Copper Flat Mine

Order 1 Soil Survey of Permit Area

Prepared For:
THEMAC Resources Group, Ltd.

September 14, 2011

STETSON ENGINEERS INC.

WATER RESOURCE PROFESSIONALS
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Executive Summary

Stetson Engineers Inc. was retained by New Mexico Copper Corporation to conduct a soil survey of the Copper Flat copper mine near Hillsboro, NM to assess the quantity of available topdressing material that would be available for mine reclamation. An Order 2 Soil Survey (1:12000) was completed in May, 2011 within the 2000-acre permit area. Approximately 1000 acres with potential topdressing sources were identified for characterization in an Order 1 Soil Survey (1:6000). The Order 1 Survey logged soil characteristics on 183 sites. These data were used to select 21 representative sites for full profile descriptions using freshly dug pits. Evaluation of these data resulted in classification of twelve soil taxonomic units and seventeen map units on about 425 acres with topdressing materials that met the suitability criteria. The median depth of available topdressing material in the map units ranged from 1 to 14 feet. These map units will yield approximately 3,391,000 cubic yards, or 2,100 acre-feet of suitable topdressing materials.

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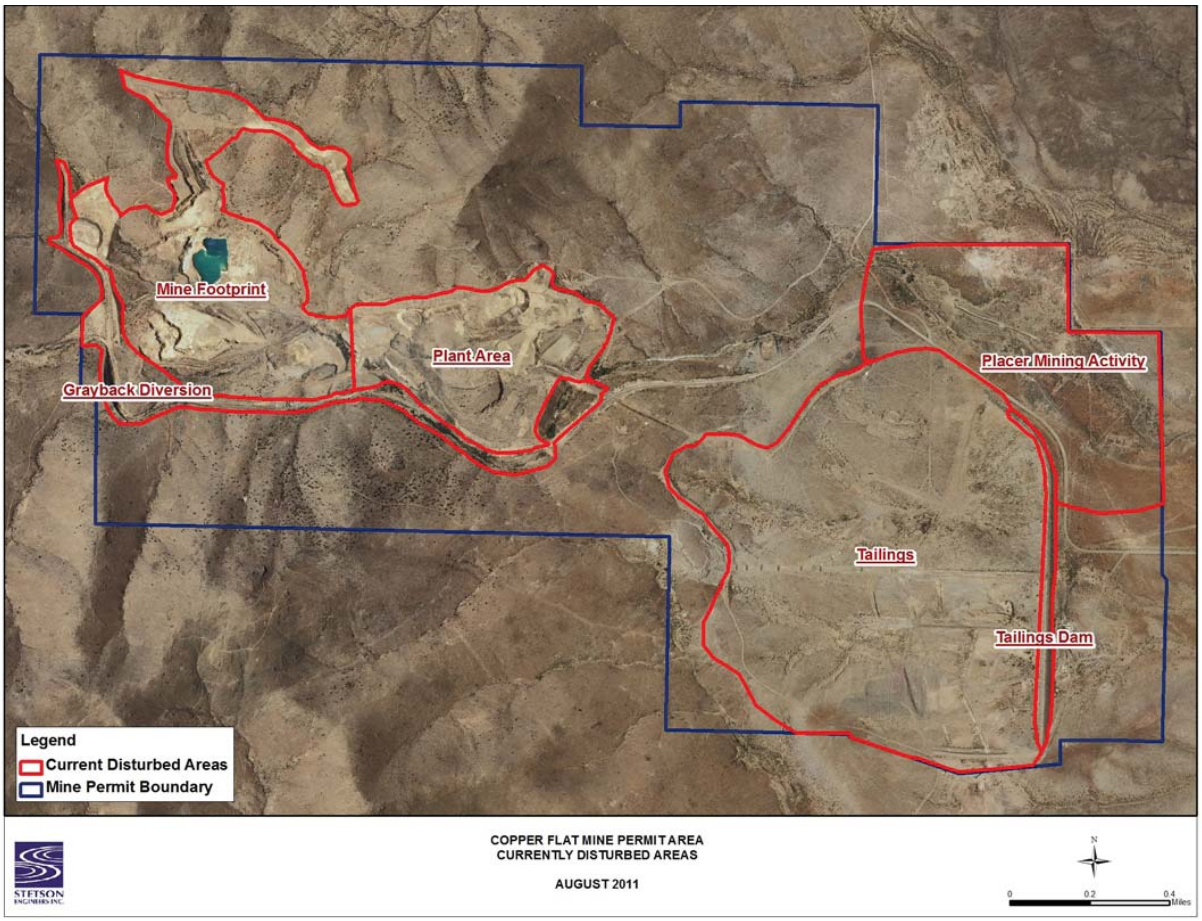
1.0 Introduction

Quintana Minerals Corporation developed and briefly operated a porphyry copper mine in the early 1980s. THEMAC Resources Group, Ltd. is evaluating resuming mining and milling operations, and is developing the materials required to obtain the permit to resume operations. The permit area includes about 2000 acres (Figure 1). The existing tailings storage facility occupies about 500 acres on the east end of the permit area. The mine, plant and Grayback Arroyo diversion occupies about 350 acres on the west end of the permit area, consisting of the pit and several levels of constructed benches containing no source of topdressing materials.

Grayback Arroyo has been diverted south of the mine, rejoining the original course east of the mine proper. Several placer gold claims have been active on Grayback Arroyo, and much of the flood plain and lower terraces have been disturbed and spoils piles are found throughout the Wash in the permit area. Some claims were also active within the current tailings storage facility area, and spoils piles are common along small arroyos and ephemeral drainage features. The tailings storage facility was reclaimed with topdressing materials.

Figure 1 Copper Flat Mine Permit Area with Previously-Disturbed Areas Identified



The Sierra County Area, New Mexico Soil Survey (Soil Survey Staff, 1983) is in MLRA 42, Southern Desertic Basins, Plains, and Mountains. An Order 3 survey, mapped at a scale of 1:48,000 (1.3 miles/inch) exists for the portion of the county where the permit area is located (Appendix A). This level of detail maps primarily at the association or consociation level. The smallest unit that can be shown on a map at this scale is about 25 acres. Soil consociations are named after the dominant soil, and may include up to 25 percent of unnamed soils that do not significantly affect management, or 15 percent of unnamed soils that would alter management practices. Associations contain two or more soils occurring in repeatable patterns that could be mapped at the given scale, and that differ in morphology or management. Associations may include up to 25 percent of unnamed soils that do not affect the management, or 15 percent of unnamed soils that would alter management practices. Four map units occur within the permit area.

The soils on the east end near Grayback and Greenhorn Arroyos generally formed in mixed gravelly alluvium, on gently sloping talf (flat plain) and treads (terraces) of fan piedmonts. All soils are deep and well-drained. Most of the soils have calcic horizons at some depth with varying calcium carbonate contents. Some of the soils have argillic horizons (and higher clay contents), and hold more plant available water. Most of the soils are nonsaline and nonsodic. Most soils have greater coarse fragment (cobbles and/or gravel) content in the lower horizons than in the A horizon. The soils in Grayback and Greenhorn Arroyos formed in mixed alluvium on nearly level to gently sloping floodplains and stream terraces. These landscape positions are younger and less stable so the soils tend to show less morphological development than those on the fan piedmont talf and treads. The soils in the west portion of the permit area formed on limestone or igneous residuum and colluvium, and tend to be steeper and shallow over bedrock, with rock outcrops.

These materials were reviewed by Stetson Engineers, Inc., prior to conducting an Order 2 Soil Survey which was mapped at a 1:12000 (1" = 1000') scale. Descriptions were made at 21 sites in the permit area to develop map unit concepts. The purpose of this survey was to identify areas that are potential topdressing sources, so areas without such potential were excluded from further evaluation. The Order 2 Soil Survey identified 12 map units, of which several were identified for closer examination in the Order 1 Soil Survey.

An Order 1 Soil Survey was conducted on approximately 1000 acres. Transects were identified across every occurrence of all Order 2 map units to delineate boundaries and determine the variability in properties existing within map units. Transects extended beyond the boundaries of the Order 2 map units to identify their extent. There were 183 log sites chosen along these transects. The majority of the log sites were in the east end of the permit area where the landscape has lesser slopes, where there was a greater likelihood that suitable topdressing materials existed. Approximately 80 log sites were described outside the tailings storage facility, 70 inside it, and 30 on the west end around the mine. No protocol was necessary for identifying

materials below free water or a water table, as neither was present on surveyed areas during sampling in June and July, 2011.

After evaluating the 183 log sites, several variations within the original Order 2 map units were found. These were evaluated and 21 sites were chosen to evaluate for the Order 1 Soil Survey at a 1:6000 (0.5" = 1000') scale (Soil Survey Staff, 1996). Backhoe pits were dug at 19 sites, and 2 pits were dug by hand (on BLM land) for pedon description and sample collection.

Descriptions of soil profiles (pedons) followed standard NRCS Soil Survey Staff protocols (Soil Survey Staff, 1996). External attributes were recorded: Location, physiography, relief, slope, aspect, parent material, indications of salt or alkali, moisture, stoniness, presence of shallow groundwater, erosion, and vegetation. These characteristics were recorded for each horizon: Depth, boundaries, dry and moist colors, texture by feel, structure, consistence, visual estimate of gravel and cobbles, effervescence, presence of roots, and presence of redoximorphic features, illuvial clays, carbonate accumulations, gypsum accumulations, and/or other features, when present. Following these descriptions, soil diagnostic horizons were identified and the soil was classified to the family level in Soil Taxonomy (Soil Survey Staff, 2010). Interpretations from the profile descriptions include drainage, permeability, and available water holding capacity. Samples were collected from representative horizons for lab testing.

The standard (Tier 1) lab tests included: USDA soil texture (sand, silt and clay percentages, Schoenberger et al., 2002) using the 6-hr hydrometer method (Gee and Orr, 2002), pH (Thomas, 1996), electrical conductivity on an extract of a saturated paste (ECe, Rhoades, 1996), calcium, magnesium, sodium (SPAC, 1999), and sodium adsorption ratio (Sumner and Miller, 1996). Additional tests conducted on specified samples included soil organic matter by loss on ignition (Nelson and Sommers, 1996), nitrate-nitrogen (USEPA, 1978a), phosphorus (USEPA, 1978b), calcium carbonate equivalent (Loeppert and Suarez, 1996), and sand size fraction (Gee and Orr, 2002). Samples inside the tailings facility or mine were screened (Tier 2) for arsenic (As), boron (B), cadmium (Cd), calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), potassium (K), nickel (Ni), sodium (Na), sulfur (S), and zinc (Zn) using an acid extraction (USEPA, 1996) and ICP detection (USEPA, 2007a), and chloride (Cl) (APHA, 2005), mercury (Hg) (USEPA, 2007b), selenium (Se) (Huang and Fujii, 1996), and acid-base potential which includes total sulfur (Tabatabai, 1996) and neutralization potential (Lawrence and Wang, 1997). Plant available fractions were determined with AB-DTPA extraction and ICP detection (SPAC , 1999).

Characterization of these profiles resulted in the selection of a representative profiles for each of the twelve taxonomic units, described in detail in Section 3.2.1 of this report. Those twelve taxonomic units were further subdivided into map units based upon the thickness of suitable topdressing material. The thickness of suitable material is indicated in each depth phase was represented as an addendum to the map unit symbol as follows:

-1 0 to 2 feet;
-2 2 to 4 feet;
-3 4 to 8 feet;
-4 8 to 12 feet;
-5 12 to 16 feet.

Map units are described in Section 3.2.2.

2.0 Determination of Suitability for Topdressing Material

2.1 Factors affecting Topdressing Suitability

Several factors may affect the suitability of soil materials for use as topdressing during reclamation. Steep slopes limit harvesting topdressing materials due to increased erosion potential and the difficulty in establishing vegetation to restabilize the slope. Soil texture, the relative amount of sand, silt, and clay, affects water available to plants (available water holding capacity, AWHC), rate of water movement into and through the soil, and seed-soil contact during germination. Cobbles and gravel decrease the total porosity, thereby decreasing the available water holding capacity. Cobbles and stones affect agricultural management equipment, though that is not an issue for this project. Stones decrease the available water holding capacity and increase the difficulty in harvesting and spreading the topdressing materials. Calcium carbonate accumulations are common in semiarid and arid regions as caliche, which limits nutrient availability, affects hydraulic properties, and may limit root growth at high concentrations. The available water holding capacity determines how much water a soil can hold against gravity and release to a plant. Soil pH affects nutrient availability, especially for micronutrients. Salinity competes with plant roots for water in the soil, decreasing the effective plant available water. Sodium has little impact on plants, but as a dispersing cation degrades soil structure and alters water movement into and through the soil. Selenium toxicity in range plants is rare, but there are accounts of selenium toxicity to livestock. Boron at high concentrations may be toxic to some plants. Acid/base accounting is a common practice for the reclamation of mine spoils.

