifier sludge, producing a high solids cake for disposal and a filtrate stream that is recycled to the lime addition/reaction system

This process would utilize a conventional building and would include influent and effluent storage capacity, and a hydrated lime storage silo. A layout of the proposed facilities is presented on Figure J2. Influent storage would provide surge control, providing a steady flow to the plant even if the collection system is delivering a higher flow rate, on a short-term basis. Influent storage would also allow for brief shutdowns of the plant as needed for scheduled maintenance or unscheduled repair. An influent storage capacity of 36,000 gallons is equivalent to three hours of flow at 200 gpm. Effluent storage may also be utilized if there is a need to recycle effluent that is not fully treated to meet the effluent target. Assuming a real time analytical instrument for iron concentration is used, the effluent tank could be sized for one hour detention, approximately 12,000 gallons.

Hydrated lime would be added to a stirred reaction tank to raise pH and precipitate iron oxyhydroxide (iron floc). The lime would be added in excess of the stoichiometric requirement for complete precipitation of the influent iron concentration as $Fe(OH)_3$ to account for additional metal precipitates and nonreactive grit in the hydrated lime as supplied. The tank would also be aerated, with a blower providing air to a diffuser near the bottom of the reaction tank.

Solids and treated water would be separated in a clarifier. The clarifier may be equipped with coagulant and flocculant addition in a "flash mix" chamber at the clarifier inlet to enhance the settling rate of the iron floc. Clarifier overflow would be polished through a final filtration step.

Clarifier solids would be collected in a cone-bottomed tank and routed to a filter press for dewatering. The cone-bottomed tank would be sized for efficient operations of the filter press, and is run most effectively in batch mode. Filter press cake is expected to be approximately 10 to 20 percent solids. Dewatered sludge would be unloaded from the filter press into a roll-off container. A roll-off container with an underdrain may be used if free water is present.

Characteristics of the dewatered sludge would be determined to ensure that it is suitable for the chosen method of final disposal. The dewatered sludge is expected to be disposed as a conventional solid waste. There would be little if any free water. The dewatered sludge may be disposed onsite at the Blacktail Pit Repository, or in locations currently being used for disposal of sludge generated by the Blackbird Mine Water Treatment Plant. Based on a treated flow of 200 gpm and treatment for 200 mg/L iron, the annual estimated sludge volume generated by this treatment alternative is 26,000 cubic feet (963 cubic yards). Using a roll-off container with a capacity of 40 cubic yards for storage and hauling of sludge, one container would be filled every two weeks.

Decant from the cone-bottomed tank and the filter press filtrate may be returned to the treatment facility headworks or to the polish filter. A collection tank and pumped transfer of collected decant and filtrate would be required.

3.2 Active Treatment Alternative II – Hybrid Chemical Precipitation

Hybrid chemical precipitation would utilize a combination of active and passive treatment unit operations. The addition of hydrated lime for the metal-hydroxide precipitation reaction would be carried out as an active treatment step, in a reaction tank. Aeration to increase the efficiency of the precipitation reaction would also be an active step. Clarification would be carried out passively in a settling pond. The hybrid chemical precipitation would consist of the following:

- **Hydrated Lime Addition** - Lime addition would be automated and flow-proportional with the addition point being in a reaction tank similar to the tank described in Alternative I. Adding lime in this manner allows for optimum mixing and reaction to efficiently carry out the metal-hydroxide precipitation step of the process. Excess lime (above the reaction chemistry indicated by pH and iron concentration) would be added to ensure complete reaction. Ancillary equipment would include a hydrated lime storage silo.
- **Aeration** – The lime addition and reaction tank would be aerated as described in Alternative I. Additional active or passive aeration could be achieved at the pond inlet through aeration equipment or a turbulent flow path (e.g. waterfall or sloped baffled inlet channel).
- **Parallel Settling Ponds** - Precipitated solids (iron floc) would be allowed to settle out to the bottom of ponds, allowing a clarified, treated overflow as an outlet (effluent) flow. Two or more ponds in series and/or parallel configuration may be used to improve solids removal by settling and to allow for sampling and pump-back recycle if iron removal is found to be inadequate. The settled solids would require removal after a period of years to maintain pond retention volume for settling. Parallel ponds would allow sludge clean out to occur without interrupting the treatment operation.
- **Polishing** – Polishing could involve additional detention time for improved settling, or a passive filtration step. If the available land area allows, a polishing pond providing additional quiescent detention could be used. Another option would be installation of a silt curtain near the pond outlet. A silt curtain would act as a passive filter, trapping any unsettled precipitates from the water column, but would require periodic maintenance (removal for cleaning). The parallel pond configuration again would facilitate continuous operation even when silt curtain maintenance was required.

There is potential to accomplish the lime addition by passive means, rather than the active reaction tanks as described above. If sufficient land area is available, a limestone channel could be constructed at the settling pond inlet which would also serve for lime addition, aeration and reaction. Disadvantages of open limestone channels include less efficient lime dosing due to limestone armoring, and the need to replace the limestone either when it is consumed or completely armored (unavailable for dissolution into the inlet flow).

Pebble quicklime could also be added through use of a passive dosing system. The Aquafix system delivers a flow-proportional dose of pebble quicklime through use of a water-wheel, powered only by the flow of the receiving water. The clear advantage to this system is its power self-sufficiency which avoids the need for installation of electrical power lines in a remote location, or placement of a diesel-fueled generator.

