FREEPORT-McMoRAN

Freeport-McMoRan Chino Mines Company
P.O. Box 10
Bayard, NM 88023

Sherry Burt-Kested
Manager, Environmental Services
Telephone: 575-912-5927
e-mail: sburtkes@fmi.com

March 5, 2018

Certified Mail #70173040000031901428
Return Receipt Requested

Mr. Bruce Yurdin, Director
New Mexico Environment Department
Water Protection Division
P.O. Box 5469
Santa Fe, New Mexico 87502

Dear Mr. Yurdin:

Re: Revised Technical Memorandum for the Groundhog No. 5 Stockpile Geochemical Evaluation for the Hanover Whitewater Creek Investigative Unit – Chino AOC

Freeport-McMoRan Chino Mines Company (Chino) submits under separate cover the *Revised Groundhog No. 5 Stockpile Geochemical Evaulation Technical Memorandum* for the Hanover Whitewater Creek Investigative Unit (HWCIU), under the Chino Administrative Order on Consent (AOC). This evaluation was performed in accordance with the recommendations of the Goundhog No. 5 Stockpile Interim Remedial Action Work Plan for Additional Characterization and Controls submitted June 3, 2014, which also includes the requirement to develop a simplistic mass balance and mass loading model. The report was submitted today to Mr. David Mercer.

Please contact Ms. Alicia Voss at (602) 366-8049 with any questions or comments concerning this report.

Sincerely,

Sherry Burt-Kested

Sherry Burt-Kested
Manager, Environmental Services

SBK:pp
20180305-003

xc: David Mercer, NMED
Joseph Fox, NMED
Patrick Longmire, NMED
Petra Sanchez, US EPA
Alicia Voss, FCX

TECHNICAL MEMORANDUM

Date:	February 27, 2018	**Project No.:**	1665189
To:	Pam Pinson	**Company:**	Freeport-McMoRan Chino Mines Company
From:	Jacob Waples & Jen Pepe		
cc:	Mark Birch	**Email:**	jpepe@golder.com

RE: REVISED GROUNDHOG NO. 5 STOCKPILE GEOCHEMICAL EVALUATION

1.0 INTRODUCTION

This technical memorandum has been prepared by Golder Associates Inc. (Golder) for Freeport-McMoRan Chino Mines Company (Chino) to summarize additional geochemical evaluation of expected water quality associated with the Groundhog No. 5 Stockpile. This evaluation was performed in accordance with the recommendations of the Groundhog No. 5 Stockpile Interim Remedial Action Work Plan for Additional Characterization and Controls (Work Plan; Golder 2014). The Work Plan includes development of a simple mass balance and mass loading model as follows:

- Estimates of stockpile mass, volume, and surface area, and site precipitation data will be used to develop a range of possible water/rock ratios in the stockpile.
- Estimates of infiltration through the stockpile will be made based on the quantity of water reporting to the seepage collection trench following rainfall events.
- Mass loading from the stockpile to its leachate will be quantified using existing field and laboratory data (including, but not limited to synthetic precipitation leaching procedure (SPLP) results from previous test pit investigations in 2004 and 2006 and data collected since this time).

2.0 BACKGROUND

The Work Plan was requested by the New Mexico Environment Department (NMED) in letter dated March 12, 2014, in response to elevated concentrations of sulfate and total dissolved solids (TDS) measured in 2013 groundwater samples from seepage collection well GH-97-04 located at the toe of the stockpile.

The NMED request included additional characterization, monitoring, and regrading to limit ponding and limit potential impacts to groundwater associated with the stockpile. In response to this request, Chino has performed additional characterization, monitoring, and remedial action work, including upgrades to surface water diversions and seepage collection systems, as described in the Work Plan, which was approved by NMED in a letter dated June 19, 2014. The Work Plan also provides a summary of previous characterization

Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, CO 80228 USA
Tel: (303) 980-0540 Fax: (303) 985-2080 www.golder.com

of the stockpile performed in 2004 (Golder 2005) and supplemental characterization performed in 2006 (Golder 2007).

The work summarized in this technical memorandum includes the geochemical modeling for assessment of the stockpile materials and expected water quality. This work is based on monitoring and characterization data collected as a part of Golder (2014), flow and surface water quality data collected in September 2016 to specifically support this evaluation, routine monitoring, and previous work at the site.

3.0 SITE DESCRIPTION

The Groundhog No. 5 Stockpile is a small waste rock stockpile with a footprint of less than 2 acres associated with the Groundhog No. 5 Shaft located on the north wall of Lucky Bill Canyon near its confluence with Bayard Canyon (Figure 1). The primary ores extracted from the Groundhog No. 5 Shaft consist of lead and zinc sulfides occurring in mineralized veins below the Sugarlump and Kneeling Nun Tuff Formations that are exposed along the surface in the canyon. The tuffs overlie Cretaceous-Tertiary sediments (the Colorado Formation), which in turn overlie a series of Paleozoic limestones and shales. Stockpile material types at the site include limestone, granodiorite, diorite, quartz monzonite, and tuff (Golder 2009) that have been deposited on colluvium overlying bedrock tuff.

Based on acid-base accounting (ABA) performed as part of Golder (2005), the stockpile materials are considered non-acid generating (additional details are provided in Section 4.3 below), with minor amounts of mineralized materials present. Supporting this, iron staining was observed to be minimal and restricted to small, isolated locations in the stockpile associated with finer-grained, mineralized material.

The current stockpile configuration is shown on Figure 2. The stockpile covers a footprint just under 80,000 square feet and averages approximately 13 feet thick. The stockpile was regraded in 2006 to a 3 horizontal to 1 vertical slope. Prior to regrading, the upper layer of the stockpile was composed primarily of angular limestone gravel with minor sulfide mineralization and iron staining. The limestone was generally underlain by unmineralized granodiorite and quartz monzonite stockpile material which in turn overlie the pre-mining surface (colluvium and tuff bedrock). Based on test pits excavated after the stockpile was regraded (Golder 2014), the materials on the top of the stockpile are generally finer in texture and predominantly angular limestone gravel. The fraction of oversize material and the amount of quartz monzonite gravel is greater on the regraded slope than on the top of the stockpile. Some finer soils have formed or been deposited by wind on the stockpile surface.

Surface water diversion ditches were installed in 2006 to prevent run-on to the stockpile. In 2014, additional regrading of the top surface of the stockpile was performed to prevent ponding on the stockpile top surface. With respect to groundwater, the stockpile is unsaturated based on the absence of springs and dry conditions in test pits performed as a part of Golder (2014) and previous studies. Groundwater is expected to be several feet below the colluvium in the bedrock based on site wide groundwater studies (Golder, 2008).

While negligible amounts of water may enter the colluvium at the upgradient portion of the drainage ditch during rainfall events that generate runoff, the majority of water inflow to the stockpile is due to incident precipitation. Precipitation onto the stockpile surface will either: evaporate (evapotranspiration), infiltrate into the stockpile, or run off the stockpile surface. Infiltration into the stockpile that reaches a depth below the influence of evaporation will migrate downward to the colluvium, and either flow along the top of the colluvium or along the colluvium/bedrock contact toward the stockpile toe. Given the low hydraulic conductivity of the underlying tuff bedrock, it is not likely that significant seepage is occurring into the regional groundwater (Golder 2014). While flow through fractures in the tuff is possible, groundwater near drainages in the Chino mine area typically exhibits an upward gradient in the valley bottoms, preventing flow downward past the water table (Golder 2007). Also, during excavation of a seepage collection trench, discussed below, the bedrock surface was observed to be weathered and stained in only the upper two to three inches, and hard and unweathered beneath, indicating flow occurs along the bedrock contact.

A shallow seepage collection well (GH-97-04) is located at the toe of the stockpile. This well was installed under the Administrative Order on Consent (AOC) in 1997 to collect samples of shallow groundwater (Daniel B. Stephens and Associates, Inc. [DBS&A], 1997). The well was installed using a backhoe to excavate to what was thought to be bedrock at that time. The well was then completed by inserting a horizontal perforated pipe into the excavation attached to a riser pipe and then backfilled.

Seepage collection well GH-97-04 often contains no water, or not enough water to purge the well prior to sampling. However, in 2013, after a typical monsoon season, the well contained enough water to purge and collect samples. The sample water qualities indicated exceedances for New Mexico Water Quality Control Commission groundwater quality standards for sulfate and TDS.

A seepage collection trench was installed to increase collection of seepage water along the length of the toe of the stockpile to allow further characterization of seepage and flow. The seepage collection trench is constructed at the colluvium-bedrock interface and drains to a collection sump. The trench was excavated along the majority of the toe of the stockpile. The greater part of the excavated trench was then included in the construction of the interceptor trench. Based on observations during excavation of the trench, and as designed, the interceptor ditch is positioned to intercept seepage at the toe of the stockpile. The surface water diversion ditches and regraded slopes were designed to drain/divert water quickly from the system to prevent ponding and limit infiltration of the stockpile.

Groundwater near the stockpile exhibits an upward gradient along the stream channel in Lucky Bill Canyon as described in the Groundhog No. 5 Stockpile Interim Remedial Action Work Plan for Additional Characterization and Controls (Golder 2014). Because seepage or surface water from the area of the stockpile that may circumvent the interceptor trench would flow to the stream channel, groundwater wells further downgradient of the stockpile in Lucky Bill Canyon would not be expected to capture discharge from the stockpile. The shallow wells that were installed and subsequently damaged did not show concentrations in the wells above groundwater standards except in the well at the toe of the stockpile.

During the development of the seepage collection trench, it was discovered that the collection point (screen) in seepage collection well GH-97-04 was several feet above the bedrock interface. Water quality samples from the seepage collection trench, as well as water volumes, were obtained in 2014. Additional information and design details are provided in Golder (2014). The locations of GH-97-04 and the seepage collection trench are shown in Figure 2.

4.0 AVAILABLE INFORMATION

To evaluate potential water quality from the stockpile, Golder relied upon the following information:

- The SPLP results for stockpile materials samples collected and tested during the Golder 2004 and Golder 2006 field investigations. The available data include SPLP results for 14 samples of limestone, quartz monzonite, or a mixture thereof.
- SPLP results for two colluvium materials, one collected during the Golder 2004 investigation from colluvium underlying the stockpile and one collected in 2014 from the seepage collection trench's west end, side gradient to the stockpile.
- Stockpile dimensions calculated from existing topography and estimates of overall Lucky Bill watershed area based on existing topography
- Grain size analysis
- Local historical precipitation data from the Fort Bayard meteorological station
- Daily precipitation data from a rain gauge located near the stockpile (Reservoir 3A).
- Groundwater results, compiled from previous reports or routine monitoring, for:
  - Seepage collection well GH-97-04 for October 2010, July 2013, and September 2013
  - Downgradient monitoring well GH-97-03 for September 1997 (partial results)
  - Downgradient monitoring well GH-97-02 in Bayard Canyon for September 1997 (partial results) and September 2010
  - The seepage collection trench (Groundhog No. 5 Seepage Collection Trench, also identified as the Lucky Bill Trench) from 2014 to 2017
- Surface water quality results collected in 2008 (Arcadis and SRK 2008):
  - Stations SW01 and SW02 upgradient of the Groundhog No. 5 Stockpile
  - Upgradient location Lucky Bill 1 (LB1) between October 2000 and September 2016; this is a surface sampling point from the Lucky Bill creek, though also downgradient of a seep and may also represent groundwater depending on flow conditions
  - Station SW03 downgradient of the Groundhog No. 5 Stockpile
- Flow measurements and results of surface water samples for water quality collected by Chino and Golder on September 6, 2016 for:
  - Surface water stations SW01, SW02, and Lucky Bill 1 (LB1) upgradient of the Groundhog No. 5 Stockpile

- Station SW03 downgradient of the Groundhog No. 5 Stockpile

Water quality data for sampling locations associated with the stockpile are presented in Table 1 and on Figure 1. The water quality data provided in Table 1 includes all measured field and laboratory parameters. Surface water sampling location SW01 is not shown on Figure 1, and is located to the east in the headwater of Lucky Bill Canyon.

