CLOSURE/CLOSEOUT PLAN

9 WASTE ROCK STOCKPILE CLOSURE/CLOSEOUT PLAN

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List of Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
ABA	acid-base accounting
ac-ft/yr	acre-feet per year
amsl	above mean sea level
AOC	Administrative Order on Consent
APP	Abatement Plan Proposal
bgs	below ground surface
BLM	Bureau of Land Management
CCP	Closure/Closeout Plan
CDQAP	Construction Design Quality Assurance Plan
CFR	Code of Federal Regulations
CGCS	Comprehensive Groundwater Characterization Study
Chino	Chino Mines Company
cm	centimeter
CQAP	Construction Quality Assurance Plan
CQAR	Construction Quality Assurance Report
DBS&A	Daniel B. Stephens and Associates, Inc.
DP	Discharge Permit
DSM	dynamic system model
EOY	end of year
EPA	U.S Environmental Protection Agency
ETS	Evaporative Treatment System
EnviroGroup	EnviroGroup Limited
FS	Feasibility Study
FSIR	Final Site Investigation Report
ft	Feet
Golder	Golder Associates Inc.
Guidelines	Closeout Plan Guidelines
HDPE	high density polyethylene
HDS	high-density sludge
IRA	Interim Remedial Act
IU	investigation unit
M3	M3 Engineering & Technology Corp.
MMD	Mining and Minerals Division
MWWCA	Middle Whitewater Creek Area

List of Acronyms and Abbreviations (Continued)

NMA	North Mine Area
NMED	New Mexico Environment Department
NMMA	New Mexico Mining Act
NMOSE	New Mexico Office of the State Engineer
NMWQA	New Mexico Water Quality Act
NMWQCC	New Mexico Water Quality Control Commission
NSR	New Source Review
O&M	Operation and Maintenance
OPCZ	Open Pit Capture Zone
OPSDA	Open Pit Surface Drainage Area
PMLU	post-mining land use
RCRA	Resource Conservation and Recovery Act
Rules	New Mexico Mining Rules
SCS	Soil Conservation Service
SMA	South Mine Area
SSE	self-sustaining ecosystem
SWQB	Surface Water Quality Bureau
SX/EW	solution extraction-electrowinning
TDS	total dissolved solids
yd^3	cubic yards

1.0 INTRODUCTION

Freeport-McMoRan Chino Mines Company (Chino) operates an open-pit copper mine, concentrator, and solution extraction electrowinning (SX/EW) plant located approximately 10 miles east of Silver City in Grant County, New Mexico (Figure 1-1). Chino is proposing to construct a waste rock stockpile over an area that includes the footprint of Reservoir 9, south of the Santa Rita Open Pit (Figure 1-2). The proposed project is located on lands owned by the BLM.

The construction and location of the 9 Waste Rock Stockpile (9 WRS) is necessary to effectively store mine rock at strategic locations near the open pit and as other stockpiles are filled to capacity. The reclamation plan proposed in this closure/closeout plan (CCP) is intended to meet all state and federal mine reclamation and environmental regulations.

The proposed 9 WRS footprint partially extends beyond the currently approved Mining and Minerals Division (MMD) of the Energy, Minerals, and Natural Resources Department Santa Rita Beneficiation Design Limits (design limits) boundary. Thus, Chino requests that the design limits be expanded to the south to facilitate the construction of the proposed stockpile and associated infrastructure. The proposed 9 WRS will increase the design limits by approximately 248 acres (Figure 1-3). The current mine permit boundary already includes the location of this proposed stockpile and no increase is necessary.

1.1 Purpose of Plan

The purpose of this CCP is to present a reclamation plan consistent with all applicable federal and state regulatory requirements and permit conditions so that a financial assurance cost estimate can be calculated to meet the financial assurance requirements of Part 19.10.12 NMAC. The reclamation plan will demonstrate, where required, that the disturbed area will be reclaimed to a condition that allows for the re-establishment of self-sustaining ecosystem as well to meet the closure requirements of Section 20.6.7.33NMAC.

1.2 Plan Organization

This CCP consists of the following sections:

- **Section 1.0** provides an overview of the CCP for the proposed 9 WRS;
- **Section 2.0** describes the permits associated with the mine;
- **Section 3.0** describes the existing facilities and current environmental setting at the Chino Mine and the proposed 9 WRS area;
- **Section 4.0** describes the proposed 9 WRS configuration;
- **Section 5.0** describes the proposed reclamation plan and associated design criteria and performance objectives for the proposed 9 WRS;
- **Section 6.0** describes the closure and post-closure monitoring plans for the proposed 9 WRS along with contingency plans and reporting schedules;

- **Section 7.0** provides details of the proposed post-mining land use and associated requirements for the proposed 9 WRS;
- **Section 8.0** presents a summary of the material take-offs and factors that will be applied in the capital and operations and maintenance (O&M) cost estimates associated with the proposed reclamation and post-closure monitoring plans presented in Sections 5.0 and 6.0;
- **Section 9.0** presents the proposed reclamation schedule associated with this CCP;
- **Section 10.0** is the signature page for the CCP; and
- **Section 11.0** lists the references used in preparation of this CCP.

The following appendix is also included in the CCP:

- **Appendix A** includes the earthwork cost estimate process report and reclamation design drawings that illustrate the CCP for the proposed 9 WRS.

1.3 Regulatory Authority

In 1993, the New Mexico legislature enacted the New Mexico Mining Act (NMMA) that requires closeout plans to be developed for applicable mines. Rules to implement the requirements of the NMMA were promulgated in 1994. This plan was prepared to comply with applicable regulations and requirements stipulated in the NMMA (NMAC Title 19, Chapter 10, Part 5), New Mexico Water Quality Act (NMWQA), and the New Mexico Water Quality Control Commission (NMWQCC) Regulations (NMAC Title 20, Chapter 6, Parts 2 and 7). In 2013, NMED adopted new rules for the copper mining industry (Copper Mine Rules Section 20.6.7 NMAC), which have been addressed in this CCP.

1.4 Development of CCP Cost Estimates

This CCP provides the engineering basis for the regulatory review of the financial assurance (FA) cost estimate assuming a default scenario, whereby a third party contractor completes the reclamation work. The CCP includes the information required by 19.10.5.506 – 19.10.5.508 NMMA and 20.6.7.33 NMAC, such as topographic maps, key design criteria, design drawings, engineering take off quantities, and reclamation schedule. The CCP is in support of and relies on the knowledge and experience of previous site specific studies, reports, and CCP submittals. With state approval of the CCP basis, the FA current and net present value calculations will be submitted for MMD and NMED approval (19.10.12.1201 NMMA and 20.6.8 NMAC). Outlined in Section 8.0 and detailed in Appendix A is the basis upon which these FA cost estimates will be developed.

2.0 PERMITS AND DISCHARGE PLANS

Chino conducts its mining operations pursuant to numerous state and federal regulations. Table 2-1 lists all state and federal permits, and permit numbers in association with the CCP.

3.0 EXISTING SITE CONDITIONS

The following sections describe the site-specific characteristics of the proposed 9 WRS area.

3.1 Description of the Proposed 9 WRS Area

The proposed 9 WRS is in the North Mine Area (NMA) in an area currently occupied in part by the operational 9 Reservoir (Figure 1-2). The proposed stockpile lies within the open pit surface drainage area (OPSDA). Mine stockpiles, the open pit, and roads are located to the north, east and west of this site. The topography consists of steeply sloping bedrock controlled mountain slopes. Two small ephemeral drainages, former tributaries to Whitewater Creek, run roughly from south to north through the valley and terminate in the 9 Reservoir.

The canyon rock is composed of Tertiary rhyolitic tuff of the Kneeling Nun Formation that is hundreds of feet thick (Figure 3-1). The slopes are vegetated with trees, forbs, grasses and shrubs. The proposed 9 WRS will cover approximately 159 acres at final build out, including approximately 99 acres outside the current design limit boundary, and 60 acres within the current design limit boundary (Figure 1-3). Two groundwater monitoring wells are currently located around the proposed 9 WRS, with one lying within the proposed stockpile footprint (526-96-15). This well will be abandoned as the proposed 9 WRS expands in accordance with Article 72-12 NMSA, all applicable New Mexico Office of the State Engineer (NMOSE) regulations, and the NMED Monitoring Well Construction and Abandonment Guidelines. Chino is currently installing additional ground water monitoring wells (20.6.7.28) within the proposed 9WRS area.

3.2 Past and Current Land Uses

Mining has been the principal land use and economic support for the area since open-pit mining began in 1910. Current land uses in the immediate vicinity of the proposed 9 WRS include mining and wildlife habitat. Additional surrounding land uses outside the mine permit area include private residences, ranching, mining, recreation, and wildlife habitat. Recreation outside the permit area includes camping, picnicking, hunting, off-road vehicle use, hiking, horseback riding, and bicycling.

3.3 Environmental Setting

The following sections present various aspects of the NMA and proposed 9 WRS area, including its topography, geology, climate, hydrology, soils and vegetation, wildlife, and material characteristics. Reservoir 9 is currently located in the approximate site of the proposed stockpile. The reservoir is located in the OPSDA based on monitoring well ground water data, topographic and geologic controls, and past and present surface water flow conditions. At this location surface water flows from south to north, and reservoir seepage continues to flow to the north into the open pit.

3.3.1 Topography

The general topography of the proposed 9 WRS area is depicted on Figure 3-1. Chino operations in the NMA are located near the base of the Cobre Mountains. The proposed 9 WRS area occupies an ephemeral valley that terminates at a mine haul road. The natural ground surface elevation ranges from approximately 6,625 feet above mean sea level (ft amsl) in the vicinity of Reservoir 9 to approximately 7,250 ft amsl along the ridge tops located south and east of the proposed stockpile area. The proposed 9 WRS area is bounded on the north by a haul road, the Upper South Stockpile, and the open pit. To the east, west and south are bedrock ridges composed of outcrops of rhyolitic tuff.