New Mexico Mining and Minerals Division required additional soil tests that are not addressed in the suitability criteria, but that will be discussed with the presentation of the soil test results.

2.2 Criteria for Topdressing Suitability

Three suitability categories were identified: Good, fair, and unsuitable. Each pedon included in this report received a good or fair rating, though materials below the suitable materials may be unsuitable. Areas identified in the Order 2 and Order 1 surveys that had no suitable materials are not included in this report.

The suitability criteria standards for these soil and landscape features (Table 1) have been adapted from those used by the Natural Resources Conservation Service, and New Mexico Mining and Minerals Division. They were modified by project soil scientists to reflect the conditions that exist within the Copper Flat Mine permit area.

Table 1 Soil and Site Evaluation as Source for Topdressing[1], Copper Flat Mine[2], New Mexico

Soil/Landscape Property	Limits			Restrictive Feature
	Good	Fair	Unsuitable	
Slope %	<15	15-25	>25	Too Steep
Texture	-	SCL, CL, SiCL	C, SiC, SC	Too Clayey
Texture	-	LVFS, LCOS, LS, LFS	COS, S, FS,VFS	Too Sandy
Cobble + Gravel %	<35	35-60	>60	Too Cobbly
Stones %	<5	5-15	>15	Too Stony
$CaCO_3$ Eq. %	<15	15-40	>40	Excess Lime
AWHC (in/in)	>0.1	0.05-0.1	<0.05	Droughty
Soil pH	<8.5	<8.5	≥8.5	Too Alkaline
Salinity (ECe, dS/m)	<4	4-8	>8	Excess Salt
SAR	<ECe x 5	<ECe x 5	<ECe x 5	Excess Sodium
Selenium (ppm)	<0.1	<0.1	≥0.1	Excess Selenium
Boron (ppm) DTPA, available	<6.0	<6.0	≥6.0	Excess Boron
Acid/Base Potential	> -5 tons $CaCO_3$/1000 T	> -5 tons $CaCO_3$/1000 T	≤ -5 tons $CaCO_3$/1000 T	High acid-forming potential

1. Topdressing: Soil material suitable for use as cover material and plant establishment. It may or may not be near the soil surface.
2. These guidelines apply only to the Copper Flat Mine project area, so soil parameters that do not exist within this project site are not incorporated into this table.

2.2.1 Explanation of Limits of Acceptability (Table 1)

Slope affects the ability to harvest the topdressing materials, and the ability to reclaim the harvested area. Steep slopes at Copper Flat Mine typically have shallow soils over bedrock and sparse vegetation. Removing the topsoil and vegetation would increase the potential to erode the remaining materials, and make stabilizing the remaining surface difficult because of difficulties in establishment of replacement vegetation. Areas with slopes less than 15 percent are classified as good, while slopes greater than 25 percent are unsuitable.

Soil texture has two extremes. Soils with too much sand are coarse, hold little plant available water, and do not provide a good media for seed germination. Coarse-textured soils are too sandy, and are unsuitable. Clay soils have such small pores that water movement through them is very slow, creating problems with infiltration, permeability and drainage, which may limit oxygen to the plant root zone. When dry, clay soils are hard, limiting root extension. Fine-textured soils are too clayey, and are unsuitable. Moderately-coarse and moderately-fine textured soils have fair suitability Medium-textured soils have good suitability.

Cobble (3- to 10-in diameter) and gravel (2-mm to 3-in diameter) content, or coarse fragments, primarily affect available water holding capacity at Copper Flat Mine. The Soil Taxonomy (Soil Survey Staff, 2010) and USDA limits (Schoenberger et al., 2002) for texture modifiers are used. Very gravelly or cobbly soils are skeletal (>35% rock fragments) and have fair suitability, while soils with greater than 60 percent coarse fragments are unsuitable. The upper limit is somewhat conservative, as soils with 70 percent gravel/cobble content and texture of loam or finer remain suitable for available water holding capacity. Several healthy vegetative communities currently exist on soils with high gravel content at Copper Flat Mine (Figure 2).

Figure 2 Vegetative Community with Gravel Content (2a) >55% and (2b) 70%.

2a.

2b.

Stones (10- to 25-in diameter) increase the difficulty in harvesting the materials, uniformly spreading the materials during reclamation, and in reseeding and revegetation. Soils with greater than 15 percent stones, the USDA modifier limit (Schoenberger et al., 2002) for stony textures, are unsuitable.

Calcium carbonate buffers the soil pH to slightly to moderately alkaline and limits availability of micronutrient metals to plants. These carbonates have very fine particle size, and at high concentrations may plug soil pores, limiting water movement through the soil. Many semiarid and most arid region soils have calcium carbonate accumulations. Calcic horizons (Soil Survey Staff, 2010) are classified when the secondary calcium carbonate accumulation in a horizon reaches 15 percent. At 40 percent, plugging of the pores in calcic horizons occurs. At this stage, root growth into the horizon becomes limited, and roots may be observed growing horizontally along the upper horizon boundary. Many thriving plant communities exist on soils with calcic horizons of less than 40 percent calcium carbonate (Figure 3). Using topdressing materials with high calcium carbonate concentrations would limit seedling germination and plant growth, so anything with greater than 40 percent calcium carbonate equivalent is unsuitable.

Figure 3 Vegetative Community with (3a) Calcic/Petrocalcic Horizon and (3b) >40% Gravel Content Over Strong Calcic Horizon.

3a.

3b.

Available water holding capacity (AWHC) in a native soil is primarily a function of soil organic matter, structure, texture, and depth, and is secondarily affected by coarse fragment content and salinity. The impact of soil structure is difficult to assess in the field, so field estimates of AWHC use the texture, depth, and gravel/cobble content of each horizon. This may be adjusted for salinity if lab results reveal it necessary. Since these materials will be harvested and used for topdressing materials, the total profile AWHC (inches) is not important, so the weighted average AWHC (in/in) for the suitable materials is used. Soils with less than 0.05 in/in are prone to drought and have difficulty sustaining healthy plant communities.

The primary impact of soil pH is on plant nutrient availability. Nutrient availability is extremely limited in strongly alkaline soils (pH ≥8.5), so such soils are unsuitable.

Salts compete with plants for water, so salinity limits plant growth, and especially affects seed germination and seedling growth. The conductivity of the soil saturated-paste extract (ECe) is a measure of the salinity. Many arid region plants are tolerant to slightly saline soils (4 ≤ ECe < 8 dS/m), but growth of most plants is affected at higher salinity levels. Unsuitable soils have salinity in of 8 dS/m or greater.

Sodium is not an issue for plants, but for soil. High concentrations of sodium ions disperse soil particles, resulting in plugging of pores and reductions in movement of water into and through the soil. Calcium and magnesium are flocculating ions and will partially mitigate the impact of sodium ions. The sodium adsorption ratio (SAR) considers the concentration of sodium relative to calcium and magnesium. Sodic soils have an SAR > 13. Soluble salts in the soil solution mitigate the sodium impact. Therefore, the effect of sodium on the soil must be considered in the context of the salinity level. Unsuitable soils have an SAR greater than five times the salinity (ECe).

Selenium and boron may be toxic to plants, but research regarding soil test levels associated with toxicity thresholds is limited. Selenium may accumulate in livestock grazing on plants growing on seleniferous soils, which average 4 to 5 ppm Se (Barker and Pilbeam, 2007). The available boron levels in most soils ranges from 0.5 to 5 ppm, which are not considered toxic (Barker and Pilbeam, 2007). The laboratory detection limit for boron in these samples was 6 ppm.

The acid/base potential considered the acid-forming potential of the total sulfur versus the acid neutralization potential of the calcium carbonate. Soils with high acid-forming potential are unsuitable, as they would require excessive amounts of lime during reclamation.

3.0 Description of the Soils

3.1 Explanation of Format

This section presents a detailed description of each type of soil mapped in the Order 1 Soil Survey (Table 2). The first section (Section 3.1.1, Soil Profile Descriptions of Taxonomic Units) is a technical profile description taken at a representative location of each named soil. This includes a discussion of the entire range of properties that occur within all areas mapped as that named soil. These descriptions are in conformance with the format and standards used in the National Cooperative Soil Survey Program (Soil Survey Staff, 1996).
The next section (Section 3.1.2, Soil Map Unit Descriptions) is a relatively brief discussion of the properties of each map unit. The soil taxonomic units were subdivided (according to depth) into map units which represent specific depth ranges of suitable material as it occurs in the project area. For example, the Typic Haplocambid soil ranges in depth from a few feet of suitable material up to several feet. In order to accurately quantify the volume of suitable topdressing material, it is necessary to map this soil in discreet units according to the thickness that material. Consequently, this soil was mapped as four distinct map units. Five depth phases were used in this report:

Depth phase	Depth range
-1	0 to 2 feet;
-2	2 to 4 feet;
-3	4 to 8 feet;
-4	8 to 12 feet;
-5	12 to 16 feet.

3.1.1. Soil Profile Descriptions of Taxonomic Units

All taxonomic units listed in Table 2 have suitable topdressing materials. Table 3 summarizes the suitability and limiting factors for each of the taxonomic units for which the descriptions follow.

Table 2 Copper Flat Mine Soil Survey, Order 1 Soil Taxonomic Units, Representative Sites and Classification

Taxonomic Unit	Site	Map Units	Soil Classification
Argic Petrocalcid	BH13	104-1	fine, smectitic, thermic Argic Petrocalcids
Calcidic Argiustoll	BH21	105-1	fine, smectitic, thermic Calcidic Argiustolls
Haplic Torriarent, loamy-skeletal	BH20	112-3	loamy-skeletal, mixed, superactive, calcareous, thermic Haplic Torriarents
Haplic Torriarent, tailings substrata	BH14	103-1	fine-loamy, mixed, superactive, calcareous, thermic Haplic Torriarents
Pachic Argiustoll	BH17	107-3	fine-loamy, mixed, superactive, thermic Pachic Argiustolls
Typic Calciargid, fine	BH18	110-1	fine, smectitic, thermic Typic Calciargids
Typic Calciargid, fine-loamy	BH11	111-1	fine-loamy, mixed, superactive, thermic Typic Calciargids
Typic Haplargid, clayey-skeletal	BH12	106-1	clayey-skeletal, smectitic, thermic Typic Haplargids
Typic Haplargid, fine	BH22	102-1 102-2	fine, smectitic, thermic Typic Haplargids
Typic Haplocambid	BH08	101-2 101-3 101-4 101-5	fine-loamy, mixed, superactive, thermic Typic Haplocambids
Typic Torriorthent, calcareous	79P	109-3 109-4	loamy-skeletal, mixed, superactive, calcareous, thermic Typic Torriorthents
Typic Torriorthent, nonacid	BH04	108-4	loamy-skeletal, mixed, superactive, nonacid, thermic Typic Torriorthents

Table 3 Copper Flat Mine Topdressing Suitability by Taxonomic Unit after Mixing Horizons that Meet Suitability Criteria

Taxonomic Unit	Taxon	Suitability	Limiting Factors
Argic Petrocalcid	104	Fair	Too clayey, Cobble+gravel
Calcidic Argiustoll	105	Fair	Too clayey, Cobble+gravel, Excess lime
Haplic Torriarent, loamy-skeletal	112	Fair	Too clayey, Cobble+gravel, Excess lime
Haplic Torriarent, tailings substrata	103	Fair	Too clayey, Cobble+gravel
Pachic Argiustoll	107	Fair	Too clayey, salinity
Typic Calciargid, fine	110	Fair	Too clayey
Typic Calciargid, fine-loamy	111	Fair	Too clayey, Cobble+gravel, Excess lime
Typic Haplargid, clayey-skeletal	106	Fair	Too clayey, Cobble+gravel
Typic Haplargid, fine	102	Fair	Too clayey
Typic Haplocambid	101	Good	
Typic Torriorthent, calcareous	109	Fair	Too clayey, Cobble+gravel
Typic Torriorthent, nonacid	108	Fair	Cobble+gravel

Taxonomic Unit: **Argic Petrocalcid**
Soil Classification: **fine, smectitic, thermic Argic Petrocalcid**
Map Unit: **104-1**

Argic Petrocalcid soils are moderately deep, alluvial soils that occur on eroded fan terrace remnants in the east part of the permit area (below the dike). These soils typically have loam to loamy sand surface layers underlain by clay loam and/or clay with gravel and cobble content ranging up to 30 percent by volume.