Flow measurements taken in September 2016 are provided in Table 2 and were collected following a storm event. Flow measurements were performed using a bucket and stopwatch; however, given streambed topography, capture of all flow was not always achieved. Additionally, communication between surface water and groundwater occurs, complicating flow measurements. In some locations surface water infiltrates to the shallow alluvial system along the wash. In other locations the groundwater intercepts surface depth to bedrock is shallow, resulting in spring and surface flow. As shown in Table 2, flow increases from upgradient to downgradient with the exception at Station SW03, the furthest downgradient station measured, where flow decreased. Communication with the alluvial groundwater flow system and difficulty in flow measurements are suspected to have resulted a low flow measurement at Station SW03.

5.0 EVALUATION OF POTENTIAL STOCKPILE WATER QUALITY AND LOADING

An assessment of potential water quality associated with stockpile materials and their loading potential was performed by a combination of geochemical evaluation and modeling, as described in the following sub-sections.

Geochemical modeling was performed in the thermodynamic equilibrium computer code PHREEQC, Version 3.1.2 (Parkhurst and Appelo 1999), developed by the United States Geological Survey (USGS). This model has been widely accepted by the international geochemical and regulatory communities. Modeling using PHREEQC allows for consideration of aqueous reactions, mineral precipitation and dissolution, gas exchange, and sorption. The PHREEQC program is capable of a range of different models, ranging in complexity from simple speciation and saturation index calculations to mixing models to complete reactive transport modeling; in this case, PHREEQC was used for calculation of saturation indices and application of solubility controls. In the modeling, Golder applied the MinteqV4 thermodynamic database included with the program without modification.

5.1 Water Quality Signatures

Water quality samples for seepage collection well GH-97-04 at the toe of the stockpile indicate near-neutral pH values (6.5 to 6.9) with alkalinity concentrations between 50 and 80 mg/L as $CaCO_3$ (Table 1). The water type for GH-97-04 samples is a calcium-sulfate water type, as shown on the piper diagram in Figure 3 and on the stiff diagrams on Figure 4. Sulfate and TDS concentrations range from 1660 to 1720 mg/L and from 2410 to 2660 mg/L, respectively, and both exceed New Mexico Water Quality Control Commission groundwater quality standards. Fluoride concentrations (1.6 to 1.8 mg/L) also exceed these standards in some samples. Standards are not exceeded for any other parameter quality samples, including metals and metalloids.

Water quality samples collected from the seepage collection trench (identified as Lucky Bill Trench in tables and figures) have a similar water quality to GH-97-04. The pH values are near neutral (6.7 to 7.2), sulfate and TDS have a similar range of concentrations and are elevated above standards, and all other constituents (including metals and metalloids) are below standards (Table 1). The Groundhog No. 5 Seepage Collection Trench samples also have a similar water type signatures to that of GH-97-04, as shown on Figure 3 where the data for each plot in a similar region of the piper diagram and on Figure 4 as the stiff diagram shapes are similar.

Groundwater quality data for monitoring wells GH-97-02, GH-97-03, and Lucky Bill 1 (which may be influenced by surface or groundwater depending on flow conditions) are also presented in Table 1 and on Figure 3 and Figure 4. Monitoring well GH-97-03 is located downgradient of the stockpile and has lower TDS and sulfate concentrations that meet standards. However, for monitoring well GH-97-03, it should be noted that complete water quality is not available to fully evaluate its signature on the piper and stiff diagrams as the only available sample is from 1997. Monitoring well GH-97-02 is located further downgradient past the confluence with stream in Bayard Canyon. The range of sulfate and TDS concentrations (200 to 340 mg/L and 470 to 650 mg/L, respectively) for this well also meet standards. Lucky Bill 1 is located upgradient of the stockpile and has a neutral to alkaline pH with low concentrations of sulfate and metals. The signature for Lucky Bill 1 shows a wider distribution due to a greater range in anion ratios (Figure 3), possibly due to varying influence of surface water, groundwater and evaporation, though the signature is still distinct from that of the seepage collection trench and GH-97-04. The Lucky Bill 1 seep originates in rhyolite and would be expected to represent water not impacted by mineralization.

Water qualities for the surface water monitoring points in Lucky Bill Creek (SW01, SW02 and SW03) have low TDS and sulfate concentrations (Table 1). Sulfate concentrations increase moving from upgradient to downgradient. While concentrations increase moving past the stockpile (i.e., concentrations increase from 13 to 32 mg/L from SW02 to SW03) a similar magnitude of increase is observed upgradient of the stockpile from SW01 to SW02 (1 to 13 mg/L); these changes in concentrations are discussed further in Section 5.3. Additionally, sulfate concentrations are very low, 1 to 32 mg/L, two orders of magnitude lower than those observed in the seepage collection trench and GH-97-04. The water quality signature for these surface water points is similar to that of the Lucky Bill 1 sampling point in terms of cation composition, but again with a range of ratios for the anions, consistent with the fact that all of these samples originate from surface water in the creek. Similar to Lucky Bill 1, the surface water signatures, as shown on the piper diagram (Figure 3) and stiff diagrams (Figure 5), are different from that of the seepage collection trench and GH-97-04.

The results from SPLP testing of stockpile and colluvium materials are shown in Table 3 and in Figure 3. The SPLP testing was performed by SVL Analytical, Inc. in Kellogg, Idaho using US EPA Method 1312 (additional details for analytical methods, sampling preparation, and results are presented in the Site Investigation Report [Golder 2005] and the Site Investigation Report Addendum [Golder 2009]). The SPLP results are from laboratory tests and should not be directly compared with water quality results from monitoring wells given the inherent differences between field and laboratory conditions. For example, the high water to rock ratio used in the laboratory testing (20 to 1 for the SPLP tests, as prescribed by EPA Method 1312) may result in lower laboratory leachate concentrations. Scaling of these concentrations to evaluate water quality in the field is addressed in the following section (Section 4.2.1). The piper diagram water quality signatures are based on the ratio of ions, rather than concentrations, constraining differences due to the water to rock ratio and allowing qualitative comparisons between field and laboratory data. Piper diagram signatures for GH-97-04 and the seepage collection Trench are similar to those of mixed limestone-quartz monzonite SPLP samples (Figure 3). However, the limestone and quartz monzonite SPLP samples also exhibit a range of signatures that are not encompassed by the field waters quality samples. Signatures for the colluvium samples are different from that of GH-97-04 and roughly fall within the range of signatures for the Lucky Bill 1 seep and the Lucky Bill Creek surface water samples (SW01, SW02, and SW03). These results confirm that the limestone and quartz monzonite materials have the potential to be sources of sulfate and total dissolved solids, affecting water quality at GH-97-04 and in the seepage collection trench. However, these effects are limited or not observed on the downgradient surface water sample (SW03), which has a different water quality signature from the seepage collection trench.

5.2 Water Quality Estimates

5.2.1 Approach

Potential water qualities were estimated by a mass loading approach using SPLP results for samples collected from stockpile test pits and nearby colluvium. The approach included the calculation of loading rates from the SPLP applied to the stockpile and combined with a range of potential infiltration rates. A range of scaling factors and infiltration rates were applied to account for additional hydraulic or hydrogeologic factors. Additionally, modeling with PHREEQC was performed to enforce geochemical constraints by application of geochemical solubility controls. Use of PHREEQC in this study was limited to enforcement of solubility controls and saturation index calculations; reactive transport and kinetic modeling were not required or appropriate following this approach. Additionally, given the focus of the modeling to evaluate sulfate load, sorption was not included in the modeling as a conservative simplification.

For the mass loading calculations, Golder estimated the tonnage for the dump using an area of 79,400 square feet (ft^2) and a volume of 39,090 cubic yards (yd^3) based on interpreted topography of pre-mining surface and the surveyed topography of the stockpile prior to regrading. An estimated bulk density of 1.8 g/cm^3 was applied, resulting in a total stockpile mass of approximately 27 million tons. As a part of a sensitivity analysis, scaling factors were applied to account for the differences between laboratory derived data (i.e., SPLP results) and actual field conditions. For example, a scaling factor was applied for the mass of stockpile material expected to be reactive in the field. According to the soil classification presented in Golder (2005), approximately 50 percent of the stockpile material can be classified as sand, silt, or clay. In general, smaller particle sizes are considered the reactive component because they are a) primarily those materials in contact with water and b) smaller particles provide higher loading given their high surface area on a per mass basis. As such, a scaling factor of 0.5 was applied as a part of the sensitivity analysis to account for the difference in total surface area and in the area that is expected to be contacted by infiltrating water.

A historical annual average for total precipitation at Ft. Bayard of 15.66 inches was used to determine the amount of water falling directly on top of the stockpile; for reference, total precipitation in 2014 measured by the Reservoir 3A gauge near the stockpile was 13.2 inches. Given the constructed diversion structures, surface runon is not expected and is not included in the model. The infiltration was assumed to be between 30 percent (%) and 60 % of annual precipitation given the climate and nature of the stockpile materials. Comparison of volumes collected from the seepage collection trench to estimated precipitation volumes at the nearby Reservoir 3A rain gauge indicated that lower infiltration values may be warranted. Therefore, infiltration values corresponding to 1%, 15%, 20%, and 60% of annual precipitation were used in the modeling.

Scaling of laboratory tests to field conditions frequently results in unrealistic elevated concentrations. Therefore, following the mass loading calculations, the water quality estimates were further constrained by geochemical thermodynamic modeling to enforce mineral solubility controls and to put the solution in equilibrium with the atmosphere. The solubility controls were applied using PHREEQC. Minerals considered kinetically reasonable and appropriate for the site conditions based on professional experience and the literature (e.g., Nordstrom and Alpers 1999) were allowed to precipitate in the model. Minerals precipitating in the model included gibbsite, aluminum hydroysulfates (using basaluminite as a proxy), ferrihydrite, gypsum, and calcite. Each of these are considered likely to be equilibrium controls on constituent concentrations in mine waters (Nordstrom & Alpers 1999). Limited quantities of magnesite, otavite, fluorite, cerussite, and rhodochrosite also precipitated in the model; however, these did not significantly affect overall chemistry.

5.2.2 Modeling Results

The range of estimated sulfate concentrations for the different potential infiltration rates is summarized in Table 4 by material type, with and without an assumed scaling factor for contact surface area. Geochemical constraints using PHREEQC have also been applied. Given the water type, TDS concentrations are dominated by sulfate; therefore, similar trends are expected for TDS as the trends for sulfate shown in Table 4.