3.3.2 Geology

Chino lies in the transition zone between the Colorado Plateau and the Basin and Range physiographic provinces. The Santa Rita ore deposit that has been mined at Chino lies in the southeastern corner of the Central Mining District (Rose and Baltosser, 1966). Figure 3-1 shows a geological map of the proposed 9 WRS area. The area is underlain mostly by welded rhyolitic tuff associated with the Tertiary Kneeling Nun Formation and other Tertiary basaltic andesite rocks that form the ridges around the area (Jones et al., 1967). The Kneeling Nun Tuff and basaltic andesite volcanic flows are relatively flat lying in this area.

The main geologic units within the proposed 9 WRS area consist of, from youngest to oldest:

- Tertiary Basaltic Andesite Flows (Tba);
- Tertiary Tuff (Tcb), composed of white pumiceous and massive crystal tuffs; and the
- Kneeling Nun Rhyolite (Tk), composed of grayish-red welded rhyolitic crystal tuff.

A northeast trending fault called the Martin Fault has been mapped through the proposed 9 WRS area (Figure 3-1). The Martin Fault is a high angle normal fault that forms a half graben with small to modest displacement downward to the southeast.

3.3.3 Climate

The Chino Mine is located in a semiarid region in southwestern New Mexico, with elevations ranging from about 5,200 to 7,700 ft amsl. The climate at Chino is warm and dry, with mean annual precipitation of about 16 inches (400 mm) and a mean annual temperature near 50˚F (10˚C). Precipitation falls mainly as rain, but snow may occur from November to March. Most of the precipitation in the area falls during July through October in the form of rain during short, intense, thunderstorms. About 60 percent of the precipitation falls during the summer months. Monthly precipitation is generally less than an inch per month from November through June, peaks in July, August, and September with between 2 and 3 inches per month, and generally falls to about 1 inch in October. Annual precipitation averages 17.2 inches at the Santa Rita weather station (elevation of 6,312 ft amsl), which is located about 1,000 feet to the west of the Santa Rita Open Pit.

Evaporative demand in this region is high and annual evaporation far exceeds annual precipitation. Annual potential evaporation measured near the nearby former Reservoir 3A area is estimated at approximately 75 inches per year.

3.3.4 Surface Water Hydrology

The proposed 9 WRS area lies within the former upper reaches of the Whitewater Creek watershed. Surface water discharge in this small basin is now collected in Reservoir 9 to prevent discharge, towards the north, into the Santa Rita Pit. High ridges separate the Whitewater Creek watershed from the Martin Canyon and Rustler Canyon watersheds, which drain towards the south. No permanent streams are present in the proposed 9 WRS area, but two small ephemeral drainages run roughly from south to north through the valley and terminate in Reservoir 9.

3.3.5 Groundwater Hydrology

Groundwater hydrology at the Chino Mine has been analyzed for several decades with the most recent comprehensive report entitled *Chino Mines Company DP-1340 Condition 83 – Hydrologic Study Final Report* submitted in June of 2007. Twice a year, potentiometric maps are submitted to the agency based on groundwater elevation data collected in a monitoring well network system located within the NMA. Conditions are stable and show that the ground water system within the vicinity of the proposed 9 WRS is within the area of hydrologic containment and seepage flows north toward the Santa Rita open pit where it is contained. Under separate application to DP-459, additional groundwater information will be supplied for the area described in this CCP. Groundwater is encountered at an elevation of approximately 6,655 ft amsl in the immediate vicinity of the proposed 9 WRS (at well 526-96-15).

3.3.6 Soils and Vegetation

The soils in the Chino area were mapped by the U.S. Soil Conservation Service (SCS) (Parnham et al. 1983). The SCS map units were composed primarily of complexes of soil series and miscellaneous land areas. The dominant soils in the northern portion of the survey area (Luzena and Muzzler series) are shallow (<50 cm [centimeters]) and fine-textured with moderate to high rock fragment contents. The soils in the uplands are mostly shallow, although moderately deep (50 to 100 cm) and deep (>100 cm) soils occur to a minor extent. The soils in the valley bottoms are generally deep, vary considerably in texture, but tend to be somewhat coarser textured than the upland soils. The proposed 9 WRS area consists of a weakly dissected pediment with moderate to steep rocky slope segments.

The distribution of native vegetation around Chino is locally complex and reflects the combined influences of environmental gradients (soils and climate), disturbance histories (drought, floods, fire, and predation) and management practices. The major structural characteristics of vegetation are controlled primarily by the prevailing environment gradients. The vegetation at Chino was classified using the nomenclature and hierarchical classification of the U. S. National Vegetation Classification (USNVC) system (Grossman et al.,

1998) and mapped at the Alliance level, which represents the sixth tier in a seven-tiered hierarchy. The vegetation alliances in the area surrounding Chino (DBS&A, 2000) are listed in Table 3-1. Golder evaluated terrestrial habitats in the proposed 9 WRS area in 2016 and confirmed that the USNVC alliances present in the area consist of the Alligator Juniper-Oak Woodland Alliance and the Alligator Juniper-Oak/Grama Woodland Alliance.

The Alligator Juniper-Oak Woodland Alliance habitat is characterized by open stands of oaks such as grey oak (*Quercus grisea*) and emory oak (*Q. emoryi*), junipers (alligator [*Juniperus deppeana*] and/or one-seed juniper [*J. monopsperma*]) and piñon pine (*Pinus edulis*), with canopy cover ranging from 10 to 50 percent. This alliance covers roughly 60% of the valley, with the densest woodland primarily on the northwest facing slopes in the southern half of the study area. This alliance is present throughout the proposed 9 WRS area, with the exception of about 15% area covered with reservoir and disturbed area surrounding it. The Alligator Juniper-Oak/Grama Woodland Alliance habitat is also dominated by oaks and alligator juniper, with occasional piñon pine, but with lower tree canopy cover (3 to 8 percent). The understory contains dense grama (Bouteloua spp.) and muhly (Muhlenbergia spp.) grasses. Beargrass is a common member of the shrub component. This alliance covers roughly 25% of the Reservoir 9 valley. This alliance is represented in scattered areas throughout the proposed stockpile site but primarily on the shallower, upper slopes on the south side of the valley.

Trees in the area are predominantly juniper and oak species (Quercus spp.), with occasional piñon pine. Common shrubs observed include banana yucca (*Yucca baccata*), mountain mahogany (*Cercocarpus montanus*), beargrass (*Nolina microcarpa*), Parry's agave (*Agave parryi*) in rocky areas, and Apache plume (*Fallugia paradoxa*). Common grass species observed included Muhlenbergia spp., Harvard's three-awn (*Aristida havardii*), sand dropseed (*Sporobolis cryptandrus*), spike dropseed (*Sporobolis contractus*), hairy grama (*Bouteloua hirsuta*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), feather fingergrass (*Chloris virgata*), cane bluestem (*Bothriochloa barbinodis*), and Tufted lovegrass (*Eragrostis pectinacea*).

Herbaceous species observed included golden crown beard (*Verbesina encelioides*), Large petalled wild onion (*Allium macropetallum*), scarlet hedge-nettle (*Stachys coccinea*), southern mountain paintbrush (*Castellija austromonana*), Fendler rockcress (*Arabis fendleri*), Wright's cudweed (*Pseudognaphalium canescens*), canyon morning glory (*Ipomoea barbatisepala*), Carruth's sagewort (*Artemisia carruthii*), Fendler globemallow (*Sphaealcea fendleri*), yellow blanket flower (*Gaillardia pinnatifida*), shepherd's purse (*Capsella bursa-pastoris*), rock fern (*Polystichum* sp.), antelope horns milkweed (*Asclepias asperula*), bahia (*Amauriopsis disecta*), Erigeron spp., and spurge (*Chamaesyce* spp.).

3.3.7 Wildlife

The proposed 9 WRS area is not expected to markedly change wildlife populations in the area because similar habitat occurs extensively on undisturbed mine property and in adjacent nearby areas. Chino contracted Golder to conduct a pedestrian wildlife survey of the proposed 9 WRS area in July 2016. The results of this survey indicated that the vegetated portions of the proposed 9 WRS area provide potential foraging, breeding, and nesting locations for different wildlife species. Twenty-nine wildlife species or their sign were observed during the July 20, 2016 site visit (Table 3-2). Most inhabited the juniper-oak woodland habitat. These included 20 birds, 4 mammals, 1 amphibian and 4 reptiles. Invertebrates were not recorded during the site visit, though several were seen. The most common birds observed were spotted towhees, house wrens, house finches, and western wood-pewees. The most common mammal sighted were rock squirrels. A mule deer was sighted on the northeast side and tracks and pellets were seen throughout the survey area. Southwestern fence lizards and crevice spiny lizards were the most common reptiles seen throughout the area, in both the alligator juniper-oak/grama woodland and juniper-oak woodland alliances. One amphibian species occurred in the area, the canyon tree frog which was sighted on the southwest side of the valley in the juniper-oak woodland habitat.

No State or Federal special-status (threatened or endangered) species of wildlife or plants were observed in the area during the survey. Potential habitat for bats may occur in the form of crevices in the rock outcrops, but no roosts were positively identified. Surveys for Piños Altos flameflower were conducted in representative areas, but none were found.

3.3.8 Material Characteristics

Stockpile and cover borrow source materials found at the Chino Mine have previously been characterized with respect to their chemical composition and physical properties.

Stockpile Materials

On February 17, 2015, Chino submitted an updated material handling plan to NMED as part of the Master Document. Chino continually characterizes mined materials during operations and uses the information to route ore and waste rock to appropriate stockpile storage facilities. The material placed in the 9 WRS will not contain ore-grade copper, but will be mineralized. Waste rock stockpiles in the arid Southwest produce little stockpile seepage relative to leach stockpiles, however, a waste rock stockpile containment plan is proposed under the operating discharge permit (20.6.7.21 NMAC) and shall be performed in accordance with the applicable engineering requirements of Subsection B of 20.6.7.21 NMAC and 20.6.7.17 NMAC.

Chino believes the proposed stockpile is located inside the OPSDA (20.6.7.21.B.2 NMAC) based on site hydrologic studies. Chino is also currently installing additional ground water monitoring wells within the proposed 9WRS area that will provide additional ground water level and water quality data for the area.