Typical pedon: A representative pedon of Argic Petrocalcid soils is located between Grayback and Greenhorn Arroyos, in the eastern part of the permit area (Site BH-13, UTM NAD83 Zone 13S 266753E 3649720N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 4.

A - 0 to 3 inches; brown (7.5YR 4/4) loamy sand, dark brown (7.5YR 3/4) moist; single grain; loose, loose, non-sticky and non-plastic; common medium and fine roots; estimated 10% gravel by volume; noneffervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bt1 - 3 to 12 inches; yellowish red (5YR 4/6) cobbly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; few coarse and common medium roots; common faint clay films; estimated 10% gravel and 20% cobble by volume; slightly effervescent; moderately alkaline (pH 7.9); clear wavy boundary.

Bt2 - 12 to 21 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; strong fine and medium prismatic parting to strong fine and medium angular blocky; hard, friable, very sticky and very plastic; few coarse and fine and common medium roots; many distinct thick clay films; estimated 5% gravel and 1% cobble by volume; strongly effervescent; few threads of carbonates below 18 inches; moderately alkaline (pH 7.9); clear wavy boundary.

Bkk - 21 to 32 inches; very pale brown (10YR 8/2) gravelly loam, very pale brown (10YR 8/3) moist; weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; common (15%) fine masses plugging pores, estimated 20% small hard gravel-size caliche fragments, 20% gravel and 5% cobble by volume; violently effervescent; nearly continuous carbonate coatings on rock fragments; moderately alkaline (pH 8.0); gradual wavy boundary.

Bkk/Bkkm - 32 to 54 inches; pinkish white (7.5YR 8/2), pink (7.5YR 7/4) moist; 70% cemented petrocalcic, 30% Bkk materials as above.

Range in characteristics:

The organic matter in the surface horizon is 3.4 percent.
The ochric horizon (A) ranges in thickness from 3 to 5 inches.
The argillic horizon (Bt1, Bt2) ranges in thickness from 15 to 20 inches.
These soils have a calcic horizon and a petrocalcic horizon (cemented caliche).

The rock fragment content ranges from 10 to 30 percent by volume and is dominantly gravel. These soils are commonly noneffervescent to slightly effervescent at the surface and violently effervescent in the lower strata.

Figure 4 Argic Petrocalcid Representative Pedon (Site BH-13) Profile (4a) and Landscape (4b).

4a

4b

Taxonomic Unit: **Calcidic Argiustoll**
Soil Classification: **fine, smectitic, thermic Calcidic Argiustoll**
Map Unit: **105-1**

Calcidic Argiustoll soils are deep, alluvial soils that occur on eroded fan terrace remnants in the east part of the permit area (below the dike). These soils typically have loam to clay loam surface layers underlain by loam, clay loam and/or clay with gravel and cobble content ranging from 15 to 35 percent by volume in the upper 3 feet.

Typical pedon: A representative pedon of Calcidic Argiustoll soils is located south of Greenhorn Arroyo, in the eastern part of the permit area (Site BH-21, UTM NAD83 Zone 13S 266935E 3649121N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 5.

Desert pavement -1 to 0 inches

A - 0 to 8 inches; dark yellowish brown (10YR 3/4) sandy clay loam, dark brown (10YR 3/3) moist; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; common very fine, fine and medium roots; estimated 5% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); clear wavy boundary.

Btk1 - 8 to 17 inches; dark brown (7.5YR 3/4) gravelly clay loam, dark brown (7.5YR 3/3) moist; weak course prismatic parting to moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; common very fine and fine roots; few faint patchy clay films; estimated 20% gravel and 5% cobble by volume; strongly effervescent; few threads of carbonates; moderately alkaline (pH 7.9); clear wavy boundary.

Btk2 - 17 to 24 inches; yellowish red (5YR 4/6) clay, reddish brown (5YR 4/4) moist; moderate fine prismatic parting to moderate medium subangular blocky; moderately hard, friable, very sticky and very plastic; common very fine and fine roots; many continuous thin clay films on ped faces; estimated 10% gravel by volume; strongly effervescent; few threads of carbonates; moderately alkaline (pH 7.9); abrupt wavy boundary.

Bkk - 24 to 38 inches; white (7.5YR 9.5/1) sandy clay loam, pinkish white (7.5YR 8.5/2) moist; weak medium subangular blocky; soft, friable, slightly sticky and slightly plastic; many fine masses of carbonate plugging pores; estimated 10% gravel by volume; violently effervescent; nearly continuous carbonate coatings on rock fragments; moderately alkaline (pH 7.9); clear wavy boundary.

Bk1 - 38 to 67 inches; pinkish white (7.5YR 8/2) extremely gravelly clay loam, brown (7.5YR 5/4) moist; weak medium subangular blocky; soft, friable, moderately sticky and moderately plastic; common (15%) fine masses of carbonates; estimated 80% gravel by

volume; violently effervescent; nearly continuous carbonate coatings on rock fragments; moderately alkaline (pH 7.9); clear wavy boundary.

Bk2 - 67 to 79 inches; pink (7.5YR 7/3) extremely gravelly clay loam, yellowish red (5YR 5/6) moist; weak medium subangular blocky; soft, friable, moderately sticky and moderately plastic; estimated 60% gravel and 10% cobble by volume; strongly effervescent; common carbonate coatings on rock fragments; moderately alkaline (pH 7.9); clear wavy boundary.

Range in characteristics:

The organic matter in the surface horizon is 3.5 percent.
The mollic horizon (A and upper part of argillic) ranges in thickness from 8 to 20 inches.
The argillic horizon (Btk1, Btk2) ranges in thickness from 6 to 16 inches.

The calcic horizon likely ranges in thickness from 10 to 20 inches. The calcic horizon is underlain by a horizon with somewhat stratified fine gravels with discontinuous lenses of calcic materials up to 2 inches thick at various depths.

The rock fragment content ranges from 0 to 30 percent by volume and is dominantly gravel. These soils are commonly strongly effervescent at the surface and violently effervescent in the lower strata.

Figure 5 Calcidic Argiustoll Representative Pedon (Site BH-21) Profile (5a) and Landscape (5b).

5a

5b

Taxonomic Unit:	**Haplic Torriarent, loamy-skeletal**
Soil Classification:	**loamy-skeletal, mixed, superactive, calcareous, thermic Haplic Torriarent**
Map Unit:	**112-3**

Haplic Torriarent, loamy-skeletal soils are constructed soils that occur in the southwest portion of the existing tailings facility. These soils typically have loam to clay loam surface layers underlain by clay loam with gravel and cobble content ranging from 10 to 40 percent by volume.

Typical pedon: A representative pedon of Haplic Torriarent soils is located west of the dike in the existing tailings facility (Site BH-20, UTM NAD83 Zone 13S 266082E 3649215N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 6.

A - 0 to 6 inches; yellowish brown (10YR 5/4) gravelly sandy clay loam, dark yellowish brown (10YR 4/4) moist; moderate, medium platy; soft, very friable, moderately sticky and moderately plastic; common very fine, fine and medium roots; estimated 25% gravel and 5% cobble by volume; violently effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

C1 - 6 to 35 inches; yellowish brown (10YR 5/4) and light gray (10YR 7/2) very cobbly sandy clay loam, brown (7.5YR 4/4) and pale brown (10YR 6/3) moist; weak medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; few fine and very fine roots; estimated 20% gravel and 20% cobble by volume; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

C2 - 35 to 52 inches; yellowish brown (10YR 5/4) very cobbly sandy clay loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky; very hard, very firm, moderately sticky and moderately plastic; few fine roots; estimated 20% gravel and 20% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

C3- 52 to 84 inches; pink (7.5YR 7/3) and reddish brown (5YR 4/4) gravelly sandy clay loam, brown (7.5YR 5/3) and reddish brown (5YR 4/4) moist; weak medium subangular blocky; very hard, very firm, moderately sticky and moderately plastic; estimated 12% gravel and 5% cobble by volume; parts of matrix violently effervescent, others slightly effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

C4 - 84 to 110 inches; brown (7.5YR 5/4) and reddish brown (5YR 4/4) clay loam, reddish brown (5YR 4/3) and dark reddish brown (5YR 3/3) moist; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; few medium roots; few soft carbonate masses; estimated 5% gravel and 5% cobble by volume; violently effervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic matter in the surface horizon is 2.4 percent.
The ochric horizon (A) ranges in thickness from 2 to 10 inches.
There is little or no pedogenic development in these constructed soils. There are several thin to discontinuous calcic lenses below 6 inches created during construction. Much of the materials between 35 and 84 inches are highly compacted.

The rock fragment content ranges from 20 to 40 percent by volume and is dominantly gravel. These soils are commonly strongly to violently effervescent throughout.

Figure 6 Haplic Torriarent, Loamy-Skeletal Representative Pedon (Site BH-20) Profile (6a) and Landscape (6b).

6a

6b

Taxonomic Unit:	**Haplic Torriarent, tailings substrata**
Soil Classification:	**fine-loamy, mixed, superactive, calcareous, thermic Haplic Torriarent**
Map Unit:	**103-1**

Haplic Torriarent soils are deep, constructed soils that occur in the existing tailings storage facility in the east part of the permit area (inside the dike). These soils were constructed circa 1986 during reclamation of the tailings facility. These soils typically have 10 to 40 inches of sandy loam to loam to clay loam surface layers underlain by tailings of very fine sandy loam to sandy loam to loam, with gravel and cobble content above the tailings ranging from 15 to 35 percent by volume. Tailings north of the east-west berm show evidence of being limed.

Typical pedon: A representative pedon of Haplic Torriarent, tailings substrata soils is located west of the dike in the eastern part of the permit area (Site BH-14, UTM NAD83 Zone 13S 266373E 3649855N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 7.

A - 0 to 12 inches; brown (7.5YR 5/3) sandy clay loam, brown (7.5YR 4/3) moist; weak medium subangular blocky; hard, friable, moderately sticky and moderately plastic; common very fine, fine and medium roots; estimated 20% gravel and 5% cobble by volume; strongly effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

C1 – 12 to 20 inches; light gray (2.5Y 7/2) fine sandy loam, light olive brown (2.5Y 5/3) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very fine, common fine and coarse roots; slightly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary.

C2 - 20 to 60 inches; pale brown (2.5Y 7/4) fine sandy loam, light olive brown (2.5Y 5/4) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very, common fine and coarse roots; noneffervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic matter in the surface horizon is 1.9 percent.
The ochric (A) horizon ranges in thickness from 4 to 12 inches.

The rock fragment content ranges from 15 to 35 percent by volume and is dominantly gravel. These soils are commonly strongly effervescent at the surface and slightly effervescent to noneffervescent in the tailings, likely dependent upon amendments during reclamation.

Figure 7 Haplic Torriarent, Tailings Substrata Representative Pedon (Site BH-14) Profile (7a) and Landscape (7b,c).

7a

7b

7c

Taxonomic Unit:	**Pachic Argiustoll**
Soil Classification:	**fine-loamy, mixed, superactive, thermic Pachic Argiustoll**
Map Unit:	**107-3**

Pachic Argiustoll soils are deep, alluvial soils that occur in valleys between fan terrace remnants in the east part of the permit area, and in a valley in the northwest part of the permit area, north of the mine. These soils typically have loam to gravelly sandy loam surface layers underlain by loam, clay loam and/or clay with gravel and cobble content ranging up to 15 percent by volume in the upper 4 feet. Some areas have an overburden of up to 6 inches of recent deposits.