Limitations on the effectiveness of passive lime addition are the availability of hydraulic head and space, which impact dissolution and reaction of pebble quicklime.

- Hydraulic head is needed for adequate mixing, to facilitate the precipitation reaction between lime and dissolved constituents of concern. While the manufacturer claims that pebble lime is highly reactive, it is less reactive than either lime in slurry form or liquid sodium hydroxide (caustic). More vigorous mixing is required with pebble lime to achieve a complete reaction. Unreacted pebble lime would accumulate and may eventually become "armored" rendering it inert. Armored pebble lime would consume available flow area in channels. It would also occupy sludge accumulation volume in ponds. If head is inadequate to generate a turbulent flow, pebble lime would be less effective. Designing a labyrinthine flow path would increase contact time, but would also result in a less turbulent flow.

- Space is needed for reaction time and accumulation of sludge. In order to minimize long term operations cost, the available space is optimally utilized with a minimum-size reaction volume and maximum sludge storage capacity. Minimized reaction time may be achieved through use of a powered mix tank and addition of lime slurry. Minimized reaction time also provides maximum settling time in the remaining available space. Better separation of the precipitated solids from the water column would occur, which in turn minimizes the potential of a downstream release in an upset condition.

Other limitations of a passive dosing system include:

- Changes in flow rate directly affect the residence time and may result in lower metal removal rates. If a water treatment alternative is selected to address the migration of Blackbird Creek sediments, and must operate with a high degree of reliability (consistently meeting human health or aquatic life water quality standards) a fully passive system may need to be sized to account for occurrence of a worst case (high) flow rate. This limitation then ties back to available space.
- Changes in temperature affect the rate of reaction and may result in lower metal removal rate at low water temperatures. Again, a fully passive system may need to be sized to account for worst case lower rate of reaction during the cold season(s).

In evaluation of the Aquafix system as part of the Superfund Innovative Technologies Evaluation (SITE) program, a rock drain specifically designed to promote dissolution of pebble lime was found to be inadequate, and an aerated mix tank with two settling tanks had to be added to the system. Residence time in the powered system downstream from Aquafix addition of pebble lime was documented at 96 hours. With a less efficient, fully passive mixing and reaction configuration, the residence time could be significantly longer and is likely not achievable in the space available for treatment of the West Fork flow into Blackbird Creek.

While the advantage to Aquafix is clearly its self-powered lime feeder with no requirement for external utility power, the limitations which directly affect the treated water quality include head, space, flow variation and temperature variation. Flow and temperature variation may be accommodated in design, if space is available for both reaction time and sludge accumulation. Surface area and head limitations constraints are more difficult to overcome while maintaining a fully passive treatment approach. At the current level of alternatives evaluation, if the water treatment system must consistently meet metals removal targets, success is more probable with a hybrid chemical precipitation treatment system rather than a purely passive treatment system.

The hybrid system eliminates the need for clarification equipment, polishing filtration equipment and sludge dewatering by simply accumulating solids at the bottom of the pond. However, the pond must be adequately sized for detention time and settling of precipitates. A layout of the proposed facilities is presented on Figure J3.

The land area required for a settling pond would utilize approximately one acre and an excavation depth of eight feet. By current estimate, settled precipitates would have to be removed from a pond of this capacity once a year. The winter operations efficiency is estimated at 70 percent of warm weather operations efficiency, due to loss of pond capacity to ice formation and increased floc settling time in cold water. The capacity of this pond does not include freeboard for containment of a storm event.

Sludge would be allowed to accumulate for one year and would reach a depth of one foot settled at the pond's bottom. The total volume of sludge would be approximately 1,600 cubic yards. Accumulated sludge could be removed from the pond as a slurry through use of a trash pump, and could be held in frac tanks or roll-off containers to drain. Frequency of pond cleanout may be determined by the laydown area available for draining the pond sludge. If available space for placement of tanks or roll-offs is a limiting factor, then cleanouts may have to be more frequent. The laydown area could be located adjacent to the pond and sloped such that water released from the sludge would drain back into the pond. A mobile filter press could also be used for annual campaign-style dewatering of the pond sludge if gravity drainage is not practical.

Pond sludge volume is expected to be greater than the sludge volume generated by the active treatment plant alternative. Pond operating conditions (uncontrolled cold temperature, windborne dust and dirt) would require use of excess lime to ensure adequate removal of iron, which would generate more sludge.

Similar to sludge generated by the active treatment process alternative, characteristics of the pond sludge would be determined to ensure that it is suitable for the chosen method of final disposal. The dewatered sludge is expected to be disposed as a conventional solid waste. There would be little if any free water. The dewatered sludge may be disposed onsite at the Blacktail Pit Repository, or in locations currently being used for disposal of sludge generated by the Blackbird Mine Water Treatment Plant. Based on a treated flow of 200 gpm and treatment for 200 mg/L iron, the annual estimated sludge volume generated by this treatment alternative is 43,000 cubic feet (1,600 cubic yards). Using a roll-off containers with a capacity of 40 cubic yards for storage and hauling of sludge, one annual campaign would require the use of 40 roll-offs.

The primary advantages of the hybrid chemical precipitation treatment system are a more environmentally friendly appearance, and being a low tech, and low maintenance alternative to a fully active treatment facility. However, the low maintenance benefit is inversely proportional to pond size (larger ponds are lower maintenance). A pond that is sized for several years (typically five or more) of solids accumulation before cleanout is necessary has a maintenance cost advantage, while a pond that is sized for one year of solids accumulation is somewhat less cost effective with respect to maintenance.