Chino under the operating permit and with NMED guidance will establish a monitoring well network and corresponding water quality sampling program. The monitoring well data will be used to demonstrate compliance with applicable rules.

Borrow Materials

Agency approved or conditionally approved borrow material will be used as Reclamation Cover Material (RCM). All RCM are tested in accordance with the approved borrow material handling plans. The RCM is overburden that consists of a heterogeneous mixture of unmineralized and weakly mineralized earthen materials. The suitability of the RCM have been demonstrated as part of the Chino Test Plot program. The fine-earth fraction of the RCM is mostly medium- and moderately coarse-textured with clay contents ranging from about 10 to 20%. The rock fragment content of the RCM ranges from about 35 to 65% by volume. The results from the 2015 vegetation surveys of the stockpile test plots and Rustler Canyon reference area indicate that the unamended, mixed lithology cover material used at the test plots is capable of supporting a diverse self-sustaining ecosystem (Golder, 2015 and 2017). These data demonstrate that the vegetation on the test plots meets or is on a trajectory to meet vegetation success standards. A 3-foot thick cover constructed from the RCM meets the water holding capacity requirements specified by the Copper Mine Rules Section 20.6.7.F (Golder, 2016).

4.0 PROPOSED 9 WRS OPERATIONAL CONFIGURATION

The proposed 9 WRS will be constructed with waste rock mined from the Santa Rita Open Pit. The proposed 9 WRS at final build-out is presented on Figure 1-3. The stockpile is located at the southern periphery of the mine and will cover approximately 159 acres. Other stockpiles and the open pit are adjacent to this location. A process water reservoir (Reservoir 9) is currently located in the northern end of the valley. At final build-out, the top of the stockpile will be at an elevation of approximately 7,000 ft amsl. The stockpile will be constructed by end dumping in lifts approximately 50 feet high. The outslope of the stockpile will be built at angle of repose with between 80 to 100-foot wide benches on each lift, which will result in an overall slope of approximately 3.5H:1V. This operational outslope design will facilitate reclamation at closure, because it allows attainment of the 3H:1V interbench slopes with minimal regrading. The top surface will be nearly level, but will be graded at closure to meet the minimum requirements (Figure 1-3).

5.0 PROPOSED 9 WRS RECLAMATION PLAN

This section presents the reclamation plan and associated design criteria for closure/closeout of the proposed 9 WRS. Reclamation design criteria were developed in consideration of the site-specific conditions that exist at Chino including soil, ecological, operational, and economic constraints. The reclamation design criteria conform to the closure requirements described in Section III of DP-1340, 20.6.7.33 NMAC, and Section 8 of MMD Permit GR009RE. Conceptual level reclamation design drawings for the proposed 9 WRS are presented in Appendix A. Final designs for reclamation of this facility will be prepared and submitted to the agencies as part of the CDQAP.

Performance objectives and design criteria were developed with the intent of meeting the NMWQA, NMWQCC Regulations and NMMA Rules. The reclamation designs were developed to provide sufficient information to calculate the financial assurance cost estimate. A summary of the key design criteria for the 9 WRS are presented in Table 5-1, and are consistent with the requirements specified in Section 20.6.7.33 NMAC. The reclamation performance objectives for the 9 WRS include: establishment of a self-sustaining ecosystem; create a post mining land use of wildlife habitat; and control discharges of water that have the potential to generate leachate and cause an exceedance of applicable standards.

Structural Stability

The operational 9 WRS will be constructed to allow for efficient closure of the facility and to ensure that the Copper Rules (20.6.7.33.B NMAC) slope stability requirements are met. The stockpile is abutted by natural hillsides on all but the north side. On the north side, the stockpile abuts a mine haul road embankment. The overall outslope following reclamation will be approximately 3.5H:1V and up to approximately 250 feet high. Based on a comparison of this configuration to the cross sections of waste and leach stockpiles evaluated in (Golder, 2007b; 2008) it is expected that the proposed stockpile will meet the slope stability criteria of 20.6.7.33.B NMAC.

Stockpile Erosion and Drainage Control

The proposed reclamation design meets the criteria stipulated in permit GR009RE, DP-1340 and Section 20.6.7.33.C NMAC. Erosion and drainage control for the stockpile will be achieved by regrading, construction of stormwater conveyances, and revegetation. Upon reclamation, the 9 WRS top surface will be graded to a minimum final grade of 1% and covered to direct non-impacted stormwater to designated discharge areas. Armored channels, perimeter berms, and hydraulic structures will be designed to control erosion and safely convey stormwater. The stockpile inter-bench outslopes will be graded to at least 3.0H:1V with uninterrupted slope lengths of no greater than 200 feet. Stormwater will be controlled using conventional terrace channels integrated to two downdrains, one on the northwest and the other on the southwest side of the stockpile (Appendix A). Erosion control will be achieved by storm water conveyance channels, stable outslopes, suitable cover material and revegetation.

Run-on from the surrounding terrain will be controlled by perimeter channels located around the 9 WRS (Appendix A). All channels will be designed to accommodate the peak discharge resulting from the 100-year, 24-hour storm event. The perimeter channels will direct surface water flows around the perimeter of the stockpile and ultimately northward toward the open pit.

Temporary erosion control measures may be provided during the construction and early vegetation establishment periods. These measures may include, but are not limited to, berms, mulch, straw bales, silt fences, and minor corrective regrading. All construction will be in compliance with federal and state regulations for temporary storm water control.

Stockpile Cover and Revegetation Specifications

Finish grading of the stockpile subgrade will be performed based on pre-construction surveys. Earth moving equipment such as bulldozers and motor graders will be used to smooth the surfaces and facilitate access for supplemental cover placement and mulching/seeding. Stockpile covers will be placed according to the following criteria:

9 WRS Cover and Grading	
Top Surface Cover Thickness	36 inches
Outslope Cover Thickness	36 inches
Top Surface Grade	1.0 to 5%
Slope (Inter-Bench Slope)	3H:1V max.

The reclamation designs and the associated estimated reclamation quantities presented in Appendix A indicate that the cover requirement for the 9 WRS is approximately 780,208 yd^3. Overburden material that has been stored at the Upper South Stockpile is the primary source of cover material for the 9 WRS.

Revegetation of the covered surfaces will be achieved by seeding with a variety of native and adapted grasses, shrubs, and forbs in accordance with Appendix C of Permit GR009RE and applicable modifications. The planned seed mix is discussed in Section 7.0.

6.0 CLOSURE & POST-CLOSURE MONITORING, REPORTING, AND CONTINGENCY PLANS

Closure and post-closure monitoring, reporting, and contingency plans are described in Chino's current operational DP-493, DP-1340, and the MMD Permit. All the closure and post-closure ground water, surface water, seep, spring, and piezometer monitoring data will be reported under the appropriate discharge permit and in accordance with DP-1340 (NMED, 2003). Chino will submit to NMED quarterly reports summarizing reclamation and post-closure activities on or before January 15, April 15, July 15, and October 15 of each year. Two potentiometric maps including data from all active monitoring wells, extraction wells, piezometers, seeps, and springs in the NMA (including the 9 WRS area) will be submitted to NMED in accordance with Section 20.6.7.35 NMAC.

The MMD requires periodic monitoring of revegetation during the responsibility period to evaluate revegetation success. DP-1340 requires the development of post-closure monitoring and contingency plans that are consistent with the terms and conditions of the applicable DP. The following sections summarize the general approach that will used to meet these requirements.

6.1 Erosion and Drainage Control Structures

The reclaimed 9 WRS will be visually inspected for signs of excessive erosion and significant erosion features will be mitigated to prevent future degradation of the site in accordance with Section 20.6.7.35 NMAC and Section 8.N.1 of the MMD Permit. Chino will conduct inspections and submit reports of the reclaimed 9 WRS monthly for the first year following completion of reclamation construction activities, and quarterly thereafter. Additional erosion inspections will also be conducted after a one inch or more rain event. Chino will report evidence of excessive erosion and/or structural failures to the appropriate agencies (MMD, NMED, or NMOSE) in a timely manner. A written report detailing the nature and extent of the problem and a corrective action plan will be developed within 15 days after the problem is identified in accordance with Section 20.6.7.30 NMAC.

As specified in Section 20.6.7.35 NMAC, Chino will routinely inspect and maintain all drainage channels, diversion structures, retention impoundments, and auxiliary erosion control features in accordance with professionally recognized standards, such as the Natural Resources Conservation Service.

6.2 Water Quality Monitoring and Reporting

Monitoring of site water quality will be accomplished through sampling and analysis of water in accordance with Section 20.6.7.35 NMAC. Water quality will be monitored throughout the post-closure period. The monitoring schedule, analytical requirements, location, and construction specifications for the monitoring wells will be determined in consultation with NMED. The analytical results will be reported to the NMED as specified in DP-1340 and Section 20.6.7.28 NMAC.

6.3 Revegetation Success Monitoring

The reclaimed area will be monitored in accordance with 20.6.7.35.C NMAC, DP-1340, and Section 8.N.2 of the MMD Permit after the final grading and the initial establishment of vegetation on the reclaimed land. Chino will conduct semi-quantitative vegetation monitoring during the third year after seeding. Quantitative vegetation monitoring will be performed at the sixth year after planting and for two of the last four years prior to bond release. Revegetation monitoring will include canopy cover, plant diversity, and woody stem density as specified in Section 8.N.2 of the MMD Permit (MMD, 2003a).

6.4 Wildlife Monitoring

Wildlife monitoring will be conducted in accordance to the approved work plan. The approved work plan includes deer pellet counts and bird diversity surveys conducted six years after seeding and two consecutive years prior to bond release. Results of the surveys will not be a condition of, or given consideration with regard to financial assurance release.

6.5 Construction Quality Assurance Plan

Pursuant to Sections 8.D.2.a and 8.E.2.a of the MMD Permit and 20.6.7.34.F and 20.6.7.34.G NMAC Chino will submit a CQAP to the MMD and NMED for approval no less than 180 days prior to regrading of the 9 WRS and placement of any cover material for final closure. The CQAP will be followed by a CQAR to be submitted to the MMD and NMED within 180 days after completion of construction.