Typical pedon: A representative pedon of Pachic Argiustoll soils is located about midway between Greenhorn and Grayback Arroyos, in the eastern part of the permit area (Site BH-17, UTM NAD83 Zone 13S 266625E 3649602N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 8.

A1 - 0 to 6 inches; brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium subangular blocky; slightly hard, friable, slightly sticky and moderately plastic; many very fine and common medium roots; estimated <1% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

A2 - 6 to 14 inches; brown (10YR 4/3) clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky parting to moderate medium granular; hard, friable, slightly sticky and moderately plastic; common fine and few medium and coarse roots; estimated <1% gravel by volume; noneffervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Bt - 14 to 29 inches; brown (10YR 4/3) clay loam, dark brown (10YR 3/3) moist; weak medium prismatic parting to moderate medium angular blocky; hard, friable, moderately sticky and moderately plastic; common very fine and few fine and medium roots; common thick clay films on ped faces; estimated <1% gravel by volume; noneffervescent; slightly alkaline (pH 7.7); gradual smooth boundary.

Bk - 29 to 40 inches; brown (7.5YR 5/4) clay loam, brown (7.5YR 4/4) moist; weak medium angular blocky; hard, friable, moderately sticky and moderately plastic; few threads of carbonates on ped faces; estimated <1% gravel by volume; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Btkb - 40 to 58 inches; brown (7.5YR 4/3) sandy clay loam, dark brown (7.5YR 3/4) moist; weak medium angular blocky; hard, friable, very sticky and moderately plastic; few thin clay films on ped faces; few threads of carbonates on ped faces; estimated <1% gravel by volume; strongly effervescent; moderately alkaline (pH 8.1); clear smooth boundary.

Bkkb - 58 to 80 inches; pinkish white (7.5YR 8/2) clay loam, light brown (7.5YR 6/4) moist; massive; extremely hard, friable, moderately sticky and moderately plastic; many fine masses of carbonate plugging pores; estimated <1% gravel by volume; violently effervescent; moderately alkaline (pH 8.0).

Range in characteristics:

The organic matter in the surface horizon is 3.9 percent.
The mollic horizon (A and upper part of argillic) ranges in thickness from 20 to 26 inches.
The argillic horizon (Bt) ranges in thickness from 15 to 37 inches.
The calcic horizon (Bkkb), when present, ranges in thickness from 10 to 22 inches.

The rock fragment content ranges from 0 to 15 percent by volume and is dominantly gravel. The gravel/cobble content below 4 feet ranges up to 45 percent. These soils commonly are noneffervescent in the surface or buried horizon, strongly effervescent in overburden material at surface, and violently effervescent in the lower strata. Some horizons in some areas are slightly saline and one horizon was sodic.

Figure 8 Pachic Argiustoll Representative Pedon (Site BH-17) Profile (8a) and Landscape (8b).

8a

8b

Taxonomic Unit: **Typic Calciargid, fine**
Soil Classification: **fine, smectitic, thermic Typic Calciargid**
Map Unit: **110-1**

Typic Calciargid soils are deep, mixed alluvial and colluvial soils that occur on fan terrace remnants in the southwest part of the tailings facility. These soils typically have gravelly loam to sandy clay loam surface layers underlain by clay loam to sandy clay loam with gravel and cobble content ranging up to 20 percent by volume in the upper 3 feet.

Typical pedon: A representative pedon of Typic Calciargid soils is located about in the southwest part of the tailings facility (Site BH-18, UTM NAD83 Zone 13S 265680E 3649473N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 9.

A - 0 to 7 inches; brown (10YR 5/3) sandy clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky parting to moderate fine subangular blocky; slightly hard, friable, slightly sticky and moderately plastic; many very fine, fine and medium roots; estimated 5% gravel by volume; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Btk - 7 to 24 inches; brown (7.5YR 5/4) gravelly sandy clay loam, brown (7.5YR 4/4) moist; moderate fine angular blocky; hard, firm, moderately sticky and moderately plastic; many very fine and fine, and common medium roots; few thin clay films on ped faces; common soft carbonate masses; estimated 15% gravel and 5% cobble by volume; violently effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bkk - 24 to 64 inches; white (10YR 8/1) sandy clay loam, light gray (10YR 7/2) moist; massive; slightly hard, very friable, very sticky and moderately plastic; few very fine roots; estimated 5% gravel and 5% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

R – 64 inches; carbonate encrusted andesite.

Range in characteristics:

The organic matter in the surface horizon is 2.9 percent.
The ochric horizon (A) ranges in thickness from 7 to 9 inches.
The argillic horizon (Btk) ranges in thickness from 15 to 37 inches.
The calcic horizon (Bkk) ranges in thickness from 20 to 40 inches.

The rock fragment content ranges up to 15 percent by volume and is dominantly gravel. These soils commonly are strongly to violently effervescent throughout the profile. Some areas slightly saline horizons below 9 inches.

Figure 9 Typic Calciargid, Fine Representative Pedon (Site BH-18) Profile (9a) and Landscape (9b,c).

9a

9b

9c

Taxonomic Unit:	**Typic Calciargid, fine-loamy**
Soil Classification:	**fine-loamy, mixed, superactive, thermic Typic Calciargid**
Map Unit:	**111-1**

Typic Calciargid, fine-loamy soils are deep, colluvial soils that occur on fan terrace remnants in the northwest part of the tailings facility. These soils typically have gravelly loam to very gravelly sandy loam surface layers underlain by loam to clay loam with gravel and cobble content ranging from 15 to 35 percent by volume in the upper 5 feet.

Typical pedon: A representative pedon of Typic Calciargid soils is located about in the northwest part of the tailings facility (Site BH-11, UTM NAD83 Zone 13S 266006E 3649936N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 10.

A1 - 0 to 3 inches; dark yellowish brown (10YR 4/4) gravelly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; estimated 15% gravel and 5 % cobble by volume; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

A2 – 3 to 10 inches; dark yellowish brown (10YR 4/4) sandy clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; common very fine, fine and medium roots; estimated 5% gravel and 5 % cobble by volume; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Btk1 - 10 to 17 inches; yellowish red (5YR 5/6) gravelly clay loam, yellowish red (5YR 4/6) moist; moderate fine angular blocky; moderately hard, friable, moderately sticky and moderately plastic; few very fine roots; common moderately thick clay films on ped faces; estimated 10% gravel and 5% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Btk2 - 17 to 26 inches; pink (7.5YR 7/3) gravelly sandy clay loam, brown (7.5YR 5/4) moist; moderate fine angular blocky; soft, very friable, moderately sticky and moderately plastic; few very fine and medium roots; few thin clay films on ped faces; estimated 10% gravel and 10% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); clear irregular boundary.

Bkk - 26 to 57 inches; white (7.5YR 9.5/1) gravelly loam, pinkish white (7.5YR 8/2) moist; weak moderate angular blocky; slightly hard, friable, moderately sticky and moderately plastic; violently effervescent; moderately alkaline (pH 8.3).

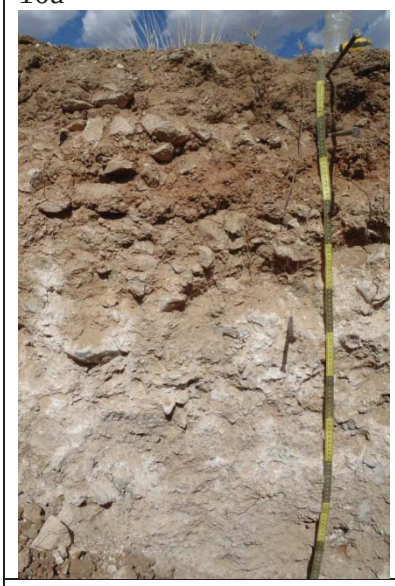
Range in characteristics:

The organic matter in the surface horizon is 3.3 percent.
The ochric horizon (A) ranges in thickness from 2 to 10 inches.
The argillic horizon (Btk1, Btk2) ranges in thickness from 10 to 26 inches.
The calcic horizon (Bkk) ranges in thickness from 20 to 40 inches.

The rock fragment content ranges from 15 to 35 percent by volume and is dominantly gravel. These soils commonly are violently effervescent throughout the profile.

Figure 10 Typic Calciargid, Fine-Loamy Representative Pedon (Site BH-11) Profile (10a) and Landscape (10b,c).

10a



10b

10c

Taxonomic Unit:	**Typic Haplargid, clayey-skeletal**
Soil Classification:	**clayey-skeletal, smectitic, thermic Typic Haplargid**
Map Unit:	**106-1**

Typic Haplargid, clayey-skeletal soils are deep, alluvial soils that occur on fan terrace remnants in the northeast part of the permit area, south of Grayback Arroyo, and in the west portion of the permit area, south of the Grayback Arroyo diversion. These soils typically have sandy loam to very gravelly loam surface layers underlain by clay loam and clay with gravel and cobble content ranging from 35 to 60 percent by volume in the upper 5 feet.

Typical pedon: A representative pedon of Typic Haplargid soils is located about in the northwest part of the tailings facility (Site BH-12, UTM NAD83 Zone 13S 266920E 3649973N). The soil was examined in a freshly-excavated hand-dug pit. The landscape is shown in Figure 11.

A1 - 0 to 5 inches; brown (7.5YR 4/4) sandy loam, dark brown (7.5YR 3/4) moist; weak medium and fine subangular blocky; soft, very friable, slightly sticky and slightly plastic; common very fine and fine roots; estimated 10% gravel and 1 % cobble by volume; noneffervescent; slightly alkaline (pH 7.7); clear wavy boundary.

Bt1 – 5 to 10 inches; yellowish red (5YR 4/6) very cobbly clay loam, dark reddish brown (5YR 3/4) moist; moderate medium prismatic parting to moderate fine subangular blocky; moderately hard, friable, moderately sticky and moderately plastic; many fine and common medium roots; many thin clay films on ped faces; estimated 20% gravel and 30 % cobble by volume; noneffervescent; slightly alkaline (pH 7.8); clear wavy boundary.

Bt2 - 10 to 24+ inches; red (2.5YR 4/6) very cobbly clay, dark red (2.5YR 3/6) moist; strong fine prismatic parting to strong fine and medium angular blocky; extremely hard, friable, moderately sticky and very plastic; few medium roots; many thick 2.5YR 3/4 clay films on ped faces; estimated 30% gravel and 30% cobble by volume; noneffervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic carbon in the surface horizon is 3.4 percent.
The ochric horizon (A) ranges in thickness from 2 to 10 inches.
The argillic horizon (Btk1, Btk2) ranges in thickness from 18 to 32 inches.

The rock fragment content ranges from 35 to 60 percent by volume and is dominantly cobbles. These soils commonly are noneffervescent throughout the profile.

Figure 11 Typic Haplargid, Clayey-Skeletal Representative Landscape (11a,b).

11a

11b

Taxonomic Unit: **Typic Haplargid, fine**
Soil Classification: **fine, smectitic, thermic Typic Haplargid**
Map Unit: **102-1; 102-2**

Typic Haplargid, fine soils are deep, residual soils formed in weathering shale that occur on fan terrace remnants in the southeast part of the tailings facility and in the west part, south of the Grayback Arroyo diversion. These soils typically have loam to clay loam surface layers underlain by clay loam and clay with gravel and cobble content less than 1 percent by volume in the upper 4 feet.

Typical pedon: A representative pedon of Typic Haplargid soils is located about midway between Greenhorn and Greyback Arroyos, in the south part of the tailings facility, near the dike (Site BH-22, UTM NAD83 Zone 13S 266381E 3648924N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 12.

A1 - 0 to 13 inches; light brown (7.5YR 6/4) clay loam, brown (7.5YR 4/4) moist; moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; many very fine and common fine and medium roots; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Btk - 13 to 30 inches; light reddish brown (5YR 6/4) silty clay loam, reddish brown (2.5YR 4/4) moist; strong fine angular blocky; hard, friable, very sticky and moderately plastic; few fine and medium roots; common thin clay films on ped faces; few threads of carbonates on ped faces; violently effervescent; moderately alkaline (pH 8.1); clear smooth boundary.

Bt - 30 to 51 inches; reddish brown (2.5YR 5/4) clay, dark reddish brown (2.5YR 3/4) moist; strong medium angular blocky; very hard, firm, very sticky and very plastic; few very fine and fine roots; common thick clay films on ped faces; strongly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary.