3.3 Evaluation and Comparison of Active Water Treatment Alternatives at the West Fork

The following sections evaluate the active and hybrid treatment alternatives with respect to three criteria: effectiveness, implementability and costs.

3.3.1 Active Treatment Alternative I - Chemical Precipitation in a Treatment Facility

3.3.1.1 Effectiveness

Given the evaluation basis influent chemistry, chemical precipitation is expected to consistently meet the goal of removing dissolved iron and preventing the downstream formation of iron floc. While the current evaluation is focused on iron and arsenic removal, the chemical precipitation alternative is expected to provide removal of copper and cobalt as well. Efficiency of removal cannot be estimated without more in-depth analysis of water chemistry and bench studies.

Chemical precipitation is a widely used and conventional treatment for MIW and is very reliable. Future modifications would only be required if changes occur to the flow rate or water chemistry. O&M labor would be required on a daily basis for process control monitoring and batch-wise operation of the filter press. Permanence of this alternative can be tailored to project requirements, with mobile equipment for short-term operation or more permanent construction for long-term operation. Generation of sludge as a secondary waste is estimated at 3 cubic yards per day, requiring hauling a 40-yd roll-off approximately once every two weeks. Lime consumption would be approximately 1,200 pounds per day. Floc associated with the surface expression of seepage from the West Fork Tailings facility would be virtually completely removed from Blackbird Creek. A chemical precipitation facility could be designed and constructed in approximately one year.

3.3.1.2 Implementability

Construction and equipment installation uses conventional construction methods; no special or unique construction is anticipated. The treatment facility building has an estimated footprint of 3,600 square feet and should be easily sited in the West Fork area. The remote location would present a level of complexity to construction but is not insurmountable. The effectiveness and reliability of the treatment process should be considered favorable to agency representatives, and the removal of metals sludge from the site effectively eliminates the potential for iron floc formation. Monitoring could be highly automated and done remotely, or could be done by daily walk-through with a "rounds sheet" checklist.

3.3.1.3 Cost

The comparative capital cost of a 200 gpm chemical precipitation facility is approximately $4,290,000 including process equipment, installation and construction of a treatment building.

O&M costs for conceptual assessment include supply of hydrated lime and sludge disposal. Chemical cost is estimated at $24,000 annually. Sludge disposal is estimated at $58,000. Annual labor and supervision is estimated at $230,000. Power consumption ($51,000) would include pumps, blowers and mixers. Including other miscellaneous O&M costs and contingency the annual total O&M cost is estimated at $500,000. Estimates for the capital and operation costs are included in Attachment J-1.

3.3.2 Active Treatment Alternative II – Hybrid Chemical Precipitation

3.3.2.1 Effectiveness

A hybrid chemical precipitation system utilizing an active lime reaction step and pond-based clarification step can consistently remove dissolved iron. It may be slightly less effective than an engineered treatment facility at controlling downstream release of iron floc, since the floc remains in the pond. Reliability of this alternative is somewhat compromised due to exposure to climatic conditions. Freezing and flooding would adversely affect the settling efficiency of a pond-based unit. Further, the hybrid alternative does not include an active polishing filtration step, which may result in release of total suspended solids at a higher concentration than in the treatment facility alternative. Passive polishing can be achieved through addition of a polishing pond or through placement of a silt curtain and could provide a higher level of control for prevention of downstream iron floc release. While the current evaluation is focused on iron and arsenic removal, the chemical precipitation alternative is expected to provide removal for copper and cobalt as well. Efficiency of removal cannot be estimated without more in-depth analysis of water chemistry and bench studies.

Lime may be added in excess of the chemical balance to ensure that reaction is complete. Use of excess lime can be expected to shorten the time between maintenance cleanouts. As noted above, the current estimated pond size (maximum to site constraints) does not account for a storm event. Multiple ponds in series or parallel may provide some operational flexibility and may be useful in controlling floc release under high flow conditions. Configuration options should be considered if the settling pond (hybrid treatment) alternative is further evaluated. Future modifications would only be required if changes occur to the flow rate or water chemistry. Daily O&M would be less intensive than a fully active treatment facility. Long-term O&M would require temporary shutdowns to remove collected iron floc sediments from the bottom of the pond, currently estimated at once per year. The level of permanence is flexible for a hybrid system, with pond related earthwork being the primary requirement for construction or decommissioning. Pond depth, surface area, and total volume would account for settling of precipitated solids. Solids could be removed campaign-style and dewatered prior to disposal, resulting in a similar secondary waste volume as described above. The design/construction schedule for a pond system could be shorter than for a conventional plant.

3.3.2.2 Implementability

The primary "treatment structure" in this alternative is a settling pond which should not present any undue construction difficulty. The lime reaction tank would be sized at 12,000 gallons, and would require a foundation and adequate shelter to prevent freezing. Pond surface area is estimated at one acre, and depth is estimated at six feet, based on understanding of site constraints. The hybrid system would have less equipment and a smaller structure, relative to a fully active treatment facility in a building. A hydrated lime storage and delivery system could be housed in a relatively small building with the reaction tank at the inlet of the pond. A series flow configuration with intermediate monitoring and pump-back capability may be needed to consistently treat and control floc from releasing. Monitoring could be highly automated and done remotely, or could be done by daily walk-through with a "rounds sheet" checklist.

3.3.2.3 Cost

The comparative capital cost of a 200 gpm chemical precipitation pond is approximately $2,262,000 including process equipment (lime and acid addition, pumps, aeration for mixing) and pond construction.