7.0 POST-MINING LAND USE DESIGNATION

This section designates the PMLU for the 9 WRS based upon the requirements of the MMD Permit, NMMA Section 69-36-11.6, and Subparts 507.A, 507.B, and 508 of the NMMA Rules (MMD, 1996). PMLUs are specified in Section 3.G. of MMD Permit GR009RE. The approved PMLUs for Chino are wildlife habitat and industrial (MMD, 2003). Wildlife habitat is the primary PMLU for the majority of the Chino mine permit area and is the proposed PMLU for the 9 WRS.

Reclamation of the 9 WRS will result in the development of an early-stage grass/shrub community that will provide a locally important increase in community-level diversity. Some infrastructure may have a post-mining wildlife use such as power poles for raptor perches and main roads for land management. Native vegetation will be established on the reclaimed area resulting in increased erosion protection, direct habitat improvement, and reduced percolation of water into the underlying materials relative to unreclaimed conditions. The proposed reclamation seed mix and seeding rates for the 9 WRS are presented in Table 7-1, and is in accordance with Appendix C of the MMD Permit and applicable modifications. These species have broad ecological amplitudes and will provide structural diversity.

The proposed seed mix was selected to provide early establishment of ground cover, erosion control, and diversity in growth forms. The species selected for the 9 WRS have been successfully used in mine reclamation and range improvement projects in many parts of New Mexico, including the Chino Mine. The primary reclamation seed mix proposed includes cool and warm season grasses, perennial shrubs, and forbs. Depending on availability, alternate species may be substituted for the primary species. The seed mix is designed for application prior to the summer rains. Table 7-2 lists some of the major attributes of the vegetation selected for use at the 9 WRS. The selected vegetation will provide erosion control, promote soil development, and provide forage, seeds, and cover for small mammals and birds. The seed mix includes a number of valuable, nutritious forage and browse species that could be used by wildlife.

7.1 Site-Specific Revegetation Success Guidelines

Section 507.A of the NMMA rules (MMD, 1996) requires that the permit area of an existing mine be reclaimed to a condition that allows the establishment of a self-sustaining ecosystem appropriate for the life zone of the surrounding area unless it conflicts with the approved PMLU. Demonstration of the establishment of a self-sustaining ecosystem is made by comparison of the vegetation on the reclaimed areas to vegetation attributes on a reference area and/or technical standards (MMD, 1996).

New disturbances located outside the current design limit will meet the reclamation standards set forth in 19.10.5.507 NMAC and will also comply with the new unit standards set forth in 19.10.5.508.E NMAC. Disturbances located within the current design limit are considered existing mine units and will meet the reclamation standards set forth in 19.10.5.507 NMAC. Site-specific revegetation success guidelines for each of these areas will follow the established permit conditions for vegetation cover, shrub density, and diversity. The numerical diversity guidelines for the Chino mine are listed in Table 7-3.

8.0 BASIS FOR CAPITAL AND OPERATION AND MAINTENANCE COST ESTIMATES

This section summarizes the material take-offs and factors that will be applied in the capital and O&M cost estimates associated with the 9 WRS reclamation plan. A detailed cost estimate for the purpose of determining the value of the financial assurance performance bond will be prepared following approval of the proposed 9 WRS reclamation plan included in this CCP. The following sections provide the basis upon which these cost estimates will be developed.

8.1 9 WRS Material Take-Offs

The earthworks material takeoff for reclamation of the 9 WRS cost estimate was developed by Chino in accordance with standard engineering practice and is supported with data from various references and is fully documented in Appendix A. The material takeoffs for the major reclamation components are summarized below:

9 WRS Reclamation Quantities[1]		
Item	**Quantity**	**Units**
Earthwork		
Grading	640,954	cubic yards
Bench Grading	14,085	linear feet
Cover Material	780,208	cubic yards
Cover and Revegetate	161	acres
Surface Water Conveyance Channels	21,920	linear feet
Riprap for Conveyance Channels	4,051	cubic yards
Filter/Gravel Below Rip Rap	5,695	cubic yards

Note:

[1] – Quantities developed by Chino

8.2 Basis for Capital Cost Estimates

The earthwork reclamation cost estimate will be based on a template originally created by the New Mexico Energy, Minerals and Natural Resources Department, Mining and Minerals Division (MMD, 1996). The estimate will include reclamation earthwork and site operations and maintenance costs and will be based on the reclamation designs for the 9 WRS included in Appendix A.

The unit rates that will be used to develop the cost estimate and equipment production factors are provided in Appendix A and are summarized below:

- **Labor Rates:** With the exception of the truck driver rate all labor rates will be developed based on the New Mexico Department of Labor (DOL) Type H (Heavy Engineering) labor rates effective for 2016. These rates include the base, fringe benefit, and apprenticeship contribution rates.
- **Truck Driver Labor Rate:** The base truck driver labor rate is assumed to be 90% of the New Mexico DOL base operator labor rate. Added to the base rate were fringe benefits, apprenticeship contributions, taxes, and Workman's Compensation Insurance.
- **Equipment Rates:** The earth-moving equipment used in the estimate would commonly be available to a contractor. The equipment unit operating costs will be taken from EquipmentWatch Custom Cost Evaluator (Penton Media, Inc., 2016). All costs taken from EquipmentWatch Custom Cost Evaluator are adjusted using the local factor for Las Cruces and overhead is removed from direct costs and included in the indirect cost percentage.
- **Fuel Costs:** The off-road diesel fuel cost will be a vendor quote for delivery of dyed ultra-low sulfur diesel to Silver City, NM.
- **Capital Indirect Costs:** The estimated reclamation costs, at a minimum include contract administration; mobilization; demobilization; engineering redesign; profit and overhead; procurement costs (Section §19.10.12.1205.A NMAC) as well as contingency and project management fee. The percentage rates are supported by using information from similar large scale earthwork projects and State and Federal Reclamation FA cost estimate guidance, Occupational Employment statics, RS Means Contractor Indirect Rates, Margins of Construction, and Business Economics.
- **Equipment Production Factors:** Production factors will be obtained from Caterpillar (2014) for each type of equipment. Productivity curves will also be developed from Caterpillar (2014). See Appendix A for further details.
- **Haul Distances:** Haul distances will be calculated along a preferred route and assumed to originate at the approximate centroid of the source and terminate at the approximate centroid of the reclamation area. A maximum of three segments will be used for each haul route.
- **Borrow Areas:** RCM will be excavated from the Upper South Stockpile.
- **Dozer Push Distances:** Dozer push distances represent the distance from the centroid of the cut block to the centroid of the fill block.
- **Dust Suppression and Site Maintenance:** A full time water truck and a motor grader will be included as part of the fleet during reclamation. The water truck and grader time was set equal to loader time.
- **Revegetation Unit Costs:** The revegetation unit cost will be based on a quote obtained when the cost estimate is being developed. The quote will include: scarifying, discing, rangeland drill seeding, mulching, crimping, and daily per diem.
- **RipRap Production:** The riprap unit cost will be developed based on experience gained producing riprap at the McCain Springs Quarry.
- **Miscellaneous Unit Costs:** Additional miscellaneous unit costs will be taken from several sources including R.S. Means Heavy Construction Cost Data Edition 30 (R.S. Means, 2016). All costs taken from R.S. Means will be adjusted using the location factor for Las Cruces (84.4%).

- **Reclamation:** Reclamation will include: minor top surface grading to achieve a smooth slope following the top surface sloping to the east; pushing down operational stockpile benches to achieve a smooth slope; hauling and grading cover material for the top surfaces; completing surface water channels and benches to collect and convey storm water from the stockpile surfaces; and scarification and revegetation of covered areas.

8.3 Basis of Operation and Maintenance Cost Estimates

Details and supporting documentation for the basis of the O&M cost estimate are provided in Appendix A and summarized below.

The basis for O&M costs related to periodic erosion control and road maintenance are already included in the Chino CCP Update and will not be included as part of the 9 WRS O&M cost estimate. For the 9 WRS, revegetation maintenance will be based on an assumed 2% failure every year for a total of 12 years, starting the year reclamation is completed. Indirect costs are included for long term O&M per MMD (1996) and OSM (2000) guidance and will comprise the same values and factors as the capital indirect costs with exception of contractor profit and overhead. Contractor profit and overhead for long term O&M will be included to account for the long term contract and repetitive annual work. Indirect cost percentages are identical to the percentages presented to MMD and the NMED in meetings with Tyrone on September 20, 2012, and on November 2, 2012.

9.0 CLOSURE SCHEDULE

The proposed reclamation schedule for the 9 WRS summarizes Chino's existing mine plans, near-term mine operation and reclamation commitments and longer-term projections.

The anticipated duration to complete closure of the 9 WRS is approximately 2 years. Under a default scenario, the reclamation would be coordinated with the site-wide reclamation program. Reclamation work will begin within 180 days following of cessation of operations. The most efficient reclamation sequence will be analyzed and developed under the CQAP. However, in preparation of the FA cost estimate the entire site reclamation schedule is developed in total based on the type and area of disturbance as well as the equipment fleet.

10.0 USE OF THIS REPORT

Golder has prepared this CCP for the 9 WRS for the NMED and the MMD of the New Mexico Energy, Minerals and Natural Resources Department. In the compilation of this plan, Golder collaborated with Chino, who prepared the reclamation drawings and basis of the reclamation cost estimate. The 9 WRS CCP has been developed to fulfill the requirements of the following permits and rules:

- Supplemental Discharge Permit for Closure, DP-1340, Chino Mines Company, issued by the NMED on February 24, 2003 (NMED, 2003);
- **Revision 01-1 to Permit GR009RE**, issued by the Director of the MMD of the New Mexico Energy, Minerals and Natural Resources Department on December 18, 2003 (MMD, 2003); and
- Applicable conditions of the **Copper Mine Rules (Section 20.6.7 NMAC)**, respectively.

Respectfully submitted,

GOLDER ASSOCIATES INC.