As noted above, scaling of water quality results from laboratory to field conditions frequently results in unrealistically high concentrations. This may be attributed to several factors, such as the fact that measured laboratory loading rates are frequently two to three orders of magnitude higher than field loading rates (e.g., Bennett et al. 2000; Malmstrom et al. 2000; Maest and Kuipers 2005; and Kempton 2012). This is generally understood to be a function of the fact that the laboratory experiments use materials representing a smaller average particle size (and thus greater reactive surface area) and that they employ a higher water to rock ratio, relative to field conditions.

In this case, scaling of the SPLP resulted in unrealistically high sulfate concentrations that were then constrained by the PHREEQC model through precipitation of gypsum and aluminum hydroxysulfates, with the exception of five of the 18 samples for the 1% infiltration scenarios, which were too concentrated to allow model convergence. The use of low infiltration rates also exacerbated the estimates of unrealistically high sulfate concentrations due to high loading into a small volume of water. The solubility constraints imposed by PHREEQC on the sulfate concentrations were a dominant factor in the modeling; while varying the infiltration rate and scaling factors resulted in a range of sulfate concentrations in the mass loading analysis, the application of solubility controls in PHREEQC, through speciation and precipitation of over-saturated minerals, resulted in a similar range of sulfate concentrations for most scenarios.

The modeled concentrations are then used to estimate the range of potential sulfate load (in kilograms per day) for the assumed annual infiltration rates (Table 4). The greatest loading is associated with the mineralized limestone materials at high annual infiltration rates; however, these materials are not representative of the entire stockpile and only represent one of the twelve samples collected for SPLP testing.

In general, the results indicate that the stockpile materials, limestone and quartz monzonite, have the potential to release sulfate at concentrations similar to those observed in the toe seepage collection well GH-97-04 and seepage collection trench. Sulfate release from the colluvium is also expected; however, the ranges of modeled concentrations and loadings are lower than those directly associated with the stockpile. Modeled colluvium sulfate concentrations are closer to, albeit higher than, measured sulfate concentrations observed upgradient at Lucky Bill 1 and farther downgradient at monitoring well GH-97-02.

5.3 Stockpile Loading Analysis

In order to evaluate the effects of potential seepage from the stockpile on surface water in Lucky Bill Canyon, water quality samples and flow measurements were collected in September 2016 to perform a preliminary mass loading analysis. The evaluation was based on comparisons of loading at the following locations:

- **SW01:** Station SW01 is furthest upgradient in the canyon and is upgradient of the stockpile.

- **SW02:** Station SW02 is downgradient of SW01, but is upgradient of the stockpile and would be unaffected by potential stockpile runoff or seepage.
- **LB1:** LB1 is a stream sample that is adjacent to and influenced by the Lucky Bill seep. The sample was not collected from the seep, rather the sample is collected from the stream. It is not expected that this location would be affected by the stockpile as it is still upgradient of the stockpile.
- **SW03:** Station SW03 is the furthest downgradient sampling location in the canyon and is downgradient of the stockpile and would be affected by potential stockpile seepage and/or runoff.

Locations are shown Figure 1, though surface water sampling location SW01 is located to the east in the headwater of Lucky Bill Canyon and not shown on Figure 1. Water quality (Table 1) and flow measurements (Table 2) were collected on the same day as a part of a synoptic sampling effort to allow a mass loading analysis. Sampling occurred during seasonal storm water runoff down the canyon, allowing sampling at all locations within the stream.

Water quality for the surface samples collected in September 2016 is summarized in Table 1 and discussed in Section 5.1. The water chemistry is represented graphically by the stiff diagrams on Figure 5 and Figure 6, the latter of which presents the stiff diagrams by location on the map and using two different scales for the stiff diagrams to emphasize the fingerprints.

As shown in Table 1 and by the stiff diagrams in Figure 6, concentrations of most constituents, including TDS and sulfate, increase from upgradient to downgradient in the canyon. For example, sulfate concentrations were measured at 20.5 mg/L at Station SW01 (furthest upgradient) and increase to 57.9 mg/L at Station SW02, to 118 m/L at LB1, and to 146 mg/L at the furthest downgradient location Station SW03. An increase in sulfate and TDS concentrations is observed consistently between each location along the canyon, regardless as to the presence of the stockpile. The increase in sulfate concentrations in the reach containing the Groundhog No. 5 stockpile (between LB1 and SW3) is from 118 mg/L at LB1 to 146 mg/L at SW3 (an approximate 20% increase). This increase is of the same order of magnitude as increases in stream reaches further upgradient. For example, between SW1 and SW2 sulfate concentrations increase from 20.5 to 57.9 mg/L (an approximate increase of 65%) and between SW2 and LB1 sulfate concentrations increase from 57.9 mg/L to 118 mg/L (an approximate increase of 50%).

The source of increasing concentrations and loading to the stream in Lucky Bill Canyon from upgradient to down gradient is considered to be natural weathering products of the Sugarlump and Kneeling Nun Tuff Formations that are exposed in the canyon. With respect to sulfate, the source is generally expected to be from pyrite in exposed mineralized areas, such as the contact between the volcanics and the underlying mineralized country rock. Secondary gypsum deposited throughout the canyon is also expected to be a source of sulfate. . Given the climate, with ephemeral stream flow, evaporative minerals, such as gypsum are expected along the stream bed. Further evidence for gypsum as a source is presented in Section 5.4.

Additionally, organic matter throughout the canyon (e.g., plants and associated detritus accumulating along the canyon) may be contributing to weathering or directly to sulfate concentrations.

To further evaluate potential contributions from natural minerals in the creek, Golder evaluated: mass loading to the creek using the September 2016 chemistry and flow measurements and the contribution (concentration and loading) per foot traveled of stream distance. Results for the loading analysis and contribution per foot are also summarized in Table 5 and discussed below.

Mass loading along the reach from SW01 to SW03 was calculated for each monitoring station using the water quality sample results and measured flows; results are shown on Table 5. Results are also shown for calculated mass load per distance traveled along the reach from SW-01 to SW03. The mass load per stream distance traveled was calculated to evaluate differences in mass loading naturally in Lucky Bill Canyon (i.e., upgradient of LB1) compared to the section containing the stockpile (between LB1 and SW03).

Mass loading increases from upgradient to downgradient, with the exception of Station SW03. Even though the concentrations increase at SW03, the relatively low flow measured results in a decrease in mass loading at this location. As noted in Section 4, the decrease in flow (and subsequently mass loading) at the downgradient location is likely due to error in flow measurements and/or communication with the alluvial groundwater. Given that a loss in flow at the downgradient location is unlikely, an extrapolated value of 15 gpm is used for the remainder of this analysis.

Overall, the results indicate that loading of sulfate, TDS, and other constituents to the stream in Lucky Bill Canyon is occurring along the entire reach between Station SW01 and Station SW03, not just in the reach with the stockpile. Furthermore, the loading of sulfate, TDS, and other constituents does not increase significantly in the reach containing the stockpile; while some increases are observed, they are similar to increases observed in upgradient reaches as well. The calculated sulfate mass loads between LB1 and SW3, using the measured and extrapolated flow at SW3, are within the range of modeled sulfate loading estimates for the stockpile (Table 4 and Section 5.2). However, this analysis is sensitive to the flow assumed at Station SW03.

.

An additional point to this analysis is the fact that the stockpile represents a very small portion of the total surface area in the canyon (2.4 acres versus 6 square miles). While the stockpile represents materials that have been disturbed, potentially increasing their reactive surface area, the stockpile is still relatively small relative to the rest of the exposed formations in the canyon. The relatively larger surface area of the canyon is expected to provide more weathering products to the Lucky Bill Canyon surface water, resulting in the increased concentrations in the surface and groundwater at downgradient locations.

5.4 Evaluation of Stockpile Geochemistry

As noted above, stockpile material types at the site include limestone, granodiorite, diorite, quartz monzonite, and rhyolitic tuff. Samples were collected as a part of Golder (2005) and Golder (2007) for ABA analysis; results are summarized in Table 6. All samples had neutral paste pH[1] values, indicating an absence of current acidic conditions. Acid generation potential for the future is generally evaluated based on the sulfur content, based on sulfide oxidation (e.g., pyrite) resulting in acid rock drainage (ARD). While the total sulfur of the samples varies from below detection (0.01%) to 2 %, the sulfur is predominantly present as sulfate sulfur for the majority of the samples, not as pyrite sulfur. Exceptions include the mineralized limestone sample and several quartz monzonite samples. This is consistent with observations in the field of limited localized area of mineralized or iron staining. Given these results, acid potential (AP) values are generally low, ranging from 0.3 to 40 tCaCO3/kt for the 14 samples.

In contrast, all of the samples had significant neutralization potential (NP), ranging from 14 tCaCO3/kt to 770 tCaCO3/kt, with an average of 440 tCaCO3/kt for the 14 samples. This result is not unexpected given the prevalence of limestone. This neutralization potential is sufficient to result in a non-acid generating classification for all samples based on net neutralization potential (NNP; NP-AP) values (greater than +20 tCaCO3/kt for all but two samples) and neutralization potential ratio (NPR; NP/AP) values (all greater than 2).

The predominance of sulfate sulfur in the materials (ranging from 0.08 to 0.8 % sulfate) indicates the presence of gypsum, dissolution of which will contribute to TDS and sulfate concentrations. The presence of gypsum is supported by speciation of water chemistries and calculation of saturation indices from seepage collection well GH-97-04 and the seepage collection trench performed in PHREEQC (Parkhurst and Appello 1999). Selected saturation index results are shown in Table 7. The speciation and calculation of saturation indices indicates that the saturation indices for gypsum are near equilibrium (i.e., saturation indices are near zero), indicating that gypsum is present and influencing sulfate concentrations. Saturation indices for the SPLP sample leachates do not indicate equilibrium with gypsum and sulfate concentrations are relatively low in the leachates. However, the SPLP tests are performed over a relatively short time period and kinetic constraints, combined with the relatively high water to rock ratio for the test, may have limited equilibrium with gypsum under test conditions.

6.0 CONCLUSIONS

Based on the geochemical evaluation and model, Golder provides the following conclusions.

- Based on the ABA testing performed (Golder 2005 and 2007), any acid generation on a local level from mineralized materials is expected to be neutralized by the overall neutralizing potential of the stockpile. The presence of localized iron staining in absence of

[1] Details of the analytical methods, sampling preparation, and results are presented in the Site Investigation Report (Golder 2005) and the Site Investigation Report Addendum (Golder 2009).

acidic drainage supports this conclusion, with localized oxidation being neutralized, resulting in staining.