Routine O&M costs for conceptual assessment include hydrated lime. Chemical cost is estimated at $24,000 annually. Labor and supervision would be lower than the lime treatment facility and is estimated at $127,000 annually. Power consumption would include active mixing and aeration in the lime reaction tank and is estimated at $20,000 annually. Long-term O&M costs would include dredging collected solids once per year, dewatering, and disposing and is assumed comparable to the routine sludge removal from a treatment facility ($217,000). The typical cost advantages normally achieved by pond systems over fully active treatment facilities are offset somewhat due to the limited land area, which leads to more frequent cleanups. The cost benefit of ponds over treatment facility alternatives may be reconsidered if the evaluation basis flow rate and/or iron concentration could be lowered from their current evaluation basis values. Annual total O&M cost including contingency is estimated at $487,000. Estimates for the capital and operation costs are included in Attachment J-1.

4.0 CONCLUSIONS

One passive treatment technology (aerobic wetlands) was considered to be potentially applicable to treatment of the evaluation basis water quality characterization and flow rate from the West Fork. This process was developed to a conceptual level for consideration of its effectiveness, implementability and cost. Due to site constraints, the effectiveness of treatment would be limited by the maximum land area that could be used for installation of an aerobic wetlands. It is estimated that approximately ten percent of the West Fork flow would consistently bypass the aerobic wetlands and pass untreated into Blackbird Creek. Site constraints also affect the implementability of the aerobic wetlands design. As described in Section 2 above, a series of 12 small wetlands was conceptualized, due to the extreme limitations of site topography. The capital cost estimate for construction of the aerobic wetlands system is $2,234,000 and the annual O&M cost is estimated at $334,000.

One active treatment system (chemical precipitation in a treatment facility) was developed from the screened technologies. This alternative presents relatively fewer effectiveness and implementability concerns than the other alternatives. The estimated capital cost is $4,290,000 and the annual O&M cost was estimated at $500,000.

One hybrid treatment system, combining aspects of passive and active treatment was developed to the conceptual level (active lime addition, mixing and aeration, with clarification in a passive settling pond). This process presents some of the advantages and disadvantages of both the fully passive and fully active systems. It is considered to be more easily implemented than the aerobic wetlands alternative, however the size of the passive settling pond presents a long-term maintenance issue – if the pond were relatively small and shallow it would require more maintenance (sludge removal) than if it were large and deep. A smaller pond also presents potential for partially treated water to be released in high flow events. The effectiveness of treatment would also be expected to be more reliable than the aerobic wetlands alternative, but not as reliable as the fully active chemical precipitation system. The capital cost estimate for the hybrid system is $2,262,000 and the annual O&M cost is estimated at $487,000.

This evaluation of water treatment alternatives has been performed at a conceptual level of detail. Additional study would be needed to optimize the identification and selection of the most effective, implementable, and economic treatment system if treatment of West Fork groundwater was determined to be necessary.

5.0 REFERENCES

Golder Associates Inc, 2002a. Focused Feasibility Study for the Blackbird Mine Site, Lemhi County, Idaho. Prepared for the Blackbird Mine Site Group. June 21, 2002.