Todd Stein, PG
Project Manager

Lewis Munk
Senior Scientist/Project Director

11.0 REFERENCES

Caterpillar, Inc. 2014. Caterpillar Performance Handbook, Edition 44. Caterpillar Inc. Peoria, Illinois. January 2014.

Chino Mines Company (Chino). 2003. Contingency Plan for Chino Mines Closure Components and Emergency Response Plan for Surface Impoundments. October 21, 2003.

Chino. 2008. MSGP-2008 Stormwater Pollution Prevention Plan, Chino Mines Company, Hurley, New Mexico.

Chino. 2014. Storm Water Handling Plan/Emergency Response Plan for Chino Pit and Adjacent Areas Discharge Permits 459 and 1568, 526, and 591. Revised June 6, 2014.

DBS&A. 1998. Borrow Materials Investigation and Soil Suitability Assessment. Prepared for Chino Mines Company, Hurley, New Mexico.

DBS&A. 1999. Interim Technical Standards for Revegetation Success, Prepared for Chino Mines Company, Hurley, New Mexico.

DBS&A. 1999a. Preliminary Open Pit and Stockpile Waiver Justification, Santa Rita Open Pit – Task 2: Evaluation of Measures to Meet Applicable Regulations and Standards. January 31, 1999.

DBS&A. 2000. Comprehensive Vegetation Survey of the Chino Mine, Grant County, New Mexico. Prepared for Chino Mines Company. June 5, 2000.

DBS&A. 2007. Supplemental Leach Ore Stockpile and Waste Rock Stockpile Mass Loading Study, Final Report for DP-1340, Condition 84, Chino Mine. June 15, 2007.

EnviroGroup Limited. 2006. Supplemental Leach Ore Stockpile and Waste Rock Stockpile Mass Loading Study, Final Report for DP-1340, Condition 84, Chino Mine. May 31, 2006.

Golder Associates Inc. (Golder). 1998a. Waste Rock Characterization – Chino Mine. Prepared for Chino Mines Company, Hurley, New Mexico.

Golder. 1998b. An Assessment of Wildlife Communities in the Chino Mine Proposed Action Area.

Golder. 2004b. Wildlife Monitoring Plan for Post Closure of the Chino Mine. December 29, 2004.

Golder, 2006a. Supplemental Materials Characterization Upper South Stockpile DP-1340 Condition 81. April 27, 2006.

Golder. 2006b. Borrow and Cover Design Report - Chino Tailing Reclamation. Prepared for Chino Mines Company, Hurley, New Mexico. November 21, 2006.

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

Golder. 2007b. Preliminary Draft, Supplemental Stability Analysis of Waste Rock Piles and Leach Ore Stockpiles, Final Report for DP-1340, Condition 80, Chino Mine. April, 2007.

Golder. 2008. Supplemental Stability Analysis of Waste Rock Piles and Leach Ore Stockpiles, Final Report for DP-1340, Condition 80, Chino Mine. March 11, 2008.

Golder. 2015. Chino Stockpile Test Plots 2015 Addendum Report. Prepared for Freeport-McMoRan Chinos Mines Company. November 30, 2015.

Golder. 2016. Determination of Reclamation Cover Material Water Holding Capacity - Chino North Mine Area. Prepared for Freeport-McMoRan Chinos Mines Company. August 16, 2016.

Greystone., 2004. Supplemental leach ore stockpile and waste rock stockpile mass loading study interim report for DP-1340, Condition 84, Chino Mine. Prepared for Chino Mines Company, Hurley, New Mexico. December 23, 2004.

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.

Jones, W.R., R.M. Hernon, and S.L. Moore. 1967. General geology of the Santa Rita Quadrangle Grant County, New Mexico. U.S. Geological Survey Professional Paper 555. US Gov. Print. Office, Washington DC.

M3 Engineering and Technology Corporation (M3., 2001. End of Year 2001 through Year 2006 Closure/Closeout Plan, Chino Mines. March 17, 2001.

Mining and Minerals Division (MMD) of the New Mexico Energy, Minerals, and Natural Resources Department. 1996. Closeout Plan Guidelines for Existing Mines. MMD Mining Act Reclamation Bureau, Santa Fe, New Mexico. April 30, 1996.

MMD. 2003. Permit revision 01-1 to Permit No. GR009RE Chino Mine Existing Mining Operation. Issued December 18, 2003.

New Mexico Environment Department (NMED). 2003. Supplemental Discharge Permit for Closure, Chino Mines Company, DP-1340. Issued February 24, 2003.

OSM, 2000. U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement Handbook for Calculation of Reclamation Bond Amounts. April 5, 2000.

Parnham, T.L., R. Paetzold, and C.E. Souders. 1983. Soil Survey of Grant County, New Mexico, Central and Southern Parts. USDA-Soil Conservation Service, U.S. Gov. Print. Office Washington DC.

Penton Media, Inc. 2015. Equipment Watch Custom Cost Evaluator Version 6.17.13A.

Rose, A.W. and W.W. Baltosser. 1966. The Porphyry Copper Deposit at Santa Rita, New Mexico. in Geology of the Porphyry Copper Deposits Southwestern North America edited by Titley, S.R. and C.L. Hicks. University of Arizona Press, Tucson, Arizona. p. 205-220.

R.S. Means. 2016. Heavy Construction Cost Data. 30th Annual Edition. R.S. Means Company, Inc.

TABLES

Table 2-1: Summary of Chino Closure/Closeout-Related Permits Pertinent to the Proposed 9 WRS

Permit or Requirement	Agency	ID Number	Area Covered
Mining Act Permit	New Mexico Mining & Minerals Division	GR009RE	Chino Mine
Groundwater Discharge Plans	NMED Ground Water Quality Bureau	DP-493, DP-1340	Operational DP for the Reservoir 3A, Reservoir 9, and Highway to Heaven Supplemental DP for Closure
National Pollutant Discharge Elimination System (NPDES)	U.S. EPA (Region 6)	NMR053259 MSGP-2008	Multi-Sector General Storm Water Permit
Water Rights	New Mexico Office of State Engineer	M-3527, M-4425, M-5010 through 5019, M-6724	Chino Mine Areas
Air Quality	U.S. EPA (Region 6)	P066R1 0298M7	Title V Mine-wide Cobre and Chino Mines
Hazardous Waste Generator / Hazardous Materials Inventory	U.S. EPA/New Mexico Department of Public Safety State and County Emergency Response Commission	NMD007396930	Chino Mine
Plan of Operation	Bureau of Land Management	Submitted in 1981 and 1997	All Federal Land

Notes:

SX/EW = Solution extraction/electrowinning
U.S. EPA = United States Environmental Protection Agency
NMED = New Mexico Environment Department
NA = Not applicable

Table 3-1: Vegetation Map Units in the Chino Survey Area

Name	Acreage	Elevation Range (ft amsl)
Mixed-Grama Herbaceous Alliance	6,717	5,200-5,750
Mesquite/Mixed Grama Shrubland Alliance	8,858	5,200-5,800
Fluvial Forest and Shrubland Alliance	1,585	5,200-5,600
Alligator juniper-Oak/Grama Woodland Alliance	10,257	5,800-7,700
Alligator juniper-Oak Woodland Alliance	4,456	5,800-7,400
Mountain mahogany Shrubland Alliance	10,038	5,600-7,600
Ponderosa pine-Oak Forest Alliance	1,552	6,000-7,600
Mine Facilities/Urban	10,122	NA

Notes: NA = Not applicable

Table 3-2. Wildlife Observed During the 2016 Survey of the Proposed 9 WRS Area

Species	Scientific Name
Birds	
Turkey vulture	*Cathartes aura*
Montezuma quail	*Cyrtonyz montezumae*
Mourning dove	*Zenaida macroura*
Black-chinned hummingbird	*Archilochus alexandri*
Norther flicker	*Caloptes auratus*
Cassin's kingbird	*Tyrannus vociferans*
Western kingbird	*Tyrannus verticalis*
Western wood-pewee	*Contopus sordidulus*
Common raven	*Corvus corax*
Western scrub jay	*Aphelocoma californica*
Violet-green swallow	*Tachycineta thalassina*
Juniper titmouse	*Baeolophus ridgwayi*
House wren	*Troglodytes aedon*
Canyon wren	*Catherpes mexicanus*
Rock wren	*Salpinctes obsoletus*
Yellow-rumped warbler	*Setophaga coronata*
Spotted towhee	*Pipilo maculatus*
Black-chinned sparrow	*Spizella atrogularis*
Black-headed grosbeak	*Pheucticus melanocephalus*
House finch	*Carpodacus mexicanus*
Reptiles	
Crevice spiny lizard	*Sceloporus poinsetti*
Southwestern fence lizard	*Sceloporus cowlesi*
Ornate tree lizard	*Urosaurus ornatus*
Whiptail lizard	*Aspidoscilus sp.*
Amphibians	
Canyon tree frog	*Hyla arenicolor*
Mammals	
Rock squirrel	*Spermophilis variegatus*
Chipmunk sp.	*Tamias sp.*
Woodrat	*Neotoma sp.*
Mule deer	*Odocoileus hemionus*

Table 5-1: Summary of Key Design Criteria for Closure of the 9 WRS

Stockpile Regrading:

- Outslope to be graded to an inter-bench slope of 3.0H:1V
- Maximum uninterrupted slope length of 200 feet for outslopes
- Terrace benches will have maximum bench width 50 feet (conceptual designs at 15 feet wide)
- Bench longitudinal slopes at maximum of 5 percent
- Bench cross slopes and channels between 1 and 5 percent
- Top surface graded at a minimum final grade of 1 percent
- Regrading to be done in such a manner that orients surface water conveyances to the exterior perimeter of the stockpile
- Slope channels will be located where possible in natural junctions or drainage chutes, but all channels will contain riprap and energy dissipation structures as appropriate
- Run-on from the surrounding terrain will be controlled by perimeter channels located around the stockpile
- Surface water conveyance channels will be designed to accommodate the peak discharge resulting from the 100-year, 24-hour storm event
- Top surface and outslope to be covered with 36 inches of suitable cover material
- Top surface and outslope to be revegetated in accordance with Appendix C of the MMD Permit and applicable modifications
- A moderate maintenance program will be acceptable until cover vegetation establishes