- Leaching of significant metals concentrations was not observed in any of the SPLP tests and is not occurring in the field based on sampling of the seepage collection trench and seepage collection well GH-97-04. As such, leaching of metals under neutral conditions is not a concern. Given the limited potential for sulfide oxidation and high neutralization potential, future leaching of metals due to acidic conditions is also not expected.
- Sulfate and TDS concentrations above standards in the seepage collection trench or GH-7-04 are likely to be due to precipitation and dissolution reactions involving gypsum based on: a) ABA data indicating the presence of sulfate sulfur and b) results of speciation and saturation index calculations for field water quality samples indicating equilibrium with gypsum.
- Surface water samples from Lucky Bill Creek do not indicate impacts from the stockpile. While concentrations of sulfate increase between surface sampling locations LB1 and SW02 to SW03 (all located within Lucky Bill Creek), sulfate concentrations are low (an order of magnitude lower than standards and two orders of magnitude lower than concentrations in the seepage collection trench). Additionally, increases in sulfate concentrations (as well as concentrations of other major ions, as shown in Figure 6) and sulfate mass loading increases from upgradient to downgradient along the length of the creek, including in those reaches above the stockpile. The stream reach with the stockpile (between LB1 and SW03) has similar increases in concentrations and mass loading to that observed between upgradient monitoring points (i.e., from SW01 to SW02 and from SW02 to LB1). In other words, sulfate loading in the reach with the stockpile is similar to loading in reaches with no stockpiles.
- Groundwater samples downgradient from the stockpile at GH-97-02 and GH-97-03 range from 201 to 339 mg/L, slightly higher than in nearby surface water (146 mg/L at SW3) in Lucky Bill Creek but much lower than that observed in groundwater at GW-97-04 (>1,600 mg/L). Therefore, any transport of sulfate from the stockpile area by groundwater appears to have a limited effect on sulfate concentrations in water in the creek.

Overall, generation of acidic conditions are not expected for the stockpile and current stockpile seepage with sulfate and TDS concentrations above standards is limited to near the current concentrations by gypsum solubility. In addition, loading of sulfate and TDS from the stockpile occurs only in response to precipitation events as groundwater does not intercept the stockpile. Furthermore, loading of sulfate and TDS from the stockpile is expected to be reduced due to the 2014 Chino remedial actions that prevent ponding of surface water on the stockpile. While stockpile seepage has elevated concentrations of sulfate and TDS, loading from the stockpile has not had a significant effect on surface water or down gradient groundwater based on water quality results for the downgradient SW03 sampling point and wells GH-97-02 and GH-97-03.

7.0 REFERENCES

Arcadis-US, Inc. and SRK Consulting (U.S), 2008. Technical Memorandum, Surface Water Sampling and Analysis of Rainfall Pools. Prepared for Chino Mines Company, Hurley, NM. September 25/ 2008.

Bennett, J.W., Comarmond, M.J. and Jeffery, J.J. (2000). Comparison of Oxidation Rates of Sulfidic Mine Wastes Measured in the Laboratory and Field. (Australian Centre for Mining Environmental Research: Brisbane).

Daniel B. Stephens and Associates, 1997. Shallow Groundwater Monitoring Wells at the Groundhog Site. Prepared for Chino Mines Company, Hurley, New Mexico. October 17, 1997.

Golder Associates Inc., 2005. Interim Remedial Action, Groundhog No. 5 Stockpile, Site Investigation Report, Hanover and Whitewater Creeks, Investigation Units. Prepared for Chino Mines Company, Hurley, New Mexico. June 3, 2005.

Golder Associates Inc., 2007. Chino Mines Company DP-1340 Condition 83 – Hydrologic Study Final Report. Prepared for Freeport McMoRan Chino Mines Company Hurley New Mexico. June 28, 2007.

Golder Associates Inc., 2008. Chino Mines Company Site Wide Stage 1 Abatement Final Investigation Report. Prepared for Freeport McMoRan Chino Mines Company Hurley New Mexico. July 18, 2008.

Golder Associates Inc., 2009. Site Investigation Report Addendum, Groundhog No. 5 Stockpile, Hanover and Whitewater Creeks, Investigation Units. Prepared for Chino Mines Company, Hurley, New Mexico. June 3, 2009.

Golder 2014. Groundhog No. 5 Stockpile Interim Remedial Action Work Plan for Additional Characterization and Controls, Hanover and Whitewater Creek Investigation Units. Golder Associates Inc., Silver City, New Mexico, project 140-3873, June 3, 2014.

Kempton, H., 2012. A Review of Scale Factors for Estimating Waste Rock Weathering from Laboratory Tests. 9th International Conference for Acid Rock Drainage.

Maest, A.S. and J.R. Kuipers, C.L. Travers, and D.A. Atkins. 2005. Predicting Water Quality at Hardrock Mines; Methods and Models, Uncertainties and State-of-the-Art. Kuipers & Associates, Butte MT. (Available online at http://www.mineaid.org/predictions/PredictionsReportFinal.pdf).

Malmstrom, M.E., G. Destouni, S. A. Banwart, and B.H.E. Stromberg, 2000. Resolving the Scale-Dependence of Mineral Weathering Rates. Environmental Science and Technology, Vol. 43, No7. Pp. 1375-1378.

Parkhurst, D.L. and Appelo C.A.J. (1999) User's Guide to PHREEQC (Version 2)—A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. US Geological Survey Water-Resources Investigations Report 99-4259

TABLES

Table 1: Water Quality Data for Groundhog No. 5 Stockpile and Lucky Bill Canyon

Sample ID	Water Type	Sample Date	Al, Diss	Alk, CO3	Alk, HCO3	Alk, Tot.	As, Diss	Ca, Diss	Cd, Diss	Cl, Tot.	Co, Diss	Cr, Diss	Cu, Diss	F, Tot.	Fe, Diss	K, Diss	Mg, Diss	Mn, Diss	Na, Diss	Ni, Diss	Pb, Diss	pH, Field	EC, Field	EC @ 25oC	SO4, Tot.	TDS	Zn, Diss
			(mg/L)	(mg/L)	(mg/L)	(mg/L as CaCO3)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(SU)	uS/cm		(mg/L)	(mg/L)	(mg/L)
GH-97-04	Groundwater	8/2/2010	<0.08	<1	82	82	0.00404	517	<0.002	3.83	<0.006	<0.006	0.01	1.79	<0.06	14.1	89.3	<0.004	77.3	<0.01	<0.003	6.53	---		1720	2660	0.176
GH-97-04	Groundwater	7/22/2013	<0.08	<1	51.5	51.5	<0.025	471	<0.002	6.7	<0.006	<0.006	0.01	1.62	<0.06	11.8	79	0.0083	55.2	<0.01	<0.0075	6.85	---		1690	2410	0.132
GH-97-04	Groundwater	9/12/2013	<0.08	<1	83.7	83.7	<0.025	535	<0.002	3.9	<0.006	<0.006	<0.01	1.19	<0.06	13	78.5	<0.004	33.9	<0.01	<0.0075	6.81	---		1660	2580	0.157
GH-97-02	Groundwater	9/1/1997	<0.0365	0	NA	NA	<0.0015	NA	0.0312	4.05	<0.0068	<0.010	0.058	0.36	<0.0417	NA	NA	2.43	NA	<0.0297	0.0144	7.03	---		339	645	3.23
GH-97-02	Groundwater	9/20/2010	<0.08	<1	113	113	<0.025	77.2	0.0143	6.89	<0.006	<0.006	0.045	0.262	<0.06	5.94	18.5	0.0145	23.9	<0.01	0.0196	6.89	---		201	469	1.56
GH-97-03	Groundwater	1997	<0.0365	0	NA	NA	<0.0015	NA	<0.0025	12.2	<0.0059	<0.010	0.0083	0.23	<0.0417	NA	NA	<0.0030	NA	<0.0297	0.0015	6.85	---		238	507	0.119
Lucky Bill Trench	Seepage collection trench	9/30/2014	<0.08	<1	132	132	<0.025	560	<0.002	3.97	<0.006	<0.006	<0.01	1.02	<0.06	33.9	144	0.0993	71.5	<0.01	<0.0075	6.70	2,831	3,110	2070	3070	0.0355
Lucky Bill Trench	Seepage collection trench	2/10/2015	<0.08		140	140	<0.025	313	<0.002	3.74	<0.006	<0.006	0.0456	0.875	<0.06	18.8	80.2	0.0206	38.4	<0.01	<0.0075	7.22	2,026	2,464	1680	2380	0.022
Lucky Bill Trench	Seepage collection trench	8/31/2015	<0.08	<1	132	132	<0.025	404	<0.002	9.68	<0.006	<0.006	0.0288	<0.5	<0.06	25.3	102	0.0047	50.2	<0.01	<0.0075	6.83	2,295	2,344	1530	2290	0.037
Lucky Bill Trench	Seepage collection trench	3/16/2016	<0.08	<1	139	139	<0.025	396	<0.002	4.03	<0.006	<0.006	0.0241	0.791	<0.06	23.8	102	<0.004	50.2	<0.01	<0.0075	7.09	1,925	2,330	1430	2100	0.034
Lucky Bill Trench	Seepage collection trench	11/8/2016	<0.08	<1	117	117	<0.025	528	<0.002	4.09	<0.006	<0.006	0.0114	1.65	<0.1	36	149	<0.008	73.8	<0.01	<0.0075	6.8	2,655	3,045	1950	3040	0.064
Lucky Bill Trench	Seepage collection trench	11/15/2016	<0.08	<1	151	151	<0.025	547	<0.002	2.99	<0.006	<0.006	<0.0100	0.564	0.105	22.9	119	0.025	65.7	<0.01	<0.0075	7.09	1,784	2,905	1910	2800	0.028
Lucky Bill Trench	Seepage collection trench	2/3/2017	<0.08	<1	129	129	<0.025	533	<0.002	3.3	<0.006	<0.006	<0.01	0.578	0.224	23.7	129	<0.008	62.9	0.0153	<0.0075	6.86	2,272	2,706	1820	2820	0.037
Lucky Bill Trench	Seepage collection trench	2/16/2017	<0.08	<1	119	119	<0.025	523	<0.002	3.21	<0.006	<0.006	<0.01	0.395	<0.1	21.5	117	<0.008	62.2	<0.01	<0.0075	6.72	2,695	3,011	1860	2690	0.069
LUCKYBILL 1	Surface water / groundwater seep	10/7/1996	<0.021	<1	76.9	76.9	<0.04	24	<0.0024	3.2	<0.005	<0.005	0.006	0.2	0.141	2.96	7.51	0.031	14.7	<0.017	<0.04	---	286		44.6	138	0.005
LUCKYBILL 1	Surface water / groundwater seep	8/1/1997	<0.037	<1	46.1	---	<0.04	24.8	0.004	4	0.005	<0.008	0.015	0.2	0.223	3.4	7.41	0.074	14.3	<0.016	<0.04	6.01	240		70.8	219	0.011
LUCKYBILL 1	Surface water / groundwater seep	11/30/1998	---	<1	85	---	<0.04	41.3	<0.002	10.3	<0.003	<0.008	0.016	0.1	<0.019	3.9	13.2	0.01	37	<0.016	<0.04	---	320		133	302	0.019
LUCKYBILL 1	Surface water / groundwater seep	2/3/1999	---	<1	79.7	---	---	30.4	<0.002	7.2	---	---	0.009	---	---	2.1	8.99	0.01	27.2	---	<0.04	---	245		---	228	---
LUCKYBILL 1	Surface water / groundwater seep	8/2/1999	---	<1	90.4	---	---	29.7	<0.0024	6.5	---	---	0.014	---	---	3.3	9.61	0.042	28	---	<0.04	---	330		---	283	---
LUCKYBILL 1	Surface water / groundwater seep	7/17/2000	---	<1	108	---	---	48.6	<0.002	9.6	---	---	0.014	---	---	6.1	14.6	0.087	31.6	---	<0.04	6.47	472		---	350	---
LUCKYBILL 1	Surface water / groundwater seep	10/17/2000	---	<1	61	---	<0.01	44.3	<0.002	8.4	<0.006	<0.006	0.009	0.1	0.04	4.4	13.3	0.005	32	<0.005	<0.005	7.43	355		161	300	0.01
LUCKYBILL 1	Surface water / groundwater seep	1/24/2001	---	<1	66.2	106	---	30.9	<0.002	6.6	---	---	0.005	---	---	3.1	9.43	0.004	22.9	---	<0.005	7.02	244		---	250	---
LUCKYBILL 1	Surface water / groundwater seep	8/6/2001	---	<1	113	113	---	54.2	<0.002	10	---	---	0.009	---	---	5.8	16.3	0.07	37.3	---	<0.005	6.93	543		---	401	---
LUCKYBILL 1	Surface water / groundwater seep	10/8/2002	---	<1	133	133	<0.01	61.1	<0.002	10.6	<0.006	<0.006	0.0054	0.33	<0.02	5.1	17.7	0.0749	40.7	<0.01	<0.005	8.48	510		179	476	0.125
LUCKYBILL 1	Surface water / groundwater seep	2/24/2004	---	<1	86.3	86.3	---	52.4	<0.002	9.34	---	---	<0.003	---	---	4	15.5	<0.002	41.7	---	<0.005	8.63	389		---	330	---
LUCKYBILL 1	Surface water / groundwater seep	4/21/2004	---	<1	85.6	85.6	<0.01	29	<0.002	7.2	<0.006	<0.006	0.0067	0.27	<0.02	3.8	8.96	0.0271	30.8	<0.01	<0.005	7.19	305		95	225	0.0384
LUCKYBILL 1	Surface water / groundwater seep	8/10/2004	---	<1	117	117	---	42.4	<0.002	8.27	---	---	0.0106	---	---	5.8	13.2	0.0352	35	---	<0.005	7.52	463		---	361	---
LUCKYBILL 1	Surface water / groundwater seep	10/28/2004	---	<1	146	146	<0.01	49.6	0.0027	8.57	<0.006	<0.006	0.0088	0.18	0.09	4.6	14.6	0.0583	34.6	<0.01	<0.005	6.95	397		124	380	0.198
LUCKYBILL 1	Surface water / groundwater seep	7/17/2006	---	<1	106	106	---	62.3	<0.002	10.8	---	---	<0.01	---	---	9.63	18.6	0.174	39.2	---	<0.0075	6.93	560		---	420	---
LUCKYBILL 1	Surface water / groundwater seep	10/12/2006	---	<1	75.4	75.4	<0.025	25.7	<0.002	4.09	<0.006	<0.006	<0.01	0.18	0.14	4.27	7.61	0.174	19.9	<0.01	<0.0075	7.35	148		52.3	197	<0.01
LUCKYBILL 1	Surface water / groundwater seep	1/29/2007	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6.48	321		109	237	---
LUCKYBILL 1	Surface water / groundwater seep	2/13/2008	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6.84	278		120	260	---
LUCKYBILL 1	Surface water / groundwater seep	8/6/2008	<0.08	<1	<1	70.8	<0.025	28.2	<0.002	4.52	<0.006	<0.006	<0.01	0.16	0.111	3.84	7.91	0.103	20.2	<0.01	<0.0075	6.68	257		69	210	<0.01
LUCKYBILL 1	Surface water / groundwater seep	10/8/2008	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.39	283		67.8	200	---
LUCKYBILL 1	Surface water / groundwater seep	3/6/2010	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.07	370		187	323	---
LUCKYBILL 1	Surface water / groundwater seep	4/19/2010	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.25	419		185	399	---
LUCKYBILL 1	Surface water / groundwater seep	8/2/2010	<0.08	<1	53.3	53.3	<0.025	57.3	<0.002	8.32	<0.006	<0.006	0.011	0.247	<0.06	6.39	16.7	0.043	36.6	<0.01	<0.0075	6.95	595		220	432	0.0175
LUCKYBILL 1	Surface water / groundwater seep	9/16/2011	<0.08	<1	69.4	69.4	<0.02	193	<0.002	26.2	<0.006	<0.006	0.01	<0.5	<0.06	10.2	57	0.04	78.7	<0.01	<0.0075	6.88	1402		787	1340	<0.01
LUCKYBILL 1	Surface water / groundwater seep	1/23/2012	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.03	297		160	293	---
LUCKYBILL 1	Surface water / groundwater seep	7/23/2013	<0.08	<1	64.1	64.1	<0.025	82.9	<0.002	13.1	<0.006	<0.006	0.018	0.34	<0.06	6.77	23	0.116	45.3	<0.01	<0.0075	7.08	749		370	626	0.0342
LUCKYBILL 1	Surface water / groundwater seep	10/23/2013	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.30	385		122	331	---
LUCKYBILL 1	Surface water / groundwater seep	10/1/2014	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.21	268		110	286	---
LUCKYBILL 1	Surface water / groundwater seep	9/6/2016	0.002	< 2	96.2	96.2		36.3	< 0.0001	6.1			0.0036	0.25	0.04	4	10.3	0.085	31.8		< 0.0001	7.9			118	346	0.003
Lucky Bill Creek SW01	Surface water	9/1/2007	0.477	---	---	26	---	11	<0.0001	2	---	---	0.0193	---	0.15	1.9	4.5	0.0085	8.4	---	0.0003	6.47	---		1	---	---
Lucky Bill Creek SW01	Surface water	9/6/2016	0.048	< 2	53.1	53.1		13.5	< 0.0001	3.6			0.0138	0.25	0.17	1.7	4.7	0.019	11.5		0.0003	7.7			20.5	176	0.004
Lucky Bill Creek SW02	Surface water	9/1/2007	0.112	---	---	40	---	16.8	<0.0001	2	---	---	0.0139	---	0.09	2.7	5.1	0.035	13.3	---	0.0002	7.06	---		13	---	---
Lucky Bill Creek SW02	Surface water	9/6/2016	0.009	< 2	57.7	57.7		22.3	< 0.0001	4.1			0.004	0.22	0.07	2.9	5.9	0.008	18.5		< 0.0001	7.6			57.9	234	< 0.002
Lucky Bill Creek SW03	Surface water	9/1/2007	0.081	---	---	58	---	26	<0.0001	3	---	---	0.014	---	0.12	3.3	7.3	0.0501	18.4	---	0.00005	7.52	---		32	---	---
Lucky Bill Creek SW03	Surface water	9/6/2016	0.002	< 2	99	99		50.1	< 0.0001	7.6			0.0049	0.25	< 0.02	4.6	12.9	0.023	33.8		< 0.0001	8.1			146	400	0.019