Cr - 51 to 90 inches; reddish brown (2.5YR 4/3) clay, dark reddish brown (2.5YR 3/4) moist; strong coarse angular blocky parting to strong fine angular blocky; extremely hard, firm, very sticky and very plastic; strongly effervescent; moderately alkaline (pH 7.9).

Range in characteristics:

The organic matter in the surface horizon is 3.1 percent.
The ochric horizon (A) ranges in thickness from 3 to 13 inches.
The argillic horizon (Bt) ranges in thickness from 36 to 48 inches.
The Cr is likely weathered shale with rock structure.

The rock fragment content is less than 10 percent by volume and is dominantly gravel. These soils commonly are strongly effervescent in the surface and violently effervescent in the lower strata.

Figure 12 Typic Haplargid, Fine Representative Pedon (Site BH-22) Profile (12a) and Landscape (12b).

12a

12b

Taxonomic Unit:	**Typic Haplocambid**
Soil Classification:	**fine-loamy, mixed, superactive, thermic Typic Haplocambid**
Map Units:	**101-2; 101-3; 101-4; 101-5**

Typic Haplocambid soils are deep, alluvial soils that occur on terraces along drainageways in the northeast part of the permit area (below the dike) and in small isolated areas in the northwest part of the area. These soils typically have loam surface layers underlain by loam, sandy loam, silt loam, and/or sand, with gravel and cobble content ranging up to 35 percent by volume.

Typical Pedon: A representative pedon of Typic Haplocambid soils (Map unit 101-5) is located near Grayback Arroyo in the northeast part of the permit area (Site BH-8, UTM NAD83 Zone 13S 266516E 3650592N). The profile and landscape are shown in Figure 13.

A - 0 to 11 inches; yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 3/4) moist; weak thin play structure overlying weak medium and coarse subangular blocky; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; slightly effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

Bw1 – 11 to 18 inches; dark yellowish brown (10YR 4/4) gravelly sandy loam, dark yellowish brown (10YR 3/4) moist; weak coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; estimated 20% gravel and 5% cobble by volume; slightly effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

Bw2 – 18 to 26 inches; brown (7.5YR 4/4) silt loam, dark brown (7.5YR 3/4) moist; weak medium prismatic parting to weak medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic; common very fine and fine roots; slightly effervescent; moderately alkaline (pH 7.9); clear wavy boundary.

Bw3 – 26 to 34 inches; brown (7.5YR 4/4) sandy loam, dark brown (7.5YR 3/4) moist; weak coarse prismatic parting to weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; slightly effervescent; moderately alkaline (pH 7.9); abrupt wavy boundary.

C1 – 34 to 46 inches; dark yellowish brown (10YR 4/4) very gravelly coarse sand, dark yellowish brown (10YR 3/4) moist; single grain; loose, loose, nonsticky and nonplastic; few medium and fine roots; estimated 40% gravel by volume; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

C2 – 46 to 63 inches; dark yellowish brown (10YR 3/6) sand, dark yellowish brown (10YR 3/4) moist; single grain; soft, very friable, nonsticky and nonplastic; few fine and medium roots; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

C3 – 63 to 87 inches; brown (10YR 5/3) coarse sand, brown (10YR 4/3) moist; single grain; loose, loose, nonsticky and nonplastic; few medium roots; noneffervescent; strongly alkaline (pH 8.5); abrupt wavy boundary.

C4 – 87 to 120+ inches; brown (7.5YR 5/4) gravelly coarse sand, brown (7.5YR 4/4) moist; single grain; loose, loose, nonsticky and nonplastic; estimated 30% gravel by volume; noneffervescent; strongly alkaline (pH 8.5).

Range in Characteristics:

The organic matter in the surface horizon is 2.1 percent.
The ochric horizon (A) ranges in thickness from 5 to 20 inches.
The cambic horizon (Bw) ranges in thickness from 20 to 40 inches.

The soil is quite variable within short distances in some areas due to alluvial deposition processes, as well as past mining activities. The rock fragment content ranges from 5 to 25 percent by volume and is dominantly gravel. These soils are commonly slightly effervescent to strongly effervescent in the upper part, and may be noneffervescent in some strata. The substrata of this soil range from sandy loam to light clay loam and may be as much as 16 feet thick.

Figure 13 Typic Haplocambid Representative Pedon (Site BH-8) Profile (13a) and Landscape (13b,c).

13a

13b

	13c 

Taxonomic Unit:	**Typic Torriorthent, calcareous**
Soil Classification:	**loamy-skeletal, mixed, superactive, calcareous, thermic Typic Torriorthent**
Map Units:	**109-3; 109-4**

Typic Torriorthent, calcareous soils are deep, alluvial soils that occur on valley terraces and floors in the west part of the tailings facility and along Grayback Arroyo. These soils typically have sandy loam to loam to clay loam surface layers underlain by alluvial deposits with varying textures with gravel and cobble content ranging from 35 to 60 percent by volume.

Typical pedon: A representative pedon of Typic Torriorthent soils is located in a small valley in the central western part of the tailings facility (Site 79P, UTM NAD83 Zone 13S 265530E 3649854N). The soil was examined from an augered core. The landscape is shown in Figure 14.

A - 0 to 6 inches; brown (7.5YR 4/3) very gravelly loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common medium and coarse roots; estimated 40% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

C1 - 6 to 16 inches; reddish brown (5YR 5/4) gravelly clay loam, reddish brown (5YR 4/4) moist; massive; hard, friable, moderately sticky and moderately plastic; common medium and coarse roots; estimated 30% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

C2 -16 to 20+ inches; reddish brown (5YR 5/4) very gravelly clay loam, reddish brown (5YR 4/4) moist; massive; hard, friable, moderately sticky and moderately plastic; common medium and coarse roots; estimated 40% gravel by volume; strongly effervescent; moderately alkaline (pH 7.9).

Range in characteristics:

The organic matter in the surface horizon is about 3 percent.
The ochric horizon (A) ranges in thickness from 4 to 16 inches.

The soil is quite variable within short distances in some areas due to past disturbances and alluvial deposition processes. The rock fragment content ranges from 35 to 60 percent by volume and is dominantly gravel. These soils commonly are strongly effervescent in the surface and may be noneffervescent in the lower strata.

Figure 14 Typic Torriorthent, Calcareous Representative Pedon (Site 79P) Landscape (14a,b).

14a

14b

Taxonomic Unit:	**Typic Torriorthent, nonacid**
Soil Classification:	**loamy-skeletal, mixed, superactive, nonacid, thermic, Typic Torriorthent**
Map Unit:	**108-4**

Typic Torriorthent, nonacid soils are deep, mixed alluvial soils that occur in upland valleys in the west part of the permit area. These soils typically have sandy loam to silt loam surface layers underlain by loam to clay loam with gravel and cobble content ranging up to 70 percent by volume.

Typical pedon: A representative pedon of Typic Torriorthent, nonacid soils is located near the west boundary of the permit area (Site BH-04, UTM NAD83 Zone 13S, 262726 E, 3650612 N). The soil was examined in a freshly excavated backhoe pit. The profile and landscape are shown in Figure 15.

A – 0 to 5 inches, yellowish brown (10YR 5/4) sandy loam, dark yellowish brown (10YR 4/4) moist; weak thin platy structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and common fine roots; estimated less than 5% gravel by volume; noneffervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

C1 – 5 to 15 inches, construction rubble; massive; hard, friable; few very fine, fine, and coarse roots; estimated 10% gravel and 60% cobble by volume; noneffervescent; slightly alkaline (pH 7.6); abrupt smooth boundary.

C2 – 15 to 49 inches, yellowish brown (10YR 5/4) extremely cobbly sandy loam, dark yellowish brown (10YR 3/4) moist; weak medium subangular blocky parting to moderate fine granular; hard, friable, slightly sticky and slightly plastic; many very fine roots; estimated 30% gravel and 30% cobble by volume; noneffervescent; slightly alkaline (pH 7.6); gradual smooth boundary.

C3 – 49 to 73 inches, brown (7.5YR 4/4) extremely cobbly sandy loam, dark brown (7.5YR 3/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine, fine and medium roots; estimated 35% gravel and 25% cobble by volume; noneffervescent; moderately alkaline (pH 7.9); gradual smooth boundary.

C4 – 73 to 110 inches, dark yellowish brown (10YR 4/4) extremely cobbly sandy loam, dark yellowish brown (10YR 3/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine, fine and medium roots; estimated 35% gravel and 25% cobble by volume; noneffervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic matter in the C2 horizon is 2.8 percent.
The ochric horizon (A) ranges in thickness from 4 to 8 inches.

The rock fragment content ranges from 50 to 60 percent by volume and is dominantly gravel. These soils commonly are noneffervescent throughout the profile.

Figure 15 Typic Torriorthent, Nonacid Representative Pedon (Site BH-04) Profile (15a) and Landscape (15b).

15a

15b

3.2.2 Soil Map Unit Descriptions

Soil map unit descriptions are presented in numerical order. Note that the number of the map unit corresponds to the polygon labels presented on the soil map.

Table 4 Map Unit Legend

Taxon	Taxonomic Unit	Map Unit
101	Typic Haplocambid	101-2 101-3 101-4 101-5
102	Typic Haplargid, fine	102-1 102-2
103	Haplic Torriarent, tailings substrata	103-1
104	Argic Petrocalcid	104-1
105	Calcidic Argiustoll	105-1
106	Typic Haplargid, clayey-skeletal	106-1
107	Pachic Argiustoll	107-3
108	Typic Torriorthent, nonacid	108-4
109	Typic Torriorthent, calcareous	109-3 109-4
110	Typic Calciargid, fine	110-1
111	Typic Calciargid, fine-loamy	111-1
112	Haplic Torriarent, loamy-skeletal	112-3

Map Unit 101-2

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 2 to 4 feet of suitable material. The median thickness of suitable topdressing is 3 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

It is underlain by strata that have high calcium carbonate contents (caliche) and that are unsuitable for topdressing.

Map Unit 101-3

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 4 to 8 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

It is underlain by unsuitable strata that have high calcium carbonate contents (caliche), high clay content and/or extremely high content of rock fragments.

Map Unit 101-4

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 8 to 12 feet of suitable material. The median thickness of suitable topdressing is 10 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

It is likely underlain by bedrock and/or other unsuitable material that has an extremely high content of rock fragments.

Map Unit 101-5

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 12 to 16 feet of suitable material. The median thickness of suitable topdressing is 14 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

The rock content is greater in the lower strata, but after mixing will average less than 25 percent gravel.

Map Unit 102-1

This soil is identified as a Typic Haplargid, fine. The area mapped as this unit has 6 inches to 2 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with rock fragments on the surface. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 35 to 40 percent. After mixing, the rock fragment content will be less than 25 percent.

It is underlain by strata of unsuitable material with high clay content.

Map Unit 102-2

This soil is identified as a Typic Haplargid, fine. The area mapped as this unit has 2 to 4 feet of suitable material. The median thickness of suitable topdressing is 3 feet.

This soil is moderately fine-textured with almost no rock fragments. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 35 to 40 percent.

It is underlain by strata of unsuitable material with high clay content.

Map Unit 103-1

This soil is identified as a Haplic Torriarent, tailings substrata. The area mapped as this unit has 10 to 40 inches of suitable material over tailings. The median thickness of suitable topdressing is 1 foot.

This soil is medium to moderately fine-textured with rock fragments in the surface foot. The texture of the suitable material (after mixing) ranges from loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will be less than 25 percent.

It is underlain by tailings with unsuitable acid/base potential, and high plant available copper.

Map Unit 104-1

This soil is identified as an Argic Petrocalcid. The area mapped as this unit has 6 inches to 2 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with almost no rock fragments. The texture of the suitable material (after mixing) ranges from sandy clay loam to clay loam, with an average clay content of 30 to 35 percent.

It is underlain by partially to completely cemented strata of unsuitable material with high calcium carbonate content (caliche).

Map Unit 105-1

This soil is identified as a Calcidic Argiustoll. The area mapped as this unit has 6 inches to 3 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with some rock fragments. The texture of the suitable material (after mixing) ranges from loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will be less than 25 percent.

It is underlain by unsuitable strata of material with high clay and/or calcium carbonate content.