Haul Roads (all haul roads except those located within PMLU access roads)

- Where located on acid-generating material, surface to be covered with 36 inches of suitable cover material
- Cover surfaces to be revegetated in accordance with Appendix C of the MMD Permit and applicable modifications
- Where located on non-acid-generating material, surface to be ripped and revegetated in accordance with Appendix C of the MMD Permit and applicable modifications
- A moderate maintenance program will be acceptable until cover vegetation establishes

Notes:

MMD = Mining and Minerals Department
PMLU = Post Mining Land Use
OPSDA = Open Pit Surface Drainage Area

Table 7-1: Proposed Interim Seed Mix and Rates for the 9 WRS Site

Species[a]	Life-Form	Duration[b]	Seasonality	Rate[a,c]
Primary				
Blue grama (*Bouteloua gracilis*)	Grass	Per	Warm	0.25
Side-oats grama (*Bouteloua curtipendula*)	Grass	Per	Warm	1.25
Black grama (*Bouteloua eriopoda*)	Grass	Per	Warm	0.10
Green sprangletop (*Leptochloa dubia*)	Grass	Per	Warm	0.15
Plains lovegrass (*Eragrostis intermedia*)	Grass	Per	Intermediate	0.05
Bottlebrush squiretail (*Sitanion hystrix*)	Grass	Per	Cool	1.25
New Mexico needlegrass (*Stipa neomexicana*)	Grass	Per	Cool	1.75
Streambank wheatgrass (*Agropyron dastachyum v. riparium*)	Grass	Per	Cool	1.50
Apache plume (*Fallugia pardoxa*)	Shrub	Per	NA	0.10
Mountain mahogany (*Cercocarpus montanus*)	Shrub	Per	NA	1.00
Winterfat (*Eurotia lanata*)	Shrub	Per	NA	0.60
White prairie clover (*Dalea candida*)	Shrub	Per	NA	0.15
Globe mallow (*Sphaeralcea sp.*)	Forb	Per	NA	0.10
Blue flax (*Linum lewisii*)	Forb	Per	NA	0.15
Total PLS (lb/ac)				**8.40**
Alternate				
Needle-and-thread (*Stipa comata*)	Grass	Per	Cool	ND
Thickspike wheatgrass (*Agropyron dastachyum*)	Grass	Per	Cool	ND
Sand dropseed (*Sporobolus cryptandrus*)	Grass	Per	Intermediate	ND
Tobosa (*Hilaria mutica*)	Grass	Per	Warm	ND
Bush muhly (*Muhlenbergia porteri*)	Grass	Per	Warm	ND
Squawberry (*Rhus trilobata*)	Shrub	Per	NA	ND
Fourwing saltbush (*Atriplex canescens*)	Shrub	Per	NA	ND
Prairie coneflower (*Ratibida columnaris*)	Forb	Per	NA	ND

Notes:

[a] Seed mix and rates are subject to change based on future investigations
[b] Per – Perennial; Ann = Annual
[c] Rate is in pounds of pure live seed per acre; substitutions may change seeding rates
lb/ac = pounds per acre
NA = Not applicable
ND = Not determined
PLS = Pure live seed

Table 7-2: Functions and Attributes of the Primary Plant Species Proposed for the 9 WRS Site

Species	Character[a]	Attributes and Function
Blue grama (*Bouteloua gracilis*)	N,P,W,G	Sod and bunch grass providing ground cover and forage
Side-oats grama (*Bouteloua curtipendula*)	N,P,W,G	Bunch grass providing ground cover and forage
Black grama (*Bouteloua eriopoda*)	N,P,W,G	Bunch grass providing ground cover and forage
Green sprangletop (*Leptochloa dubia*)	N,P,W,G	Erect bunch grass; aggressive short-lived nurse plant with forage value
Plains lovegrass (*Eragrostis intermedia*)	N,P,C,G	Bunch grass providing ground cover and early spring forage
Bottlebrush squiretail (*Sitanion hystrix*)	N,P,C,G	Persistent (moderately palatable) bunch grass providing ground cover
New Mexico needlegrass (*Stipa neomexicana*)	N,P,C,G	Persistent bunch grass providing ground cover and forage
Streambank wheatgrass (*Agropyron dastachyum v. riparium*)	N,P,C,G	Sod-forming grass providing ground cover and forage
Apache plume (*Fallugia pardoxa*)	N,P,S	Mid-height shrub providing browse, cover, and erosion control
Mountain mahogany (*Cercocarpus montanus*)	N,P,S	Mid-height to tall shrub providing browse and cover
Winterfat (*Eurotia lanata*)	N,P,HS	Low shrub providing winter browse
White prairie clover (*Dalea candida*)	N,P,S	Early season legume providing ground cover and forage
Globe mallow (*Sphaeralcea sp.*)	N,P,F	Persistent mid-height forb providing browse
Rubber rabbitbush (*Chrysothamnus nauseosus*)	N,P,S	Mid-height shrub providing cover and erosion control
Blue flax (*Linum lewisii*)	N,P,F	Persistent forb with a pretty blue flower

Notes:

[a] N = Native
I = Introduced
P = Perennial
A/B = Annual or biannual
W = Warm season
C = Cool season
G = Grass
S = Shrub HS = Half shrub
F = Forb

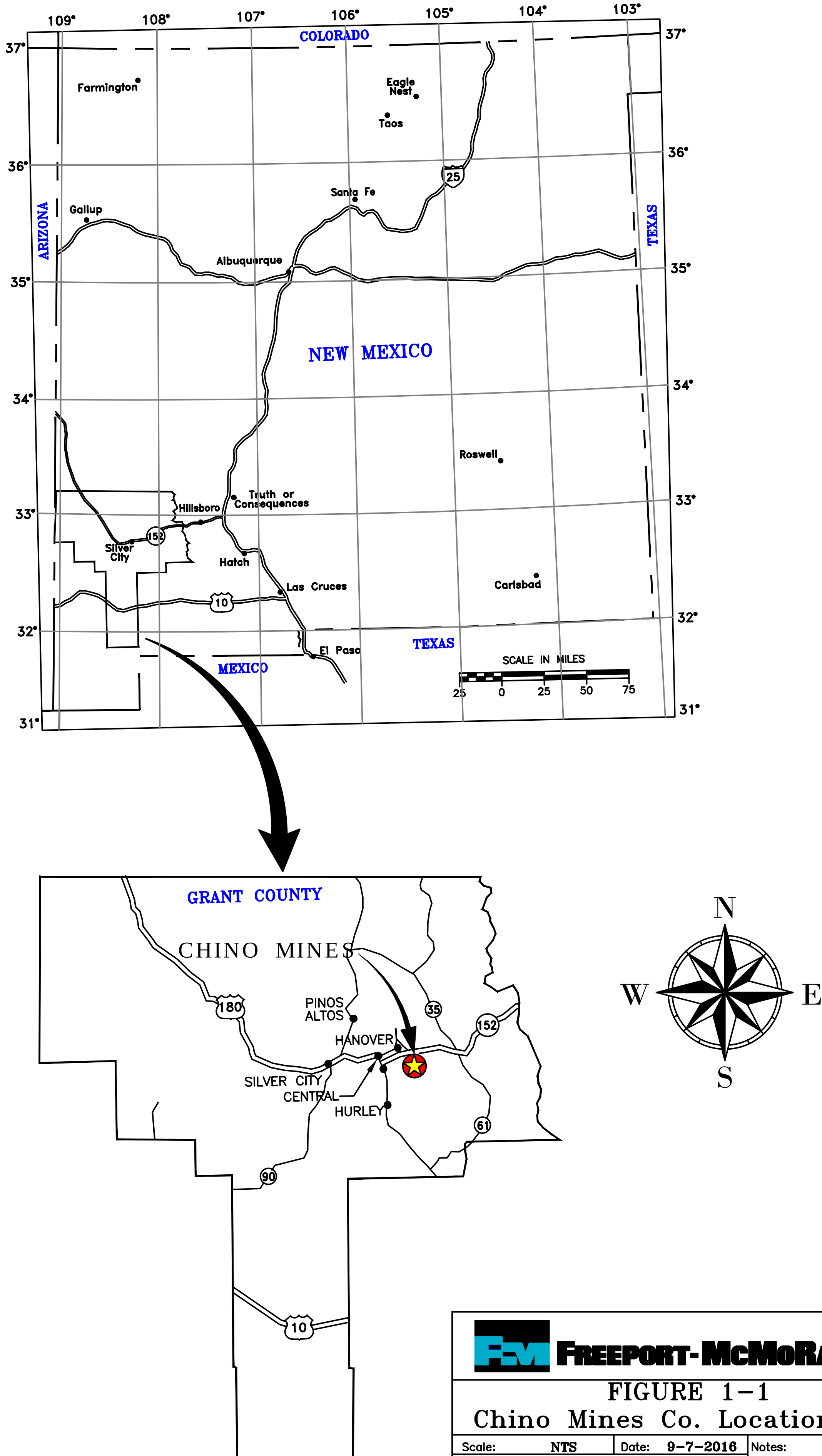
Table 7-3: Proposed Plant Diversity Guidelines for the 9 WRS Site

Class	Seasonality	Number	Minimum Occurrence (% cover)
Perennial grass	Warm	3	1
Perennial grass	Cool	1	0.5
Perennial shrub	NA	2	1
Forbs	NA	2	0.1

Note:

NA = Not Applicable

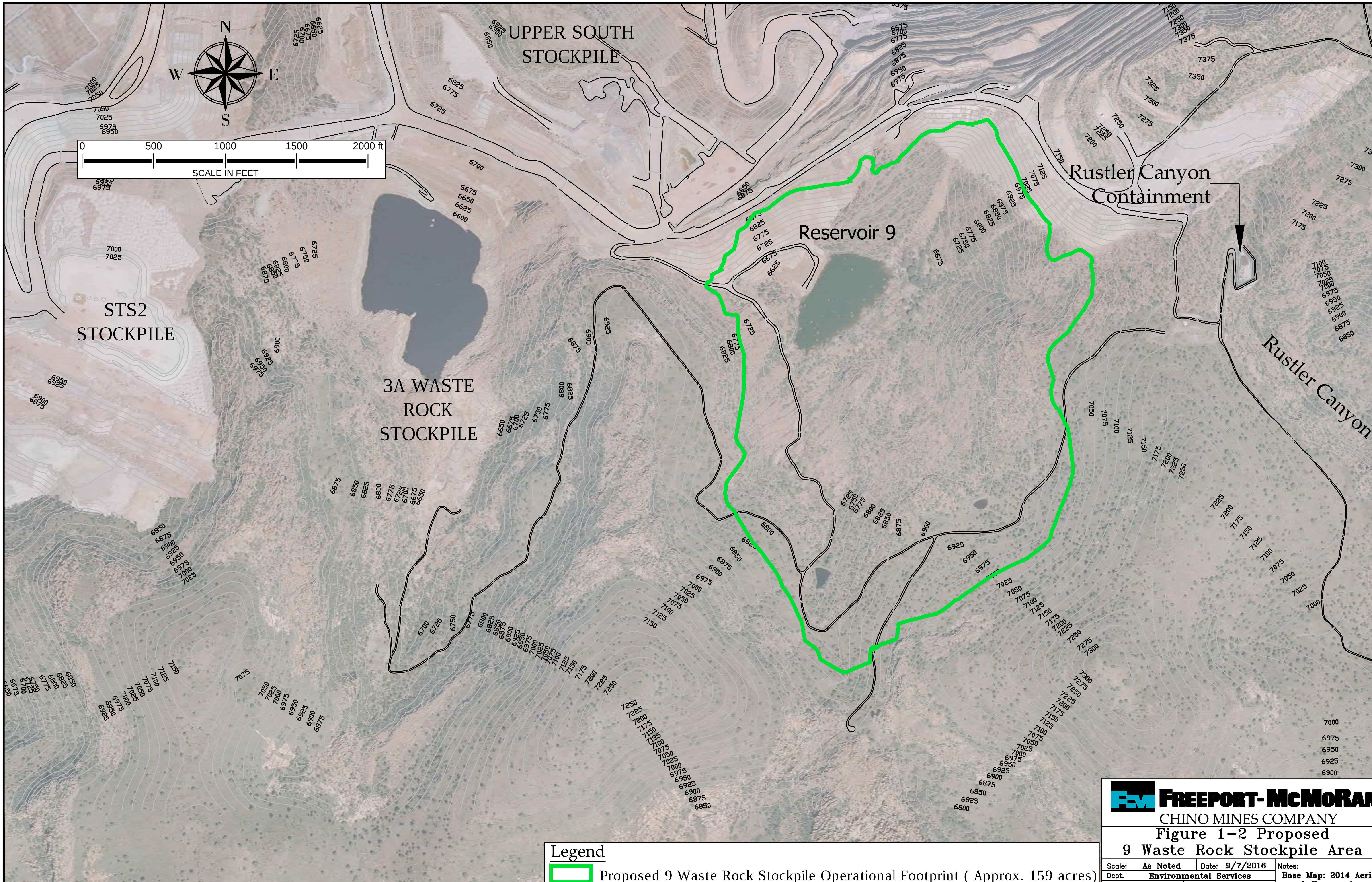
FIGURES



FREEPORT-MCMORAN

FIGURE 1-1
Chino Mines Co. Location Map

Scale: NTS	Date: 9-7-2016	Notes:
Dept. Environmental Services		
Drawn By: SMG	Checked By: RLM	


UPPER SOUTH STOCKPILE
N
S
E
W
0
500
1000
1500
2000 ft
SCALE IN FEET
STS2 STOCKPILE
3A WASTE ROCK STOCKPILE
Reservoir 9
Rustler Canyon Containment
Rustler Canyon
Legend
Proposed 9 Waste Rock Stockpile Operational Footprint (Approx. 159 acres)
FREEPORT-McMoRAN
CHINO MINES COMPANY
Figure 1-2 Proposed
9 Waste Rock Stockpile Area
Scale: As Noted
Date: 9/7/2016
Dept. Environmental Services
Drawn By: SMG
Checked By: RLM
Notes:
Base Map: 2014 Aerial & Topography