Notes:
-Data only shown for dates when a sample was able to be collected; monitoring dates with no sample (e.g., dry conditions at sampling point) are not shown

Table 2: Flow Measurements Collected September 2016

Station ID	Measurement Date	Flow Measurement (gpm)
Lucky Bill Creek SW03	9/6/2016	5
LUCKYBILL 1	9/6/2016	15
Lucky Bill Creek SW02	9/6/2016	15
Lucky Bill Creek SW01	9/6/2016	1.5

Table 3: SPLP Results for Groundhog No. 5 Stockpile

Sample Type	Sample ID	Depth Interval	Lithology	Sample Date	Al, Diss (mg/L)	Alk, CO3 (mg/L)	Alk, HCO3 (mg/L)	Alk, Tot. (mg/L)	As, Diss (mg/L)	Ca, Diss (mg/L)	Cd, Diss (mg/L)	Cl, Tot. (mg/L)	Co, Diss (mg/L)	Cr, Diss (mg/L)	Cu, Diss (mg/L)	F, Tot. (mg/L)	Fe, Diss (mg/L)	K, Diss (mg/L)	Mg, Diss (mg/L)	Mn, Diss (mg/L)	Na, Diss (mg/L)	Ni, Diss (mg/L)	Pb, Diss (mg/L)	pH, Field (SU)	SO4, Tot. (mg/L)	TDS (mg/L)	Zn, Diss (mg/L)
SPLP	GH5-1	0-2'	Limestone	2005	0.0604	<1.0	18.3	18.3	<0.0006	11.3	<0.0002	0.209	<0.0005	<0.0003	<0.0004	0.112	<0.0059	1.22	0.759	<0.0006	0.409	<0.0017	0.0013	6.28	16.3	5060	0.00052
SPLP	GH5-1	4'	Quartz Monzonite	2005	0.145	<1.0	21.79	21.79	<0.0006	8.82	<0.0002	0.221	0.00051	<0.0003	<0.0004	0.158	<0.0059	1.23	0.987	<0.0006	0.275	<0.0017	0.00085	6.4	9.93	60	0.00034
SPLP	GH5-1	6-10'	Quartz Monzonite	2005	0.0947	<1.0	29.4	29.4	0.0065	6.37	<0.0002	<0.2	<0.0005	<0.0003	<0.0004	<0.1	0.0068	1	1.18	0.0011	3.17	<0.0017	0.0011	6.39	3.67	55	0.00066
SPLP	GH5-1	12-16'	Quartz Monzonite	2005	0.407	<1.0	44.4	44.4	0.0016	5.5	<0.0002	<0.2	<0.0005	0.00075	0.0013	0.286	0.247	0.492	1.27	0.0061	15.6	<0.0017	0.002	6.52	7.74	99	0.0052
SPLP	GH5-1	18-20'	Colluvium	2005	1.28	<1.0	25	25	0.0036	6.57	<0.0002	0.777	0.0006	0.00042	0.0052	0.386	0.771	0.691	1.2	0.0247	4.07	<0.0017	0.0037	6.32	4.52	69	0.0095
SPLP	GH5-2	0-6"	Mineralized Limestone	2005	<0.0121	<1.0	30.3	30.3	<0.0006	128	0.00038	<0.2	<0.0005	<0.0003	<0.0004	0.289	0.0065	2	1.51	0.0462	0.876	<0.0017	0.0012	6.21	315	537	0.0016
SPLP	GH5-2	4-8"	Limestone	2005	0.0848	<1.0	12.2	12.2	0.00086	99	<0.0002	<0.2	0.00051	<0.0003	<0.0004	0.408	0.0068	2.36	4.69	0.0065	0.445	<0.0017	0.0011	6.31	268	445	<0.0003
SPLP	GH5-2	12-20'	Quartz Monzonite	2005	0.0983	<1.0	15.6	15.6	0.0031	21.8	0.0002	<0.2	<0.0005	<0.0003	<0.0004	0.308	<0.0059	2.95	2.26	0.0086	1.02	<0.0017	0.00093	6.24	55.8	117	<0.0003
SPLP	GH5-3	0-2'	Limestone	2005	0.155	<1.0	19.3	19.3	0.0008	7.95	0.00022	0.214	<0.0005	<0.0003	<0.0004	<0.1	<0.0059	1.2	0.908	0.00084	0.303	<0.0017	0.0011	6.54	8.38	41	<0.0003
SPLP	GH5-3	3A	Limestone	2005	0.196	<1.0	20.2	20.2	<0.0006	7.25	<0.0002	0.235	0.00057	0.00032	<0.0004	<0.1	<0.0059	1.26	0.838	<0.0006	0.329	<0.0017	0.00093	6.39	5.27	55	<0.0003
SPLP	GH5-4	0-3'	Limestone	2007	0.011	0	22.21	22.2	<0.0036	19.2	<0.0005	<0.2	<0.0002	0.00088	<0.0002	0.12	<0.017	1.37	0.554	0.0034	2.28	<0.0027	<0.0031	6.74	31.6	60	<0.0009
SPLP	GH5-5	0-18"	Limestone	2007	0.125	3.5	26.28	29.8	<0.0036	6.89	<0.0005	<0.2	<0.0002	0.00062	<0.0002	0.25	<0.017	0.916	1.34	<0.0015	2.06	<0.0027	<0.0031	8.52	2.46	20	<0.0009
SPLP	GH5-6	0-3'	Limestone / Quartz Monzonite	2007	0.15	4.56	24.57	29.1	<0.0036	6.65	<0.0005	<0.2	<0.0002	0.00049	<0.0002	0.26	<0.017	0.977	1.23	<0.0015	1.2	<0.0027	<0.0031	8.61	1.91	17	<0.0009
SPLP	GH5-7	0-6"	Limestone / Quartz Monzonite	2007	<0.0056	0	20.13	20.1	<0.0036	49.4	<0.0005	0.34	<0.0002	0.0014	<0.0002	<0.1	<0.017	1.37	0.592	0.0079	1.86	<0.0027	<0.0031	6.72	108	178	<0.0009
SPLP	GH5-8	0-3'	Limestone / Quartz Monzonite	2007	0.0156	0	21.02	21	<0.0036	53.3	<0.0005	0.26	<0.0002	0.00099	<0.0002	0.13	<0.017	1.8	1.98	0.0216	2.71	<0.0027	<0.0031	6.96	117	195	<0.0009
SPLP	GH5-Dup	0-3'	Limestone / Quartz Monzonite	2007	0.008	< 1	15.7	15.7	<0.0036	60.7	<0.0005	0.5	<0.0002	0.0011	<0.0002	0.1	<0.017	1.58	2.04	0.0096	3	<0.0027	<0.0031	6.34	137	221	<0.0009
SPLP	Colluvium	--	Colluvium	5/20/2014	36.2	<1	8.9	8.9	<0.025	7.03	<0.002	1.38	<0.006	0.0073	0.024	<0.5	13.7	6.85	9.96	0.226	<4	0.00756	0.0116	7.36	6.31	433	0.0388