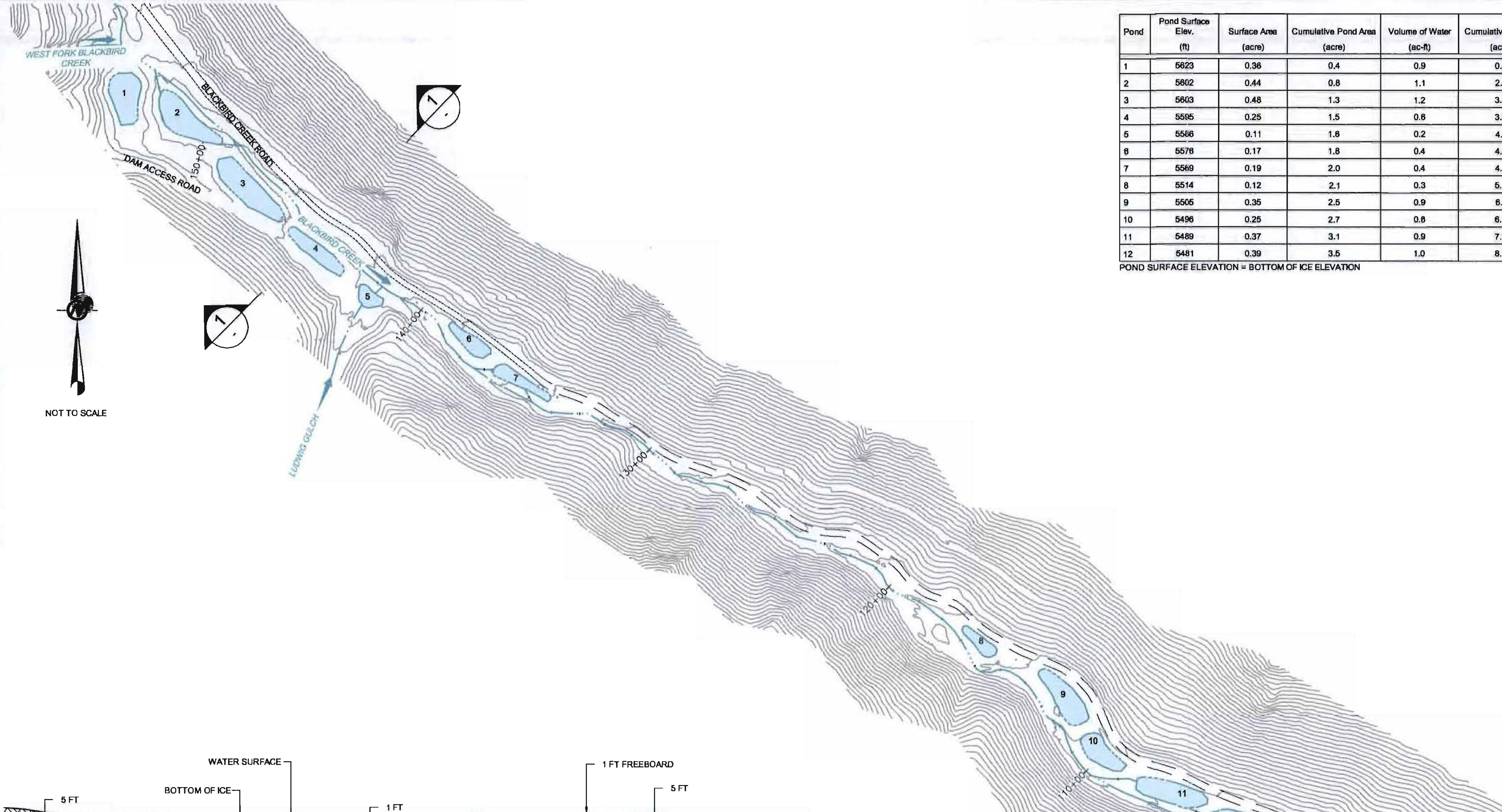
List of Figures

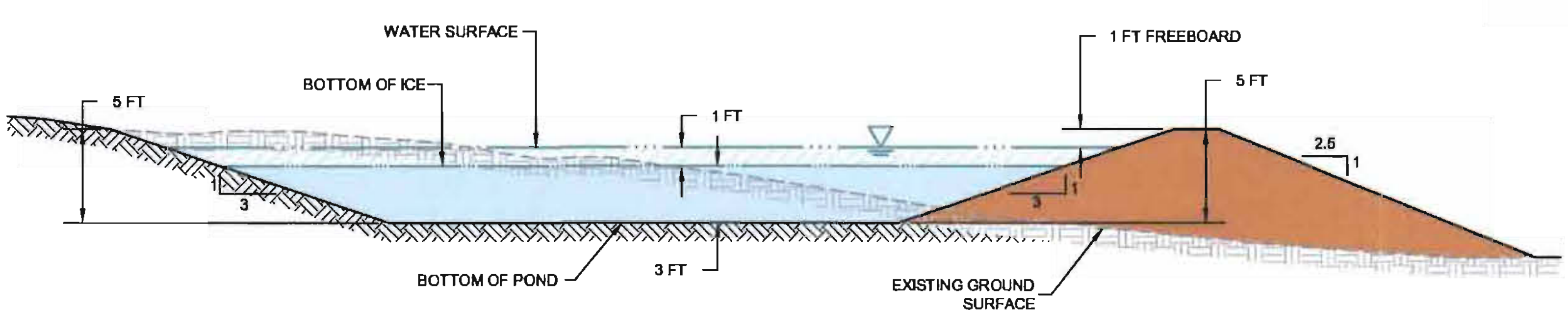
List of Attachments

FIGURES

Pond	Pond Surface Elev. (ft)	Surface Area (acre)	Cumulative Pond Area (acre)	Volume of Water (ac-ft)	Cumulative Volume (ac-ft)
1	5623	0.36	0.4	0.9	0.9
2	5602	0.44	0.8	1.1	2.0
3	5603	0.48	1.3	1.2	3.3
4	5595	0.25	1.5	0.6	3.9
5	5586	0.11	1.6	0.2	4.1
6	5576	0.17	1.8	0.4	4.5
7	5569	0.19	2.0	0.4	4.9
8	5514	0.12	2.1	0.3	5.2
9	5505	0.35	2.5	0.9	6.1
10	5496	0.25	2.7	0.6	6.7
11	5489	0.37	3.1	0.9	7.7
12	5481	0.39	3.5	1.0	8.7