Map Unit 106-1

This soil is identified as a Typic Haplargid, clayey-skeletal. The area mapped as this unit has 8 to 20 inches of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is medium to moderately fine-textured with up to 60 percent rock fragments. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 28 to 40 percent. After mixing, the rock fragment content will be about 30 percent.

It is underlain by unsuitable strata with high clay content.

Map Unit 107-3

This soil is identified as a Pachic Argiustoll. The area mapped as this unit has 4 to 8 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will be less than 15 percent.

It is underlain by unsuitable strata with high clay and calcium carbonate content.

Map Unit 108-4

This soil is identified as a Typic Torriorthent, nonacid. The area mapped as this unit has 8 to 12 feet of suitable material. The median thickness of suitable topdressing is 10 feet.

This soil is medium-textured with up to 70 percent rock fragments which are dominantly gravel. The texture of the suitable material (after mixing) is sandy loam to loam, with an average clay content of 15 to 25 percent. After mixing, the rock fragment content will range from 50 to 60 percent.

It may be underlain by bedrock.

Map Unit 109-3

This soil is identified as a Typic Torriorthent, calcareous. The area mapped as this unit has 4 to 8 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium to moderately fine-textured with 35 to 60 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will range from 40 to 50 percent.

It is underlain by unsuitable strata with high clay content or limited available water holding capacity due to excessive gravel/cobble content.

Map Unit 109-4

This soil is identified as a Typic Torriorthent, calcareous. The area mapped as this unit has 8 to 12 feet of suitable material. The median thickness of suitable topdressing is 10 feet.

This soil is medium to moderately fine-textured with 35 to 60 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will range from 40 to 50 percent.

It is underlain by unsuitable strata with high clay content or limited available water holding capacity due to excessive gravel/cobble content.

Map Unit 110-1

This soil is identified as a Typic Calciargid, fine. The area mapped as this unit has 6 inches to 2 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with 5 to 20 percent rock fragments. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 30 to 38 percent. After mixing, the rock fragment content will be less than 15 percent.

It is underlain by unsuitable strata with high calcium carbonate content.

Map Unit 111-1

This soil is identified as a Typic Calciargid, fine-loamy. The area mapped as this unit has 6 to 30 inches of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is medium to moderately fine-textured with 15 to 35 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 20 to 35 percent. After mixing, the rock fragment content will be about 25 percent.

It is underlain by unsuitable strata with high calcium carbonate content.

Map Unit 112-3

This soil is identified as a Haplic Torriarent, loamy-skeletal. The area mapped as this unit has 2 to 9 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium to moderately fine-textured with 10 to 40 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will range from 20 to 30 percent.

It is underlain by unsuitable strata with high clay content.

3.3 Laboratory Testing and Test Results

Representative samples from each soil taxonomic unit were collected for laboratory analysis. These tests were conducted in two tiers. Tier 1 analysis was conducted on all samples: texture, pH, electrical conductivity (salinity), and SAR. Calcium carbonate equivalent was specified for selected calcic horizons. Organic matter, nitrate/nitrite-nitrogen and phosphorus (total and available) were evaluated on most surface samples. Sand size fractions were determined on tailings substrata. When field texture estimates and lab texture varied widely, a professional judgment was used in the profile descriptions. Tier 1 results for all soils are presented in Table 5.

The Haplic Torriarents, tailings substrata horizons were sieved for sand size fraction: 12-20 inches, 26% very fine sand and 29% fine sand; 22-60 inches, 22% very fine sand and 43% fine sand.

There were no serious concerns with the results of the Tier 1 results relative to topdressing suitability. The Pachic Argiustoll had a minor salinity issue in the lower horizons, but this could be an isolated event, as samples analyzed were collected only from the backhoe pit. Mixing of materials during collection would diminish the salinity impact. The bottom horizon of the fine Typic Calciargid had a high calcium carbonate equivalent, but that horizon was excluded from the suitable materials. Nitrogen and phosphorus levels were low, as would be expected in arid region range and disturbed soils. Available potassium levels were on the lower end of the range typically expected in semiarid and arid region soils.

A second tier of samples were conducted on those pedons within the tailings facility or possibly disturbed by mining activities. The acid/base potential and available elements results were presented in Table 6a. The data to calculate acid/base potential and total results were presented in Table 6b. Elements not detected during analysis were not included in the tables: Total and available arsenic, available boron, total and available cadmium, total and available mercury, available nickel.

The tailings substrata were unsuitable due to the acid/base potential, and will be discussed in more detail later in the report. None of the available element levels were present in amounts likely to be toxic to plants, or to bioaccumulate in animals, as they were within or below the normal ranges of these elements commonly found in soil (Baker and Pilbeam, 2007; Havlin et al., 1999). Further, though the lab procedures extracted some of the elements, the actual plant availability in the soil likely would be less due to the slightly to moderately alkaline pH that reduces availability of the metals, Cu, Fe, Mn, and Zn. The high total potassium levels did not result in high plant available levels.

Table 5 Tier 1 Soil Test Results for Representative Horizons of Typical Pedons by Taxonomic Unit

Taxonomic Unit	Taxon	Depth	Texture	pH	ECe	SAR	$CaCO_3$	Organic Matter	NO_3/NO_2	Phosphorus		Clay	Sand	Silt
										Avail.	Total			
		- in -			dS/m		--------- % ---------		---------- ppm ----------			--------- % ---------		
Argic Petrocalcid	104	0-12	SC	7.9	0.4	0.1		3.4	3	ND	50	38	58	5
Calcidic Argiustoll	105	0-8	SCL	7.8	0.5	0.2		3.5	1	3	105	27	60	13
		8-17	SC	7.9	0.3	0.9		4.0				37	53	10
		17-24	C	7.9	0.4	0.4	9					61	30	9
		24-38	SCL	7.9	0.6	1.9	18					24	58	18
Haplic Torriarent loamy-skeletal	112	0-6	SCL	7.9	0.5	0.2	19	2.4	2	5	130	23	64	13
		6-35	SCL	8.0	0.4	1.5	15					34	53	13
		35-52	SCL	7.8	1.8	1.3	8					27	60	13
		52-84	SCL	7.9	1.6	2.5	12					34	53	13
		84-110	SC	7.8	2.4	2.0	12					40	48	12
Haplic Torriarent. tailings substrata	103	0-12	SCL	7.8	0.4	0.3		1.9	1	ND	93	27	58	15
		12-20	FSL	8.0	1.2	0.2						15	55	30
		20-60	FSL	7.8	2.7	0.2						15	60	25
Pachic Argiustoll	107	6-14	CL	7.8	1.4	1.0		3.9	12	2	105	35	38	28
		14-29	C	7.7	6.7	4.9		4.1				43	39	19
		40-58	SCL	8.1	8.1	14.1						34	48	18
Typic Calciargid, fine	110	0-7	SCL	8.0	0.4	0.1		2.9	1	ND	117	30	57	13
		7-24	SCL/SC	7.9	0.5	0.4	11					35	55	10
		24-64	SCL	7.8	1.3	1.7	43					27	53	20
Typic Calciargid, fine-loamy	111	3-10	SCL	7.8	0.3	0.1		3.3	0	ND	95	33	58	10
		10-17	C/SC	7.9	0.3	0.3	13					45	45	10
		17-26	SCL	8.0	0.3	0.7	23					22	65	13

Table 5 Tier 1 Soil Test Results for Representative Horizons of Typical Pedons by Taxonomic Unit (continued)

Taxonomic Unit	Taxon	Depth	Texture	pH	ECe	SAR	CaCO3	Organic Matter	NO_3/ NO_2	Phosphorus		Clay	Sand	Silt
										Avail.	Total			
									---------- ppm ----------			---------- % --------		
		- in -			dS/m		-------- % --------				-			----
Typic Haplargid,	102	0-13	SC	7.8	0.4	0.1		3.1	1	ND	54	40	50	10
fine		13-30	CL/C	8.1	0.3	1.9	22					40	35	25
		30-51	C	8.0	2.9	3.0						50	25	25
		51-90	C	7.9	2.4	2.9						50	25	25
Typic Haplocambid	101	0-18	SL	8.0	0.5	0.1		2.1	3	5	125	15	75	10
		18-34	SL	7.9	0.6	0.5		2.4				18	62	20
		34-63	SL	7.8	2.7	0.9						11	70	19
		63-110	S	8.5	0.3	1.6						8	92	0
Typic Torriorthent,	108	15-49	SL	7.6	0.8	0.5		2.8	12	ND	157	18	65	18
nonacid		49-73	SL	7.9	0.4	1.5		3.2				13	73	15
		73-110	SL	7.8	0.5	1.7		3.3				18	68	15

Table 6a Tier 2 Acid/Base Potential and Available Results for Representative Horizons of Typical Pedons for Selected Taxonomic Units

Taxonomic unit	Taxon	Depth	Acid/ Base Potential	Cl	Cu	Fe	Mn	Mo	K	Se	Ca	Mg	Na	Zn
		- in -	T $CaCO_3$ /1000 T	---------- ppm ----------										
Haplic Torriarent loamy-skeletal	112	0-6	185	20	3	5	4.6	ND	231	ND	73	4	7	ND
		6-35	146	ND	5	9	0.9	ND	95	0.007	36	3	36	ND
		35-52	75	67	5	9	1.4	ND	187	0.004	218	12	75	ND
		52-84	119	99	3	5	0.6	ND	127	0.002	153	17	123	ND
		84-110	124	412	3	5	0.9	ND	154	0.006	254	23	125	ND
Haplic Torriarent. tailings substrata	103	0-12	126	17	3	10	2.6	ND	166	ND	62	7	11	ND
		12-20	-6	ND	85	108	4.7	1.2	70	0.025	174	39	13	4.7
		20-60	-13	ND	74	64	1.8	1.7	73	0.046	514	75	17	3.6
Typic Calciargid, fine	110	0-7	21	ND	4	9	2.9	ND	425	0.005	63	4	3	ND
		7-24	113	ND	4	8	1.4	ND	160	0.002	73	3	13	ND
		24-64	428	36	1	6	0.6	ND	62	ND	179	6	85	ND
Typic Calciargid, fine-loamy	111	3-10	134	ND	8	5	1.4	ND	138	0.004	58	2	4	ND
		10-17	129	ND	8	6	1.0	ND	136	ND	48	2	7	ND
		17-26	234	ND	3	8	0.9	ND	66	0.002	37	2	15	ND
Typic Torriorthent, nonacid	108	15-49	16	ND	15	14	2.4	ND	94	ND	84	19	21	ND
		49-73	16	ND	12	9	1.1	ND	77	0.005	30	8	35	ND
		73-110	20	ND	8	8	0.8	ND	81	0.010	34	8	43	ND

Not detected: Arsenic, boron, cadmium, mercury, and nickel.

Table 6b Tier 2 Data to Calculate Acid/Base Potential and Total Results for Representative Horizons of Typical Pedons for Selected Taxonomic Units

Taxonomic unit	Taxon	Depth	$CaCO_3$	S	Acid Neutral-ization Potential	Acid Generating Potential	B	Cu	Fe	Mn	Mo	Ni	K	Zn
		- in -	----- % -----		-- T $CaCO_3$/1000 T --		---------- ppm ----------							
Haplic Torriarent loamy-skeletal	112	0-6	19	0.02	185.0	0.6	ND	62	26400	755	ND	10	1950	60
		6-35	15	0.09	149.0	2.8	ND	44	29100	494	ND	11	2060	57
		35-52	8	ND	75.2	0.2	ND	48	35500	631	ND	15	2820	63
		52-84	12	0.02	120.0	0.6	ND	32	28700	466	ND	16	2160	58
		84-110	12	ND	124.0	0.4	ND	37	31700	431	ND	16	2540	59
Haplic Torriarent. tailings substrata	103	0-12	13	ND	126.0	0.5	ND	40	29100	541	ND	12	2370	60
		12-20	2	0.9	21.7	28.1	ND	716	22400	356	9	7	2880	64
		20-60	2	1.02	18.6	31.8	ND	612	20000	270	15	5	2420	48
Typic Calciargid, fine	110	0-7	2	0.02	21.7	0.5	32	34	38400	636	ND	17	4230	69
		7-24	11	0.02	114.0	0.5	30	26	31800	517	ND	14	3230	62
		24-64	43	0.02	429.0	0.6	ND	23	15600	399	ND	8	977	44
Typic Calciargid, fine-loamy	111	3-10	13	ND	134.0	0.4	ND	62	34700	535	ND	14	2780	63
		10-17	13	0.02	130.0	0.6	ND	69	31100	452	ND	14	2760	63
		17-26	23	0.02	234.0	0.5	ND	58	23500	553	ND	9	1440	52
Typic Torriorthent, nonacid	108	15-49	2	ND	16.6	0.3	49	486	65000	1290	ND	16	5390	70
		49-73	2	ND	16.6	0.4	54	735	73900	1680	ND	24	6420	92
		73-110	2	ND	20.7	0.4	50	450	68600	1400	ND	19	5050	68

Not detected: Arsenic, cadmium, and mercury.