Table 4: Summary of Modeled Water Qualities and Loading Estimates for the Groundhog No. 5 Stockpile

SPLP Sample Lithologies	Range of Modeled Sulfate Concentrations (mg/L) in Seepage for Different Infiltration Rates (1%, 15%, 20% and 60 % of Annual Precipitation)		
		Scaled for 50% Reactive Material	No Scaling Factor
Colluvium	Maximum	346	687
	Median	162	186
Limestone	Maximum	6,041	11,533
	Median	124	252
Limestone/Quartz Monzonite	Maximum	2,859	4,597
	Median	109	345
Quartz Monzonite	Maximum	2,548	3,876
	Median	150	200
SPLP Sample Lithologies	**Calculated Maximum Sulfate Loading (Kg/day)**		
	% of Annual Precipitation	**Scaled for 50% Reactive Material**	**No Scaling Factor**
Colluvium	60%	1.9	3.7
	20%	0.6	1.2
	15%	0.5	0.9
	1%	0.03	0.1
Limestone	60%	32.6	62.3
	20%	10.9	20.8
	15%	8.2	15.6
	1%	0.5	1.0
Limestone/Quartz Monzonite	60%	15.4	24.8
	20%	5.1	8.3
	15%	3.9	6.2
	1%	0.3	0.4
Quartz Monzonite	60%	13.8	20.9
	20%	4.6	7.0
	15%	3.4	5.2
	1%	0.2	0.3

Table 5: Lucky Bill Canyon Mass Loading Calculations

	Station	Measured Concentrations						Increase in Concentration per Stream Foot Distance to Each Station					
September 2016 Data		Chloride	Sulfate	TDS	Fluoride	Magnesium, dissolved	Copper, dissolved	Chloride	Sulfate	TDS	Fluoride	Magnesium, dissolved	Copper, dissolved
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	SW3	7.6	146	400	0.25	12.9	0.0049	0.001	0.019	0.04	0.00000	0.002	0.000001
	LB1	6.1	118	346	0.25	10.3	0.0036	0.001	0.030	0.06	0.00001	0.002	0.000000
	SW2	4.1	57.9	234	0.22	5.9	0.004	0.000	0.010	0.02	-0.00001	0.000	0.00000
	SW1	3.6	20.5	176	0.25	4.7	0.0138	na	na	na	na	na	na

	Station	Mass Load at Each Station						Mass Load per Stream Foot Distance to each Station					
Calculated Mass Load Based on Measured Flows		Chloride	Sulfate	TDS	Fluoride	Magnesium	Copper	Chloride	Sulfate	TDS	Fluoride	Magnesium	Copper
		kg/day	kg/day	kg/day	kg/day	kg/day	kg/day	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000
	SW3	0.21	3.97	10.89	0.01	0.35	0.0001	-0.20	-3.83	-11.76	-0.01	-0.33	-0.0001
	LB1	0.50	9.63	28.25	0.02	0.84	0.0003	0.08	2.44	4.55	0.00	0.18	0.0000
	SW2	0.33	4.73	19.11	0.02	0.48	0.0003	0.08	1.23	4.75	0.00	0.12	0.0001
	SW1	0.03	0.17	1.44	0.00	0.04	0.0001	na	na	na	na	na	na

	Station	Mass Load at Each Station						Mass Load per Stream Foot Distance to each Station					
Calculated Mass Load Based on Extrapolated Flow of 15 gpm for SW3		Chloride	Sulfate	TDS	Fluoride	Magnesium	Copper	Chloride	Sulfate	TDS	Fluoride	Magnesium	Copper
		kg/day	kg/day	kg/day	kg/day	kg/day	kg/day	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000	kg/ft/d*1000
	SW3	0.62	11.92	32.66	0.02	1.05	0.0004	0.08	1.55	2.99	0.0000	0.14	0.0001
	LB1	0.50	9.63	28.25	0.02	0.84	0.0003	0.08	2.44	4.55	0.0012	0.18	0.0000
	SW2	0.33	4.73	19.11	0.02	0.48	0.0003	0.08	1.23	4.75	0.0043	0.12	0.0001
	SW1	0.03	0.17	1.44	0.00	0.04	0.0001	na	na	na	na	na	na

Table 6: ABA Results for Stockpile Lithologic Components

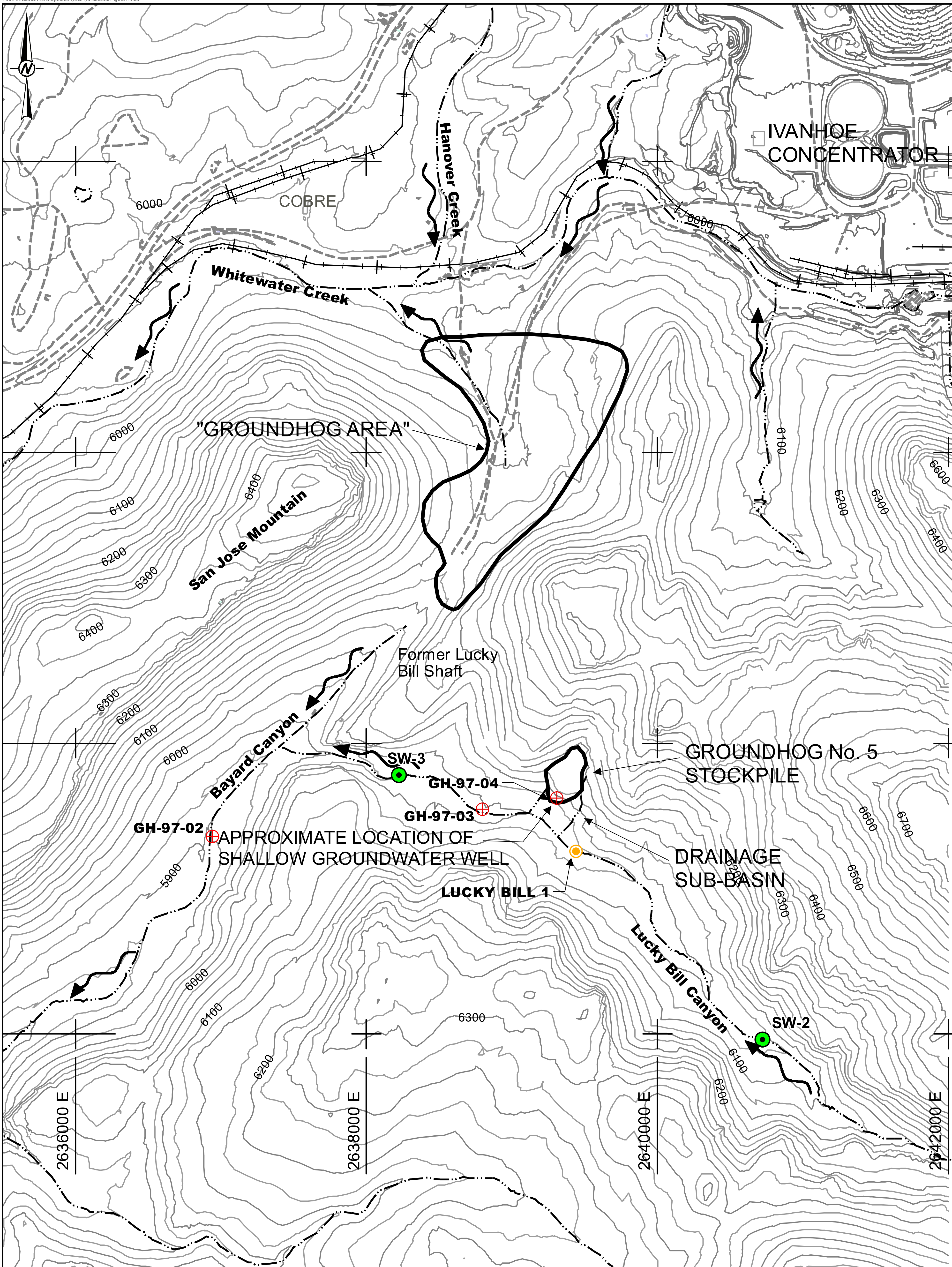
Sample	Sample Year	Depth	Lithology	Paste pH (s.u.)	Total Sulfur	Pyritic Sulfur	Sulfate Sulfur	Unident. Sulfur	Neutralization Potential (NP)	Acid Potential (AP; (based on Pyr-S)	NP/AP Ratio (Pyr-S)	Net Neutralization Potential
					(% as Sulfur)				tons CaCO3/Kton			tons CaCO3/Kton
GH5-1_0-2	2005	0' – 2'	Limestone	7.96	0.52	0.10	0.33	0.09	736	3.13	235	733
GH5-1_4	2005	4'	Quartz Monzonite	8.16	0.17	0.17	<0.01	0.01	769	5.31	145	764
GH5-1_6-10	2005	6' – 10'	Quartz Monzonite	8.09	<0.01	<0.01	<0.01	<0.01	64	<0.3	212	64
GH5-1_12-16	2005	12' – 16'	Quartz Monzonite	7.72	<0.01	<0.01	<0.01	<0.01	17	<0.3	55	17
GH5-1_18-20	2005	18' – 20'	Colluvium	8.39	<0.01	<0.01	<0.01	<0.01	14	<0.3	46	14
GH5-2_0-6	2005	0 – 6"	Mineralized Limestone	7.25	1.20	0.77	0.34	0.09	343	24.06	14	319
GH5-2_4-8	2005	4' – 8'	Limestone	7.61	0.24	0.03	0.20	0.01	452	0.94	481	451
GH5-2_12-20	2005	12' – 20'	Quartz Monzonite	7.69	0.35	0.25	0.09	0.01	99	7.81	13	92
GH5-3_0-2	2005	0 – 2'	Limestone	7.89	0.10	0.01	0.08	0.01	715	0.31	2308	715
GH5-3 – 3A	2005	Blind Field Duplicate 0 – 2'	Limestone	7.95	0.09	0.01	0.08	<0.01	768	0.31	2478	768
GH5-4	2007	0 – 3'	Limestone	7.86	0.45	<0.01	0.44	0.01	654	<0.30	>2181	654
GH5-5	2007	0 – 18"	Limestone	8.25	<0.01	<0.01	<0.01	<0.01	699	<0.30	>2329	699
GH5-6	2007	0 – 3'	Limestone / Quartz Monzonite	7.55	2.02	1.31	0.71	<0.01	568	40.94	14	527
GH5-7	2007	0 – 6"	Limestone / Quartz Monzonite	7.46	0.82	<0.01	0.82	<0.01	535	<0.30	>1783	535
GH5-8	2007	0 – 3'	Limestone / Quartz Monzonite	7.51	0.51	0.07	0.44	<0.01	448	2.19	205	446
GH5-Dup	2007	Field Duplicate 0 – 3'	Limestone / Quartz Monzonite	7.59	0.67	0.13	0.53	<0.01	443	4.06	109	439