POND SURFACE ELEVATION = BOTTOM OF ICE ELEVATION





1 TYPICAL POND GEOMETRY

FIGURE **J1**

PASSIVE TREATMENT POND LOCATIONS

BMSG/BLACKBIRD MINE/ID

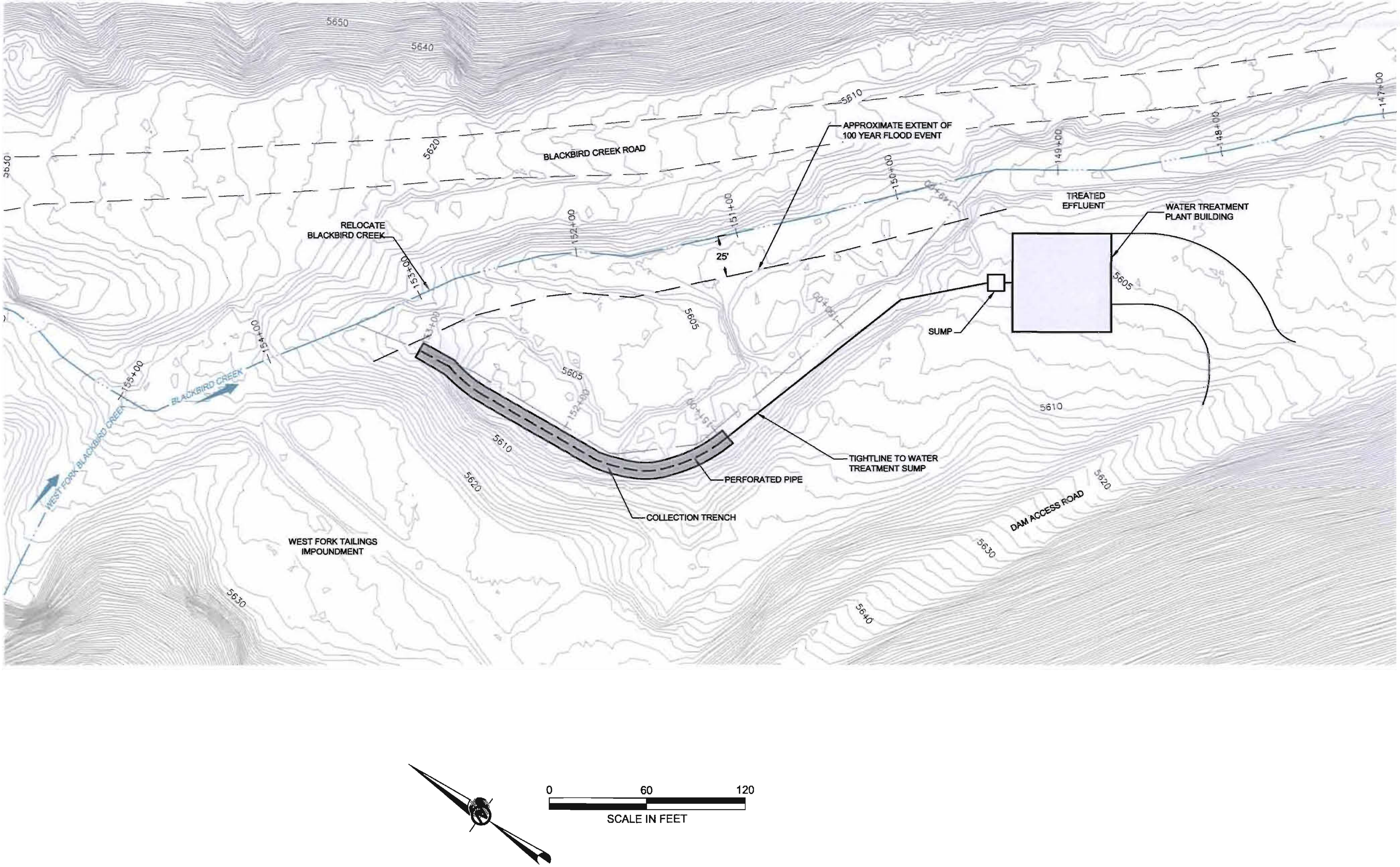


FIGURE **J2**
ACTIVE TREATMENT
CHEMICAL PRECIPITATION WITH TREATMENT FACILITY
BMSG/BLACKBIRD MINE/ID

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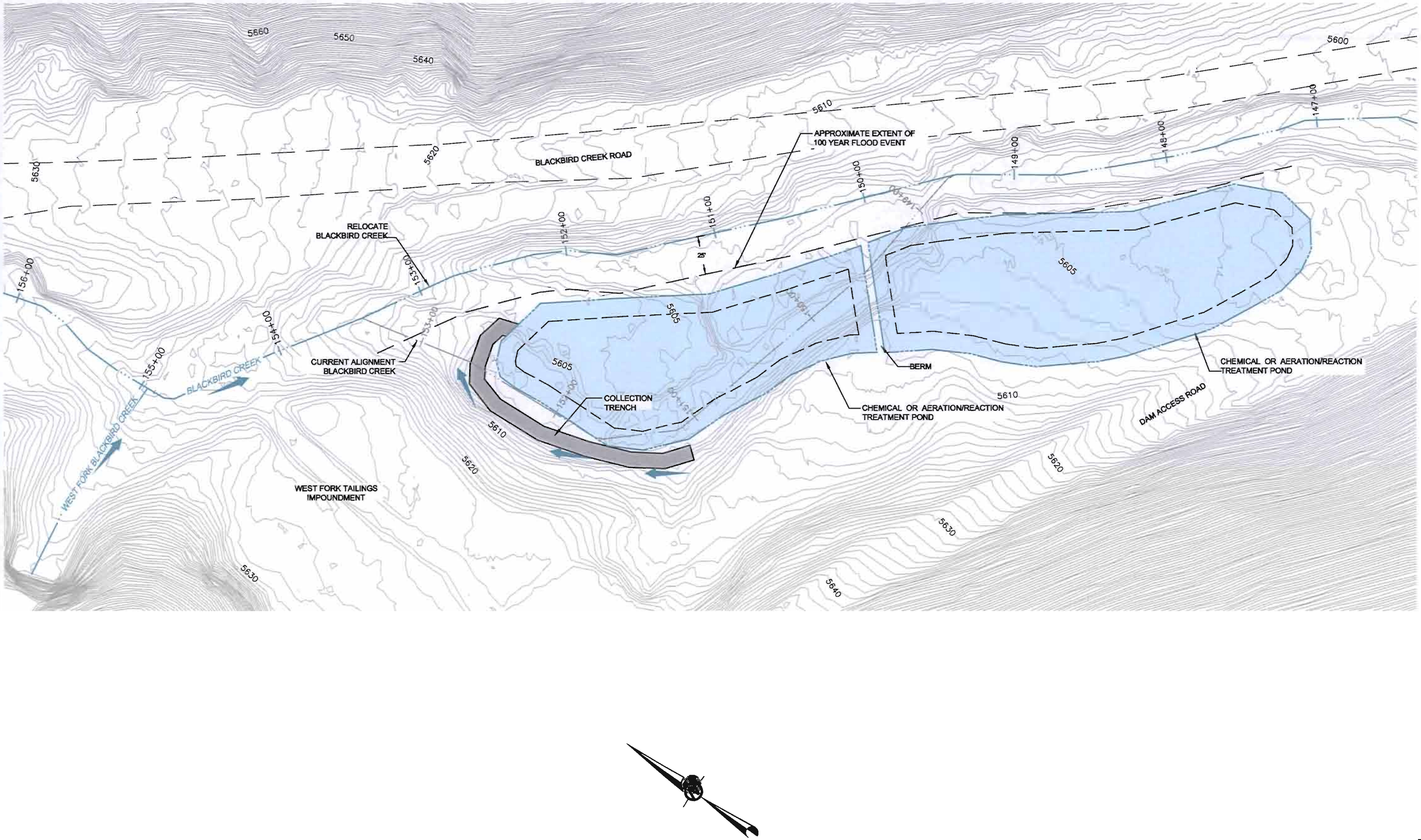