4.0 Summary

4.1 Location and Quantity of Suitable Material

There are about 425 acres that will yield approximately 3,391,000 cubic yards, or 2,100 acre-feet of suitable topdressing materials (Figures 16-17, Table 7 contains the map unit legend). Suitable topdressing materials were determined as the product of the area of each map unit and the median depth of the suitable material (after mixing) in that unit.

Figure 16 Location of Map Units with Suitable Topdressing Materials, East Portion of Permit Area

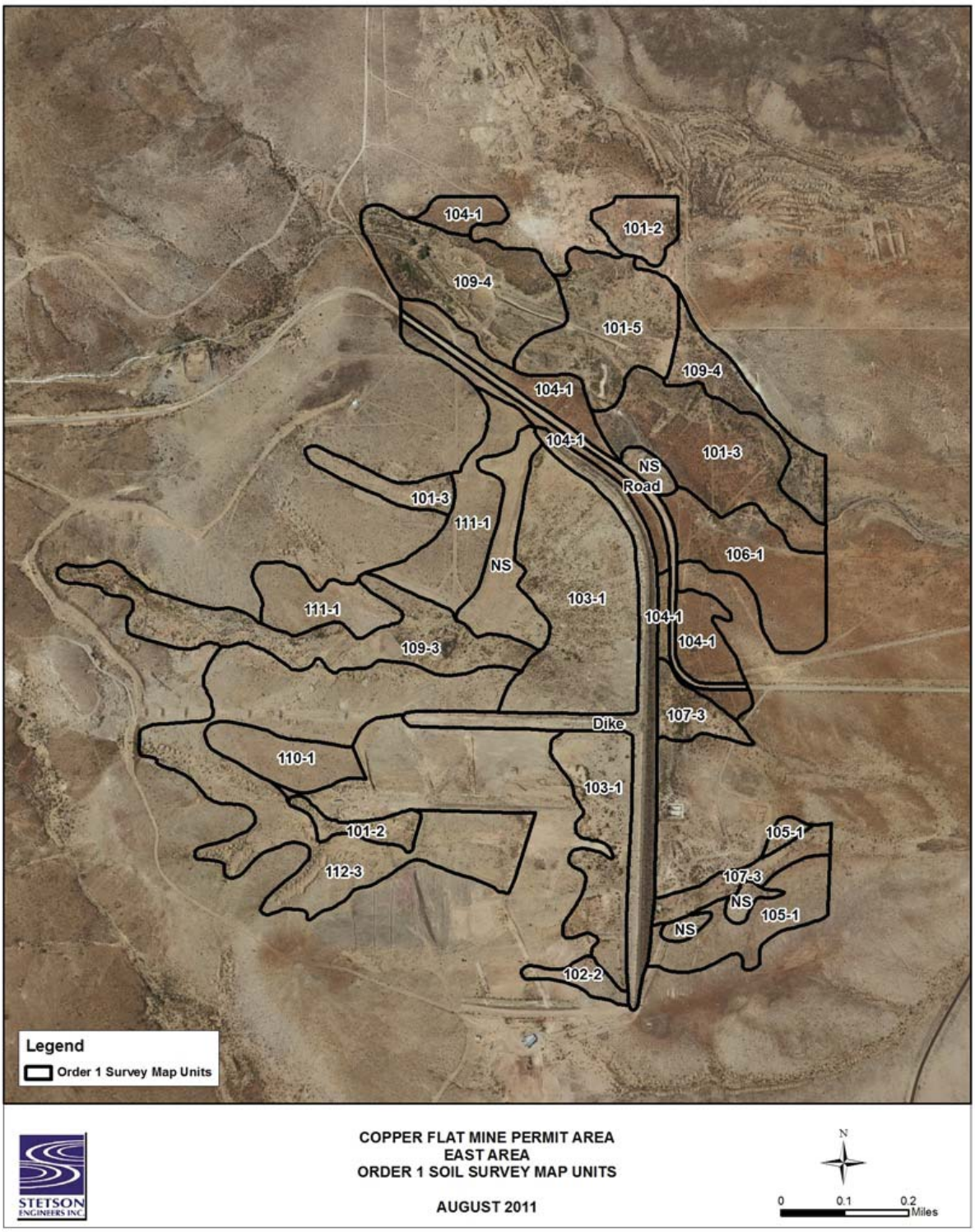


Figure 17 Location of Map Units with Suitable Topdressing Materials, West Portion of Permit Area.

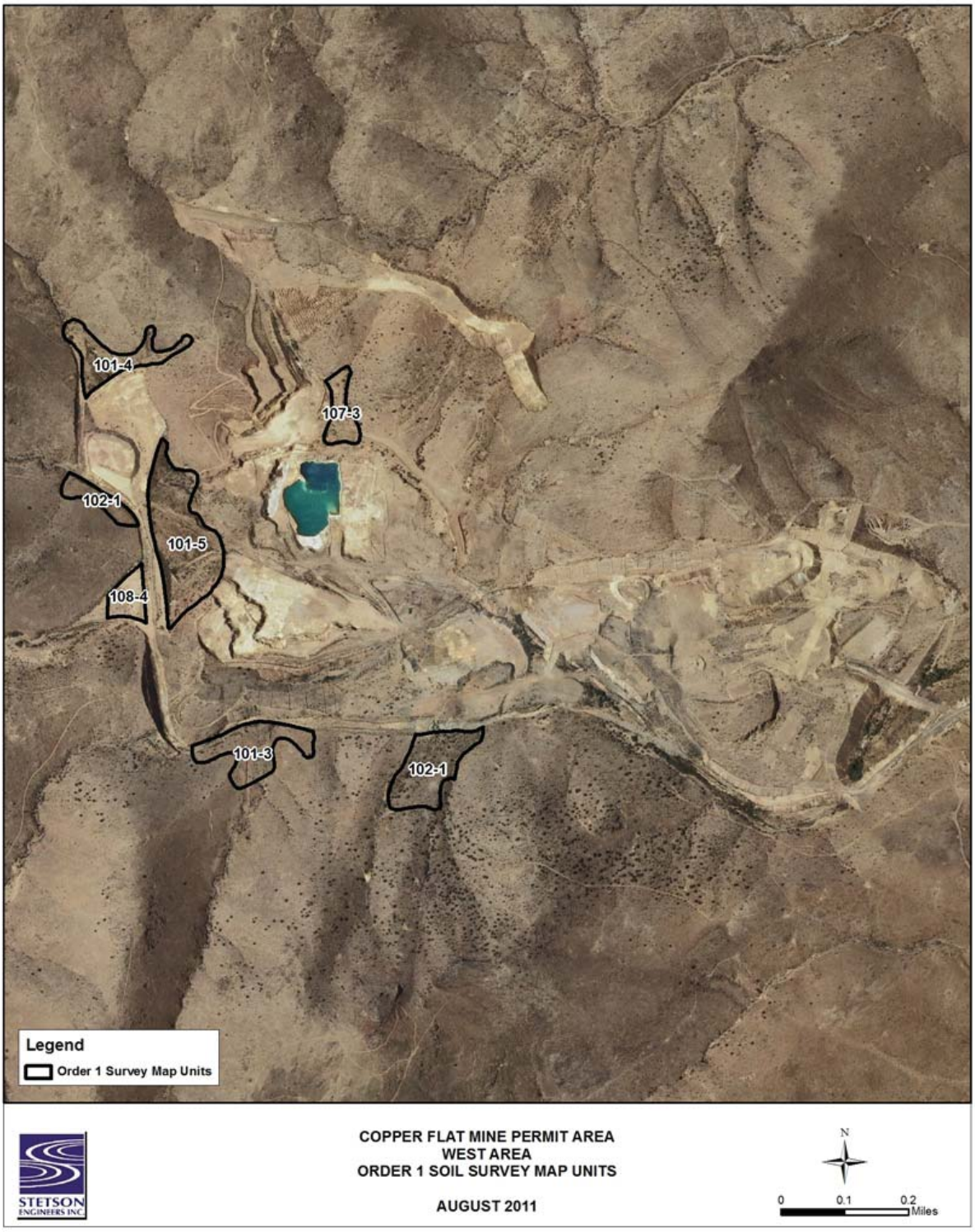


Table 7 Estimate of Suitable Topdressing Materials (after mixing)

Taxonomic Unit	Map Unit	Median Depth	--------- Area ---------		Volume
		feet	acres	sq-ft	cubic yards
Typic Haplocambid	101-2	3	11.0	480,019	53,335
	101-3	6	40.5	1,762,671	391,705
	101-4	10	4.9	213,589	79,107
	101-5	14	37.0	1,611,406	835,544
Typic Haplargid, fine	102-1	1	8.9	388,346	14,383
	102-2	3	3.3	145,357	16,151
Haplic Torriarent, tailings substrata	103-1	1	61.7	2,687,769	99,547
Argic Petrocalcid	104-1	1	29.9	1,303,273	48,269
Calcidic Argiustoll	105-1	1	15.5	677,352	25,087
Typic Haplargid, clayey-skeletal	106-1	1	20.6	899,213	33,304
Pachic Argiustoll	107-3	6	15.8	690,114	153,359
Typic Torriorthent, nonacid	108-4	10	2.3	99,799	36,963
Typic Torriorthent, calcareous	109-3	6	30.3	1,321,143	293,587
	109-4	10	38.0	1,653,361	612,356
Typic Calciargid, fine	110-1	1	10.1	440,689	16,322
Typic Calciargid, fine-loamy	111-1	1	27.7	1,206,996	44,704
Haplic Torriarent, loamy-skeletal	112-3	6	65.8	2,867,270	637,171
Total			**423.5**		**3,390,894**

4.2 Tailings Discussion

Though available copper, iron, zinc, molybdenum and selenium were elevated to some degree, available research suggests these values are not toxic (Baker and Pilbeam, 2007; Havlin et al., 1999). These conditions apparently have little negative impact on the plant communities currently growing on soils underlain by tailings. Roots readily grow into the tailings substrata (Figure 18a), and the vegetative community is thriving (Figures 7 b,c, 18b).

The tailings were not considered suitable for topdressing materials due to the acid/base potential. However, one could argue that given the high calcium carbonate content of the lower horizons in four of the Order 1 map units, there would be more than adequate acid neutralizing potential were the tailings substrata mixed with material from calcic horizons. Mixing the materials would lower the available copper due to the pH increase and carbonate-metal chemistry decreasing solubility of copper and other metals.