Table 7: Results for Selected Modeled Saturation Indices

Sample ID	Sample Date	Measured Sulfate Concentrations (mg/l)	Saturation Indices			
			Ferrihydrite	Basaluminite	Gypsum	Calcite
GH-97-04	2-Aug-10	1720	1.0	-1.1	-0.05	-0.8
GH-97-04	22-Jul-13	1690	1.4	1.7	-0.1	-0.7
GH-97-04	12-Sep-13	1660	1.4	2.2	-0.04	-0.5
Lucky Bill Creek SW01	16-Sep-16	20.5	3.1	-1.1	-2.8	-0.9
Lucky Bill Creek SW02	6-Sep-16	57.9	2.6	-3.1	-2.2	-0.8
Lucky Bill Creek SW03	6-Sep-16	146	2.1	-8.2	-1.5	0.2
LUCKYBILL 1	6-Sep-16	118	2.6	-7.1	-1.7	-0.1
Lucky Bill Trench	30-Sep-14	2070	1.3	2.2	0.01	-0.4
Lucky Bill Trench	10-Feb-15	1680	1.8	2.2	-0.2	-0.1
Lucky Bill Trench	31-Aug-15	1530	3.0	1.8	-0.2	-0.2
Lucky Bill Trench	16-Mar-16	1430	3.3	0.5	-0.2	0.1
Lucky Bill Trench	8-Nov-16	1950	3.2	0.8	-0.1	-0.2
Lucky Bill Trench	15-Nov-16	1910	3.8	0.6	-0.05	0.2
Lucky Bill Trench	3-Feb-17	1820	3.9	1.6	-0.1	-0.1
Lucky Bill Trench	16-Feb-17	1860	3.1	2.1	-0.1	-0.3

FIGURES

Path: L:\Site\Chino\Maps\LuckyBillHydroModel\Figure1.mxd



LEGEND

- SHALLOW GROUNDWATER WELL
- APPROXIMATE SURFACE WATER SAMPLING LOCATION
- SEEP-INFLUENCED SURFACE WATER SAMPLING LOCATION
- SURFACE WATER SAMPLING LOCATION
- WATER COURSE
- DIRECTION OF FLOW

NOTES

1. CONTOUR INTERVAL = 25 FEET

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEW MEXICO WEST FIPS 3003 FEET

CLIENT
FREEPORT-MCMORAN CHINO MINES COMPANY
HURLEY, NEW MEXICO

PROJECT
GROUNDHOG NO. 5 WORK PLAN FOR ADDITIONAL CHARACTERIZATION AND CONTROLS

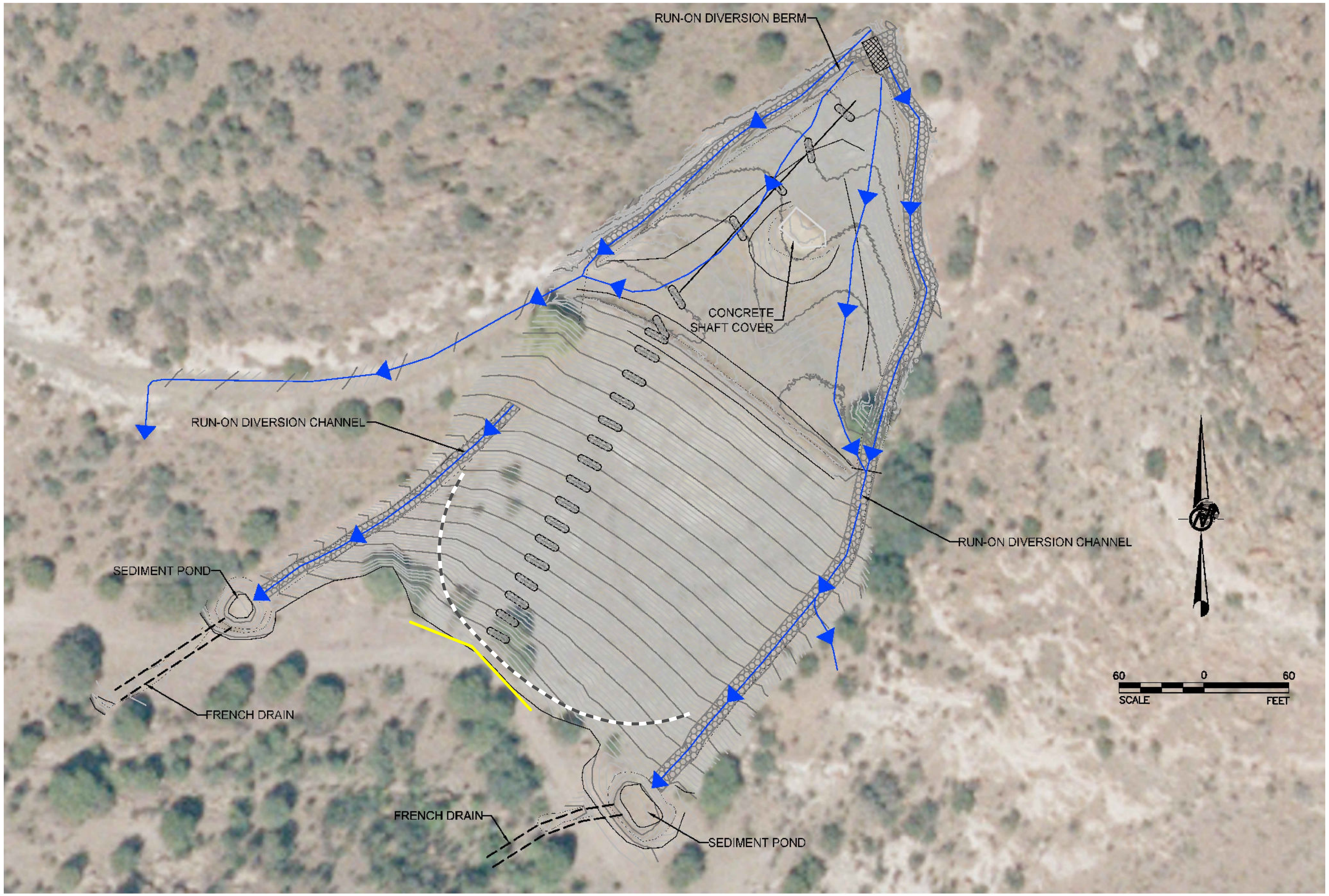
TITLE
GROUNDHOG NO. 5 STOCKPILE LOCAITON AND ADJACENT GROUNDWATER WELLS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-12-20
PREPARED	DZF
DESIGN	DZF
REVIEW	JP
APPROVED	MB

PROJECT No.	REVIEW	FIGURE
1403873	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:



LEGEND

FLOW

DOWNHILL TOE OF STOCKPILE MATERIALS

GROUNDHOG NO. 5 STOCKPILE SEEPAGE COLLECTION TRENCH

NOTES

REFERENCE

1. DRAWING PROVIDED BY TELESTO SOLUTIONS INCORPORATION AFTER REGRADING IN 2006

CLIENT
FREEPORT-MCMORAN CHINO MINES COMPANY
HURLEY, NEW MEXICO

PROJECT
GROUNDHOG NO. 5 WORK PLAN FOR ADDITIONAL CHARACTERIZATION AND CONTROLS

TITLE
GROUNDHOG NO. 5 STOCKPILE – 2014 IMPROVED DRAINAGE MODIFICATION

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-12-19
PREPARED	DZF
DESIGN	DZF
REVIEW	JP
APPROVED	MB

PROJECT No.	Rev.	FIGURE
1403873	1	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI B