FIGURE **J3**

ACTIVE TREATMENT

HYBRID CHEMICAL PRECIPITATION

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ATTACHMENT J1-1
COSTS TABLES

TABLE J1
Preliminary Cost Estimate - Active Treatment Alternative I: Chemical Precipitation in a Treatment Facility

ITEM	QUANTITY	UNITS	UNIT RATE	COST	TOTAL
Water Treatment Plant					
Clearing and Grubbing	556	cy	$15	$8,483	
Treatment Plant Building (3600 sf) inc. tank, HVAC	1	ls	$700,000	$700,000	
Chemical Precip Components	1	ls	$200,000	$200,000	
Lime System	1	ls	$220,000	$220,000	
Air Blower	1	ls	$15,000	$15,000	
Filter	1	ls	$50,000	$50,000	
Sludge Tank	1	ls	$30,000	$30,000	
Filter Press	1	ls	$200,000	$200,000	
Ancillary equipment	1	ls	$400,000	$400,000	
Backup generator	1	ls	$150,000	$150,000	
Electrical line (WTP to West Fork)	1	ls	$320,000	$320,000	
Access Driveway	100	lf	$15	$1,500	
SUBTOTAL					$2,294,983
Relocate Blackbird Creek					
Excavation	1,956	cy	$5	$9,778	
Restoration and Permitting	1	ls	$30,000	$30,000	
SUBTOTAL					$39,778
Collection System					
Collection Ditch Excavation	140	cy	$20	$2,800	
Riprap	62	cy	$55	$3,422	
6-inch pipe (perforated and tightline)	410	lf	$20	$8,200	
Underground Sump Vault	1	ea	$9,630	$9,630	
Pump (200 gpm, low TDH)	1	ea	$8,000	$8,000	
SUBTOTAL					$32,052
Subtotal Construction Cost:					**$2,366,813**
Mobilization at	10%			$236,700	
Subtotal				$2,603,513	
CQA	10%			$260,351	
Subtotal				$2,863,865	
Final Design Engineering	15%			$429,600	
Subtotal				$3,293,465	
Contingency at	30%			$988,000	
TOTAL CONSTRUCTION COST:					**$4,281,000**
O&M Total Cost					
Chemcial Treatment Plant O&M	1	ls	$6,255,000		$6,255,000
(NPC and contingency of 15% already included in lump O&M)					
TOTAL ALTERNATIVE COST					**$10,536,000**

Notes and Assumptions:
1. O&M costs include labor, materials, chemicals, utilities and misc. costs.

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TABLE J2
Preliminary Cost Estimate - Active Treatment Alternative II: Hybrid Chemical Precipitation

ITEM	QUANTITY	UNITS	UNIT RATE	COST	TOTAL
Clearing and Grubbing	1,613	cy	$15	$24,636	
Pond	1	ls	$50,000	$50,000	
Treatment Plant Building (800 sf) inc. tank, HVAC	1	ls	$175,000	$175,000	
Chemical Precip Components	1	ls	$100,000	$100,000	
Flow Baffles	1	ls	$50,000	$50,000	
Lime System	1	ls	$220,000	$220,000	
Mixer (blower)	1	ls	$15,000	$15,000	
Ancillary equipment	1	ls	$100,000	$100,000	
Backup generator	1	ls	$150,000	$150,000	
Electrical line (WTP to West Fork)	1	ls	$320,000	$320,000	
SUBTOTAL					$1,204,636
Relocate Blackbird Creek					
Excavation	1,956	cy	$5	$9,778	
Restoration and Permitting	1	ls	$30,000	$30,000	
SUBTOTAL					$39,778
Collection System					
Collection Ditch Excavation	140	cy	$20	$2,800	
Riprap	62	cy	$55	$3,422	
SUBTOTAL					$6,222
Subtotal Construction Cost:					**$1,250,636**
Mobilization at	10%			$125,100	
Subtotal				$1,375,736	
CQA	10%			$137,600	
Subtotal				$1,513,336	
Final Design Engineering	15%			$227,000	
Subtotal				$1,740,336	
Contingency at	30%			$522,100	
TOTAL CONSTRUCTION COST:					**$2,262,000**
O&M Total Cost					
Chemcial Treatment Plant O&M	1	ls	$6,044,000		$6,044,000
(NPC and contingency of 15% already included in lump O&M)					
TOTAL ALTERNATIVE COST					**$8,306,000**

Notes and Assumptions:
1. O&M costs include labor, materials, chemicals, utilities and misc. costs.