Figure 18 Roots (18a) and Vegetative Community on Soils Overlying Tailings (18b)

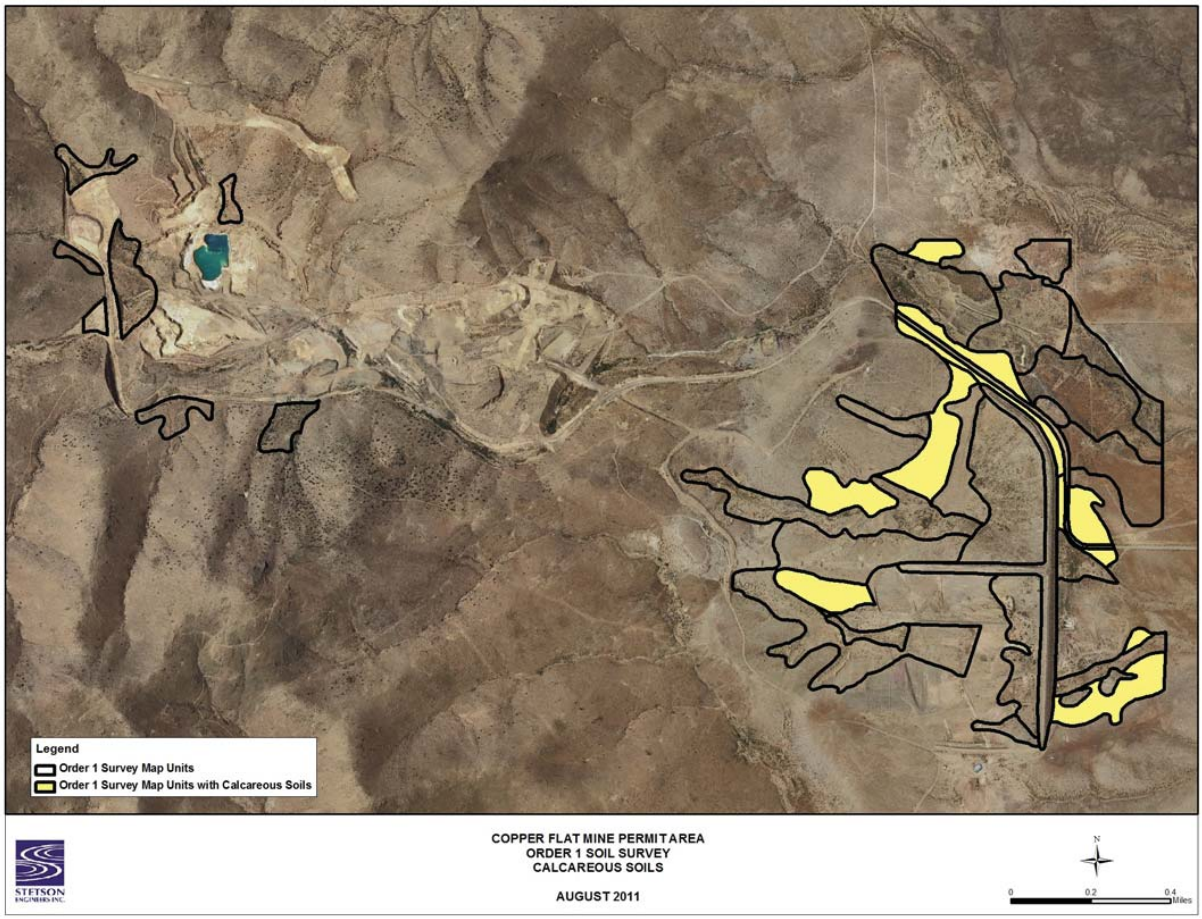
18a

18b

4.3 Neutralization Potential

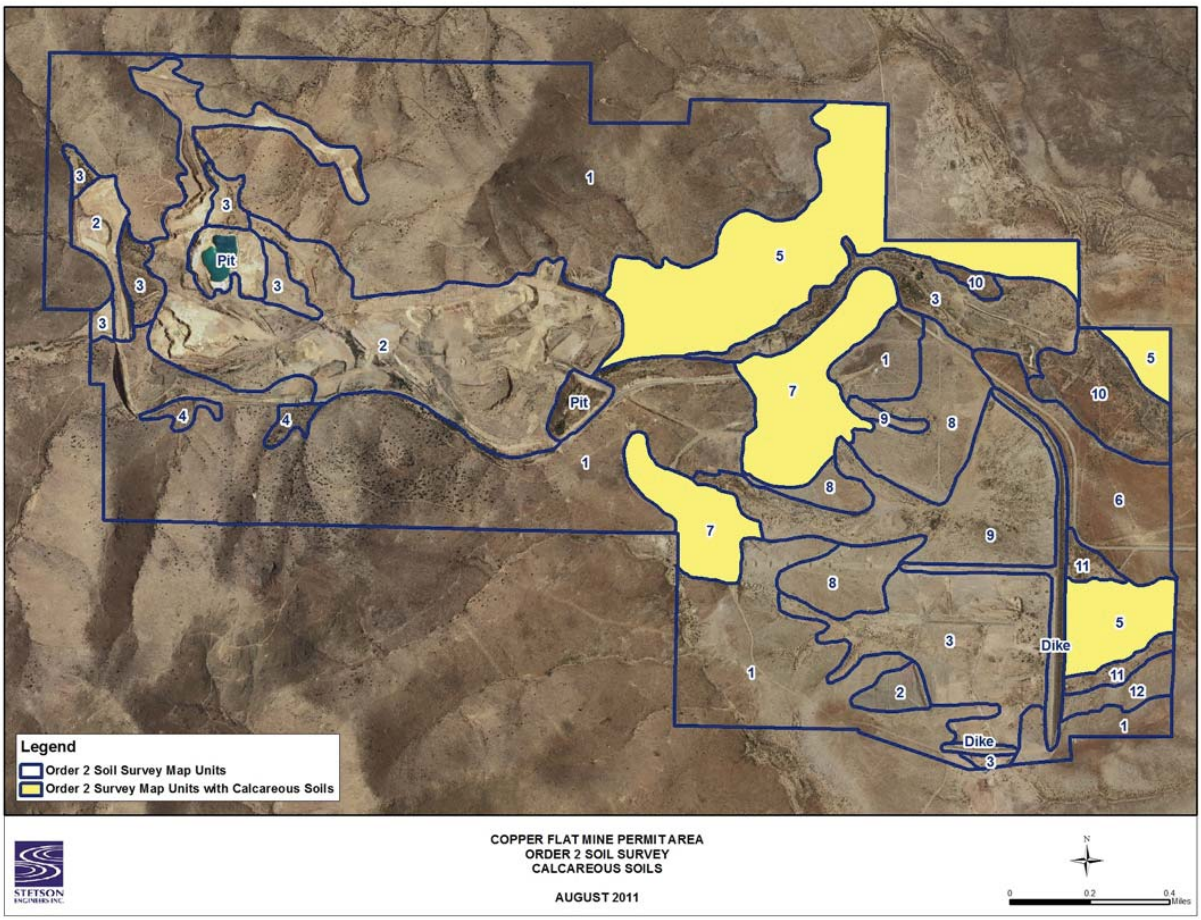
As mentioned in the tailings discussion, four of the Order 1 map units had calcic horizons with high calcium carbonate equivalents below the suitable topdressing materials (Figure 19). Tables 5 and 6 reported three horizons with greater than 20% calcium carbonate equivalent. The acid neutralizing potential was 10 times the calcium carbonate equivalent. Most of the calcic horizons in the Order 1 soil survey were not sampled for lab analysis, since the scope of this study was to map and characterize sources of suitable topdressing materials and these horizons were unsuitable. The total depth of the calcic materials was not characterized in three of the four map units (about 70 acres) with calcic horizons, as the deepest horizon described was calcic, and calcic materials usually continued below the last horizon described. Thus the volume of calcareous materials and total acid neutralization potential was not characterized in the Order 1 map units.

Figure 19 Order 1 Map Units with Calcic Horizons and High Acid Neutralization Potential



Two Order 2 map units had shallow topsoil overlying calcic horizons (Figure 20). These map units were not considered significant sources of suitable topdressing material, so they were not included in the Order 1 survey. However, the calcareous materials in these soils could be characterized and quantified for acid neutralization potential, as well. There were approximately 360 acres identified as calcareous soils in the Order 2 soil survey in which the material volume and acid neutralization potential could be characterized.

Figure 20 Order 2 Map Units with Calcic Horizons and High Acid Neutralization Potential



Thus the calcareous soils in the eastern end of the permit area could have substantial acid neutralization potential that has not yet been characterized.

5.0 References

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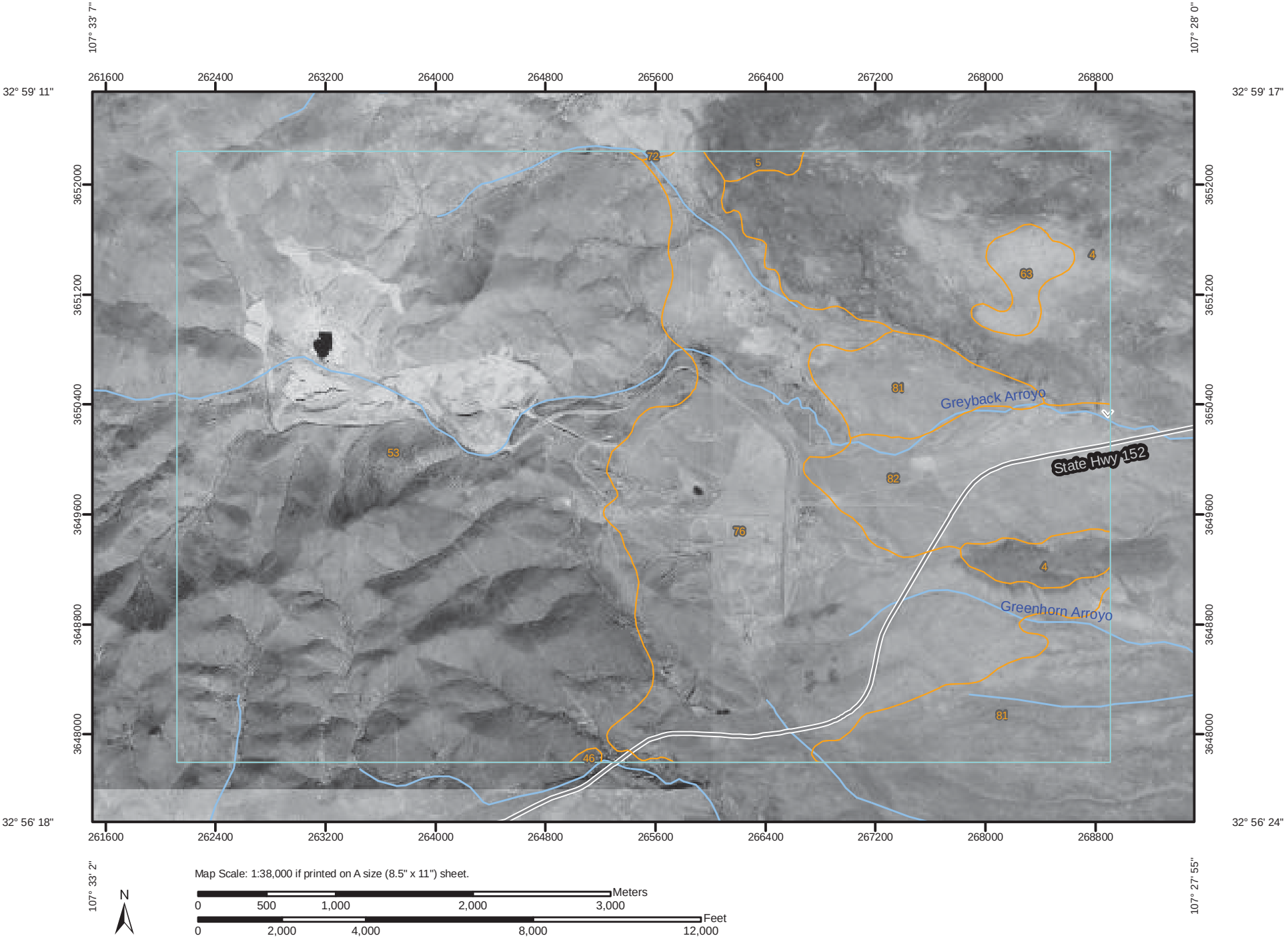
Appendix A
Copper Flat Mine Permit Area
NRCS Soil Map

Soil Map—Sierra County Area, New Mexico
(Copper Flat mine and tailings storage facility)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:38,000 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:48,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Sierra County Area, New Mexico
Survey Area Data: Version 10, May 13, 2009

Date(s) aerial images were photographed: 10/2/1996; 10/8/1996

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Sierra County Area, New Mexico (NM660)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
4	Akela very gravelly loam, moderately rolling	907.8	12.2%
5	Akela-Rock outcrop association, very steep	27.0	0.4%
46	Ildefonso-Scholle association, hilly	4.2	0.1%
53	Luzena-Rock outcrop association, very steep	3,749.3	50.3%
63	Nickel-Chamberino association, gently sloping	78.7	1.1%
72	Rock outcrop-Deama association, extremely steep	3.3	0.0%
76	Scholle-Ildefonso association, moderately rolling	1,705.4	22.9%
81	Tres Hermanos gravelly fine sandy loam, gently sloping	534.1	7.2%
82	Tres Hermanos-Hap association, gently sloping	446.7	6.0%
Totals for Area of Interest		**7,456.4**	**100.0%**