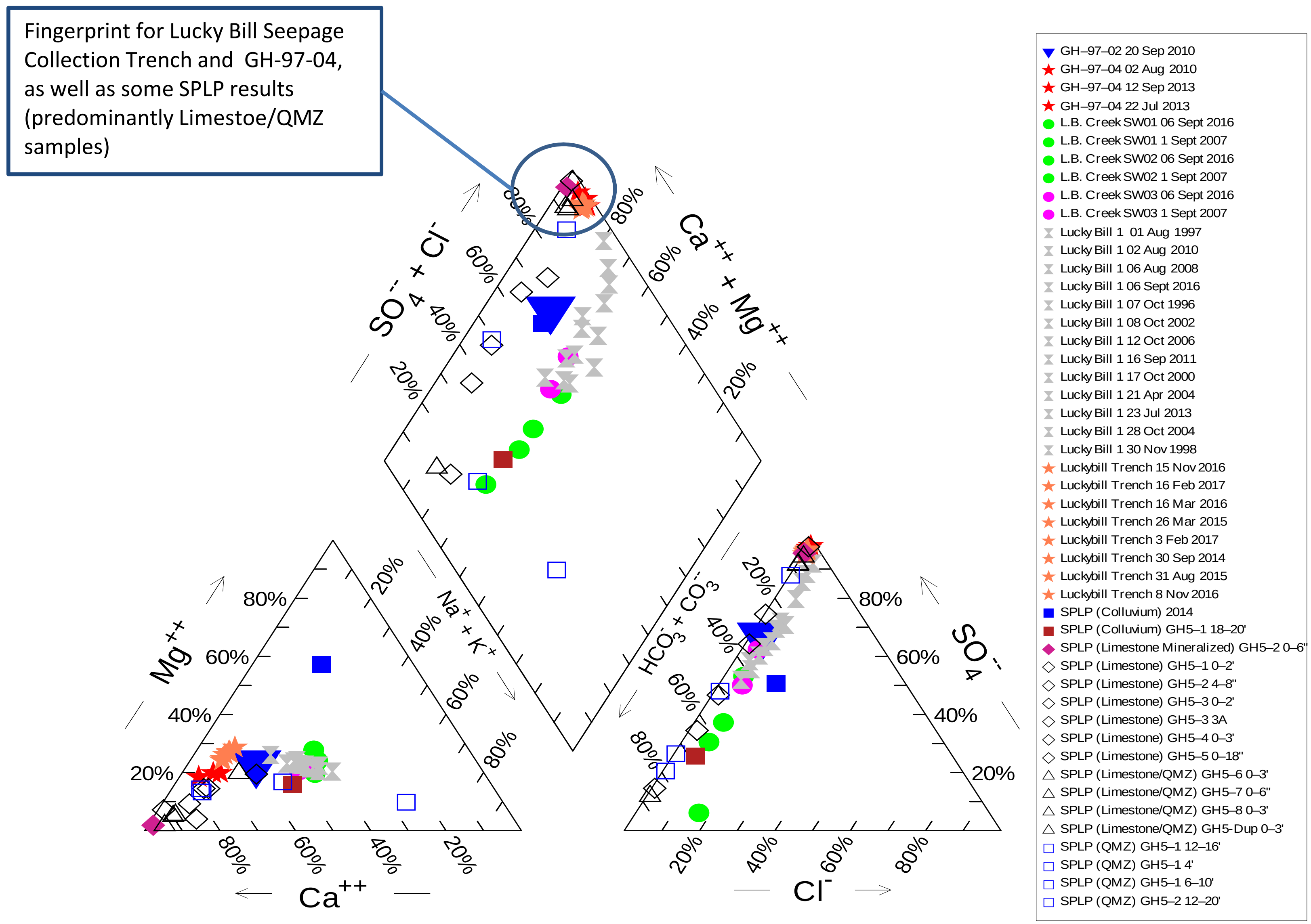


Figure 3

Piper Diagram

Technical Memorandum

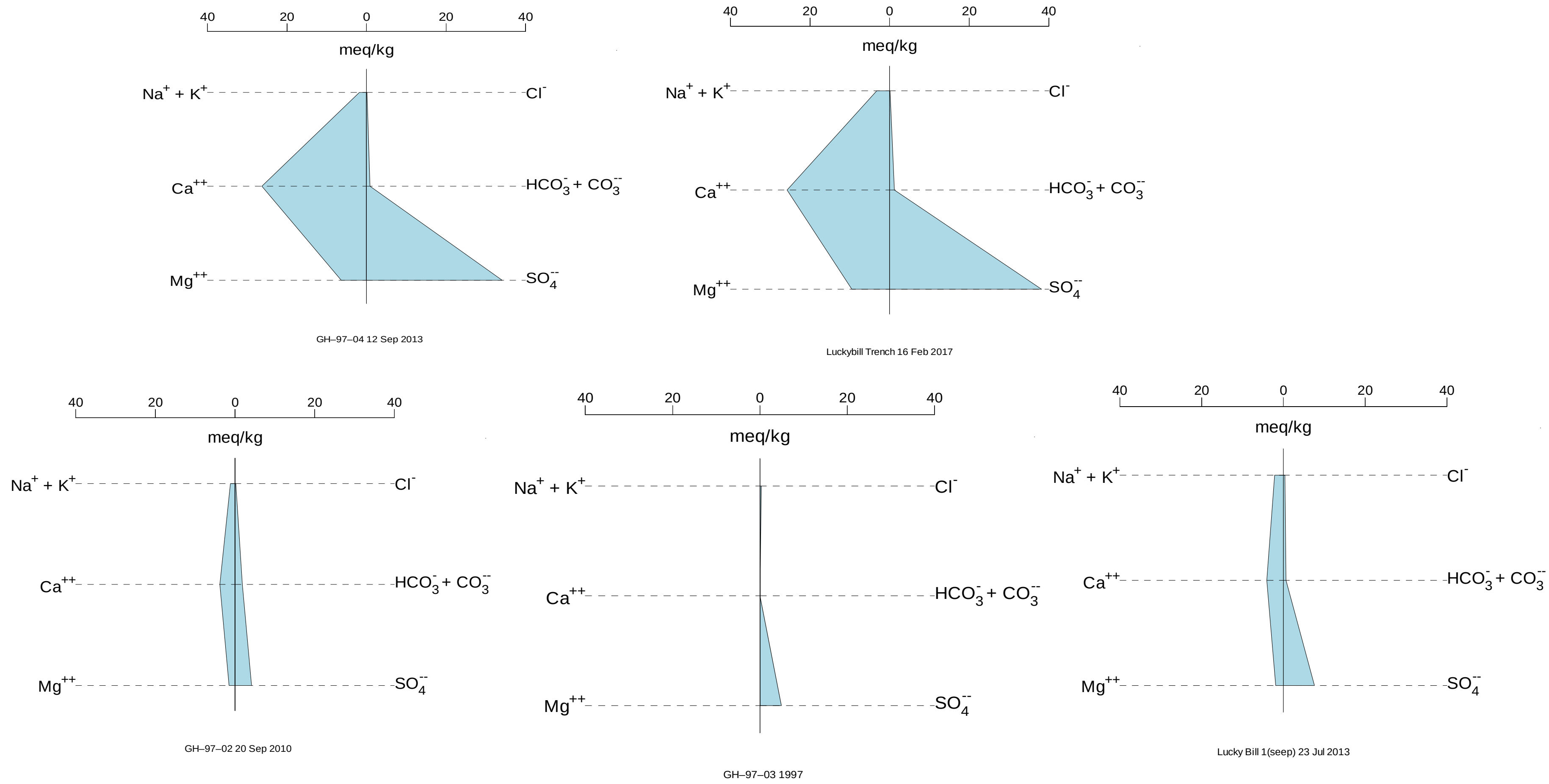
Groundhog No. 5 Stockpile Goochemical Evaluation

Golder Associates

Lakewood, Colorado, USA

2/27/2018

1665189



Notes:

-Results for GH-97-03 from 1997 and do not include full cation/anion data

Figure 4

Stiff Diagrams Comparing Seepage Collection Well, Seepage Collection Trench, and Groundwater Chemistries

Technical Memorandum

Groundhog No. 5 Stockpile Goochemical Evaluation

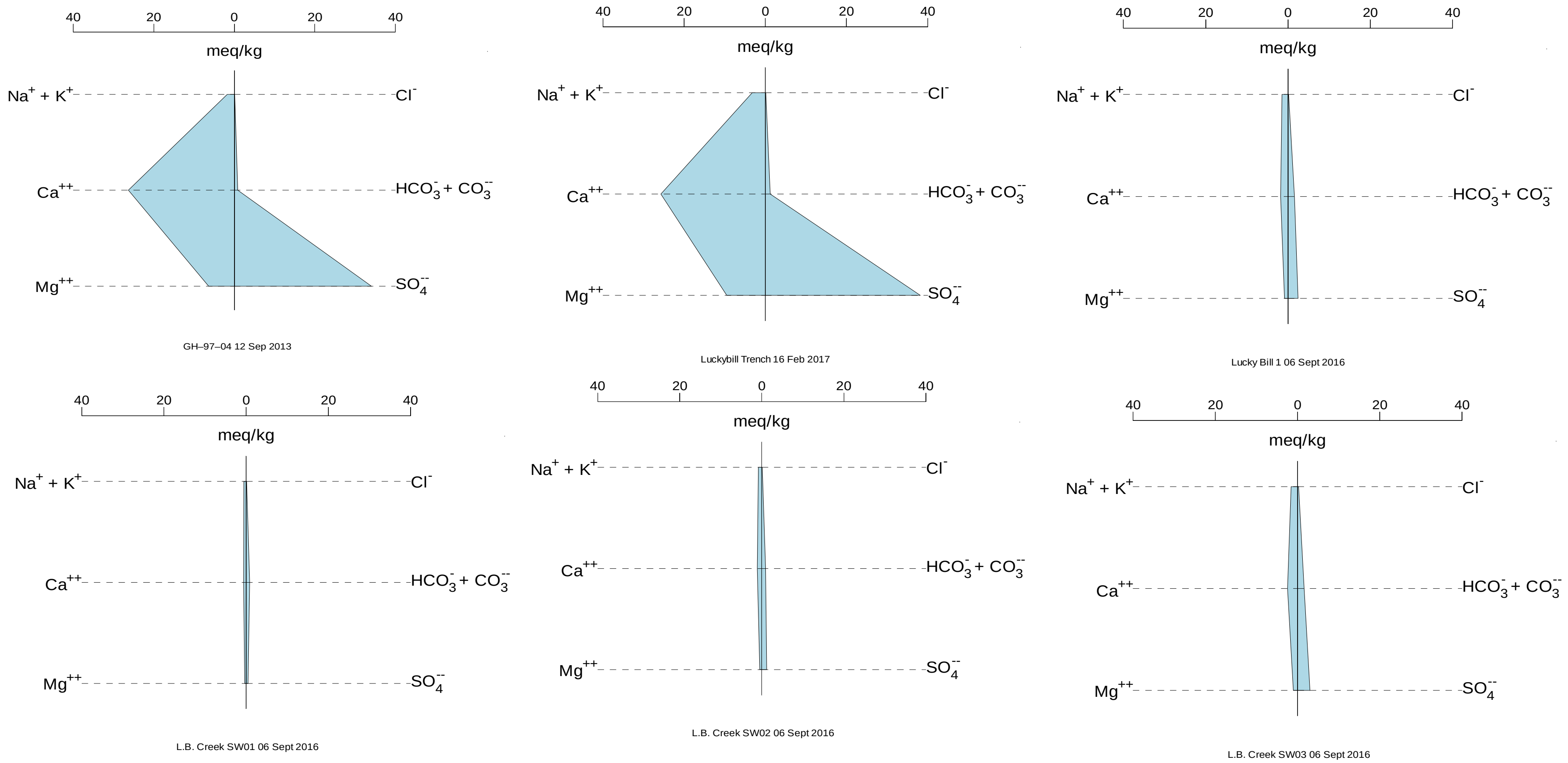


Figure 5

Stiff Diagrams Comparing Stockpile Seepage Collection Trench/Well and Surface Water Chemistries

Technical Memorandum

Groundhog No. 5 Stockpile Goochemical Evaluation

Lakewood, Colorado, USA

2/27/2018

1665189

Golder Associates

LEGEND

WELL LOCATION

SURFACE WATER SAMPLING LOCATION

Sampling Notes:

-Results for SW-1, SW-2, SW-3, and LB1 for the same day (Sept 2016).

-Results for GH-97-04 & Trench from September 2013 and March 2015, respectively

-Results for GH-97-03 from 1997

600 300 0 600 Feet

1 inch = 600 feet

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE NEW MEXICO WEST FIPS 3003 FEET

SERVICE LAYER CREDITS: ESRI, USDA FARM SERVICE AGENCY

CLIENT

FREEPORT-MCMORAN CHINO MINES COMPANY

HURLEY, NEW MEXICO

PROJECT

GROUNDHOG NO. 5 WORK PLAN FOR ADDITIONAL CHARACTERIZATION AND CONTROLS

TITLE

STIFF DIAGRAMS BY SAMPLING LOCATION

CONSULTANT	
YYYY-MM-DD	2018-02-21
PREPARED	DZF
DESIGN	DZF
REVIEW	JP
APPROVED	MB

Golder Associates

PROJECT No.	Rev.	FIGURE
1665189	1	6