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TABLE J3
Preliminary Cost Estimate - Passive Treatment: Aerobic Wetlands P1 (Ponds 1-7)

ITEM	QUANTITY	UNITS	UNIT RATE	COST	TOTAL
Passive Water Treatment Pond					
Pond Construction[1]	1	ls	$400,000	$400,000	
Pond Excavation	11,000	cy	$5	$55,000	
Pond Fill (Dike Construction)	11,000	cy	$10	$110,000	
Riprap on Dike Face	370	cy	$55	$20,370	
Other Infrastructure (collection piping, etc.)	1	ls	$10,000	$10,000	
Monitoring Instrumentation	1	ls	$100,000	$100,000	
SUBTOTAL					$695,370
Maintain Blackbird Creek Channel					
Excavation	900	cy	$7	$6,300	
Channel Protection (riprap)	400	cy	$55	$22,000	
SUBTOTAL					$28,300
Subtotal Construction Cost:					**$723,670**
Mobilization at	10%			$72,400	
Subtotal				$796,070	
CQA	10%			$79,607	
Subtotal				$875,677	
Final Design Engineering	5%			$43,800	
Subtotal				$919,477	
Contingency at	30%			$275,800	
TOTAL CONSTRUCTION COST:					**$1,195,000**
O&M Total Cost					
Passive Treatment Pond	1	ls	$217,000		$217,000
Present Value of O&M	12.41	PV Factor			$2,692,970
Contingency (15% applied to total O&M cost)	15%	percent			$403,900
O&M Total Cost					**$3,096,900**
TOTAL ALTERNATIVE COST					**$4,291,900**

Notes and Assumptions:
1. Pond construction cost estimate includes: clear and grub of area, substrate cost (limestone and organic material), substrate placement, vegetation cost, vegetation planting, synthetic liner, and a safety factor. Costs developed using AMDtreat.

TABLE J4
Preliminary Cost Estimate - Passive Treatment: Aerobic Wetlands P2 (Ponds 1-12)

ITEM	QUANTITY	UNITS	UNIT RATE	COST	TOTAL
Passive Water Treatment Pond					
Pond Construction[1]	1	ls	$700,000	$700,000	
Pond Excavation	18,500	cy	$5	$92,500	
Pond Fill (Dike Construction)	18,500	cy	$10	$185,000	
Riprap on Dike Face	740	cy	$55	$40,700	
Other Infrastructure (collection piping, etc.)	1	ls	$20,000	$20,000	
Monitoring Instrumentation	1	ls	$200,000	$200,000	
SUBTOTAL					$1,238,200
Maintain Blackbird Creek Channel					
Excavation	3,800	cy	$7	$26,600	
Channel Protection (riprap)	1,600	cy	$55	$88,000	
SUBTOTAL					$114,600
Subtotal Construction Cost:					**$1,352,800**
Mobilization at	10%			$135,300	
Subtotal				$1,488,100	
CQA	10%			$148,810	
Subtotal				$1,636,910	
Final Design Engineering	5%			$81,800	
Subtotal				$1,718,710	
Contingency at	30%			$515,600	
TOTAL CONSTRUCTION COST:					**$2,234,000**
O&M Total Cost					
Passive Treatment Pond	1	ls	$334,000		$334,000
Present Value of O&M	12.41	PV Factor			$4,144,940
Contingency (15% applied to total O&M cost)	15%	percent			$621,700
O&M Total Cost					**$4,766,600**
TOTAL ALTERNATIVE COST					**$7,000,600**

Notes and Assumptions:
1. Pond construction cost estimate includes: clear and grub of area, substrate cost (limestone and organic material), substrate placement, vegetation cost, vegetation planting, synthetic liner, and a safety factor. Costs developed using AMDtreat.

TABLE J5
Water Treatment O&M Costs

ITEM	QUANTITY	UNITS	UNIT RATE	COST
O&M Costs				
O&M for Aeration Ponds (1-7, 1-12)				
Assume O&M costs to be the same as				
the sludge removal cost only for the chemical precipitation				
ponds (for Ponds 1-7).				
Mobilization	1	LS	$100,000	$100,000
Onsite Processing	264	tons	$163	$43,000
Disposal (assumes 10 percent solids)	5950	wet tons	$12	$74,000
O&M Cost for Ponds 1-7 (mobilization, processing, disposal)		1	ea	$217,000
O&M Cost for Ponds 1-12 (mobilization, 2x processiong, 2x disposal)		1	ea	$334,000
Hybrid Monitoring and Removal Costs				
Assume monitoring occurs after depositional events (assume once/4 years)				
Monitoring, sampling, reporting (per event)	1	LS	$25,000	
Lab Testing	1	LS	$5,000	
Break into a yearly cost:			**$7,500**	
Assume removal and replacement once every 4 years:				$139,562.05
Break into a yearly cost:				**$34,890.51**
Hybrid Treatment Plant O&M				
From Treatment Plant Eval - Annual O&M, incl. 15% cor	1	LS	$487,000.00	
Apply NPV	12.41	PV Factor		
TOTAL NPC O&M:				$6,043,203