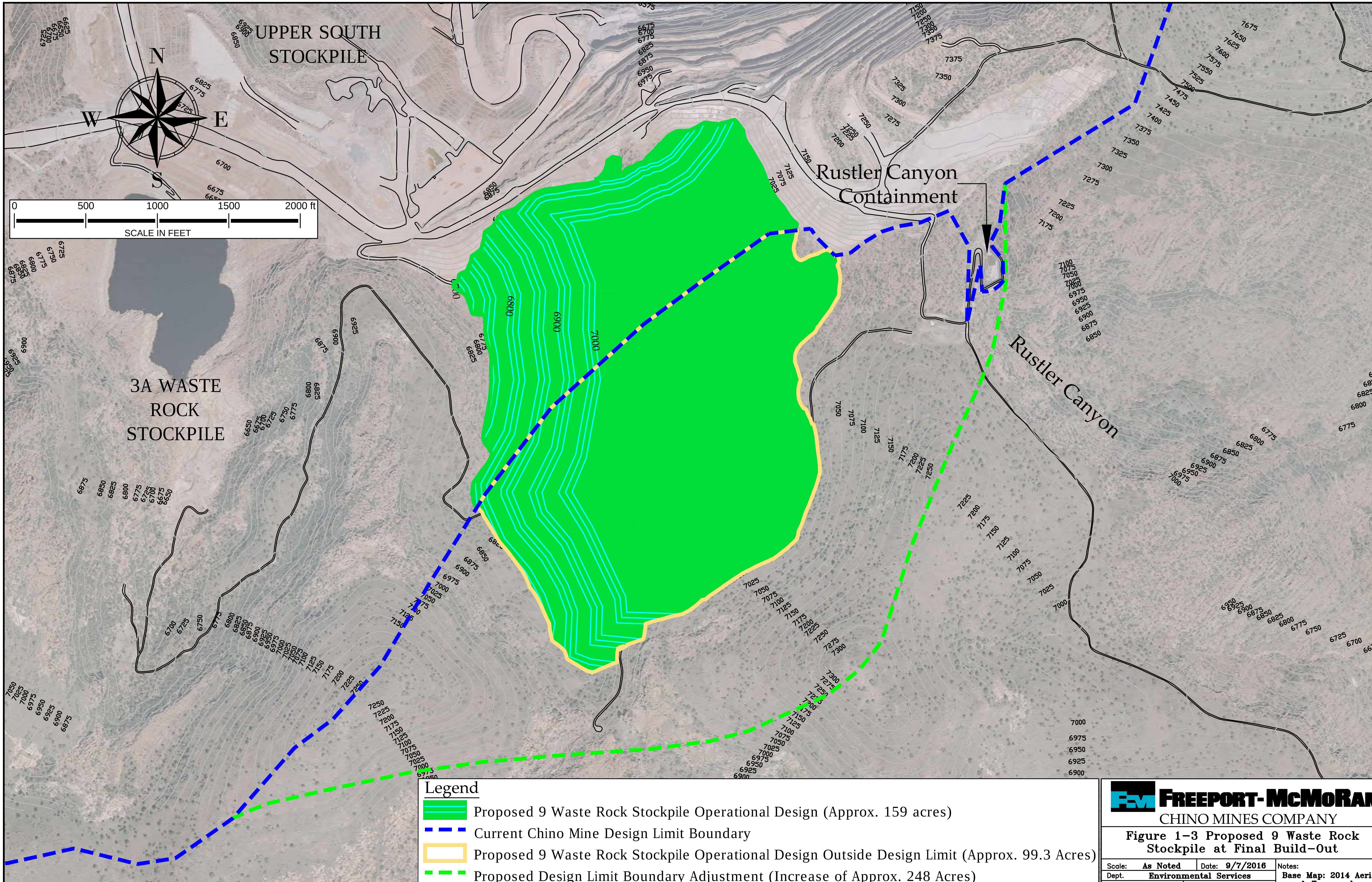


Figure 1-3 Proposed 9 Waste Rock Stockpile at Final Build-Out

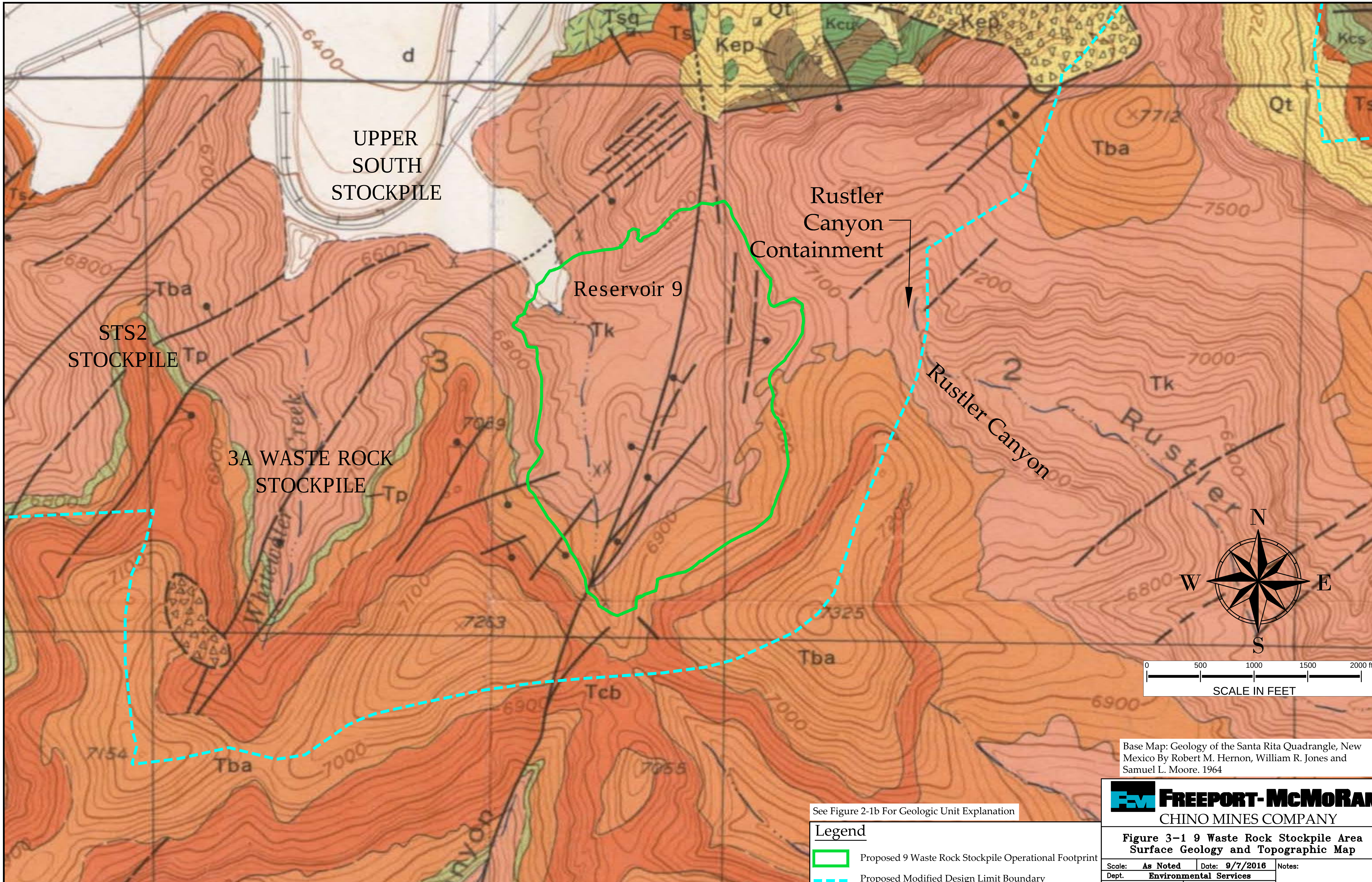


Figure 3-1 9 Waste Rock Stockpile Area Surface Geology and Topographic Map

Scale: As Noted	Date: 9/7/2016	Notes:
Dept. Environmental Services		
Drawn By: SMG	Checked By: RLM	

EXPLANATION

QUATERNARY

Recent

Qal

Younger alluvium
Sand, gravel, and soil. Mapped only where significant geologic relations are hidden

Qt

Hillside rubble and talus

Pleistocene

Qoa

Older alluvium
Gravel and sand cemented with quartz and iron oxides

UNCONFORMITY

TERTIARY

Upper Miocene(?) and Pliocene

Tmg

Semiconsolidated gravel deposits in the Mimbres Valley
In part equivalent to Gila Conglomerate

UNCONFORMITY

Miocene(?)

Tba, Tcb

Flows and tuffs
Tba, *basaltic andesite flows.*
Tcb, *white pumiceous and massive crystal tuffs equivalent to the Caballo Blanco Rhyolite Tuff of Elston (1957) intercalated between flows of basaltic andesite south of the Chino mine*

Tbi

Basaltic andesite plugs and dikes
Probable feeders of basaltic andesite flows (Tba)

Tgr

Gravel and boulder deposits
In northwest part of quadrangle

DISCONFORMITY

Tp

Pitchstone, sandstone, and rhyolite tuff
Indurated tuff at top equivalent to Box Canyon Rhyolite Tuff of Elston (1957). Pitchstone at base, locally overlain by sandstone

Tk

Kneeling Nun Rhyolite Tuff[1]
Massive welded and cemented ash flow ranging in composition from quartz latite to rhyolite

Ts

Sugarlump Tuffs[2]
Thin-bedded pumiceous rhyolite tuffs; brown sandstone containing clinoptilolite locally

Ttn

Rhyolite tuff
Underlies basaltic andesite flows (Tba) *in northern part of quadrangle; resembles Kneeling Nun Rhyolite Tuff*

Tri

Felsitic rhyolite plugs and dike
Relative age not determinable; assumed to be related to extrusion of rhyolite tuffs of Miocene (?) age. Has texture of shallow intrusive

Tr, Trf

Rubio Peak Formation[3]
Tr, *conglomerates and gravels;*
Trf, *rhyodacite-quartz latite flows*

DISCONFORMITY

Lower Tertiary

Tli

Rhyodacite porphyry plug and dikes
Plug underlies Bull Hill; intrudes conglomerate west of Wimsattville (Tw). *Includes quartz latite dikes of Lasky (1936) with sparse phenocrystal quartz*

Tt, Tlq

Quartz latite porphyry dikes and plugs
Quartz phenocrysts abundant.
Tt, *Trevarro plug and apophyses;*
Tlq, *all other dikes and plugs of quartz latite porphyry except that of the Turnerville and Republic dike systems* (Ttr) *and those at Copper Flat. Not all of exactly same age*

Tw

Conglomerate west of Wimsattville
Contains fragments of quartz latite porphyry (Ttr). *It is intruded by quartz latite poryhyry plug* (Tlq) *south of Oswaldo No. 1 shaft; it is also intruded by plugs and dikes of rhyodacite porphyry* (Tli)

Ttr

Quartz latite porphyry of Turnerville and Republic dike systems
Line pattern indicates southeast facies of Turnerville. Possibly as old as the quartz monzonite porphyry of the Santa Rita stock (Tsq) *or the granodiorite porphyry dikes* (Tg)

Tqm

Quartz monzonite porphyry dikes

Tg

Granodiorite porphyry dikes
May include apophyses of Hanover-Fierro pluton and Santa Rita stock

Relative ages indeterminable; age relations to andesite breccia (TKab) unknown

Thg

Granodiorite porphyry of the Hanover-Fierro pluton and apophyses

Tsq

Quartz monzonite porphyry of the Santa Rita stock and apophyses

Tcf

Quartz latite porphyry at Copper Flat
One complex pluton and two dikes. Relative age uncertain but between hornblende quartz diorite (Klp) *and main epoch of hypogene metallization; that is, before the time of intrusion of the Turnerville and Republic dike systems* (Ttr)

CRETACEOUS(?) AND TERTIARY

Upper Cretaceous(?) and lower Tertiary

TKg

Orthoclase gabbro
Small plug in North Star Basin

TKm, TKd

Diorite and mafic porphyry dikes
TKd, *plagioclase-hornblende diorite porphyry dikes; some are older than the andesite breccia* (TKab).
TKm, *predominantly pyroxene andesite to pyroxene syenite porphyry dikes and a few biotite-plagioclase porphyry dikes. Some are apophyses of orthoclase gabbro plug* (TKg). *Most are younger than the andesite breccia, and one, at least, is older than a granodiorite porphyry dike* (Tg). *Only about 10 percent of dikes in North Star Basin are shown.*

TKab

Andesite breccia
Dark purplish-green indurated volcanic breccia and conglomerate containing blocks and cobbles of older rocks, but mostly of mafic porphyries and dark volcanic rocks. In North Star Basin

CRETACEOUS(?)

Upper Cretaceous(?)

UNCONFORMITY

Ksy

Syenodiorite porphyry
Sills and laccoliths

Age with respect to syenodiorite porphyry (Ksy) and andesite breccia (TKab) not shown

Kt

Trachyte porphyry
Sills and small plutons; chilled margins along hornblende quartz diorite (Klp) *and quartz diorite porphyry* (Kep). *Intrudes ancestral Mimbres fault*

Klp

Hornblende quartz diorite
Sills, laccoliths, and few dikes, some in quartz diorite porphyry sills (Kep). *Cut by mafic porphyry dike* (TKm) *north of Hanover Mountain*

Kep

Quartz diorite porphyry
Sills and laccoliths

Krp

Rhyolite porphyry
Sills. Appears to have blocked the extension of hornblende quartz diorite sill (Klp) *in Groundhog mine. Age relative to quartz diorite porphyry* (Kep) *indeterminable. Cut by granodiorite porphyry* (Tg) *and quartz monzonite porphyry* (Tqm) *dikes. In section C-C′ only*

Ka

Augite-hornblende andesite porphyry sills
Near Georgetown. Relative age indeterminable; assumed to have been intruded during time of dominance of the sill form; definitely older than rhyodacite porphyry dikes (Tli) *and younger then Percha Shale*

CRETACEOUS

Upper Cretaceous

Kcs, Kcsh, Kcu

Colorado Formation
Kcs, *sandstone member; alternating beds of sandstone, arkose, and shale. Upper part equivalent to Mesaverde Formation; thin limestone beds in base 100 feet equivalent to Greenhorn Limestone. Chain of circles is a key conglomerate bed.*
Kcsh, *shale member; black shale except for quartzite 20 feet thick in middle part. Equivalent of Graneros Shale.*
Kcu, *Colorado Formation, undivided. 0-1,000 feet thick*

Kb

Beartooth Quartzite
Reddish fine-grained orthoquartzite, minor black shale and conglomerate locally. 50-140 feet thick

UNCONFORMITY

PERMIAN

Lower Permian

Pa

Abo Formation
Red shale, mudstone and limy mudstone, limestone and chert conglomerate. 0-265 feet thick

PENNSYLVANIAN

Magdalena Group

Ps

Syrena Formation
Upper part argillaceous limestone, some shale; lower part limy shale and argillaceous limestone. 170-390 feet thick

Po

Oswaldo Formation
Limestone, some thin shales; sandstone lenses shown by stipple or line of dots where lens is thin. Siliceous shale 20-40 feet thick at base. 330-420 feet thick

PPm

Metasedimentary rocks
Chlorite-actionlite-epidote-garnet-diopside-magnetite alteration, cut by stringers of pyrite

DISCONFORMITY

CARBONIFEROUS — MISSISSIPPIAN

Lower Mississippian

Ml

Lake Valley Limestone
Limestone and marly limestone. Upper part pure crinoidal limestone, some white chert nodules. 300-400 feet thick

DEVONIAN

Upper Devonian

Dp

Percha Shale
Box Member of Stevenson (1945), gray shale with calcareous nodules; Ready Pay Member of Stevenson (1945), black fissile shale. 230-315 feet thick

DISCONFORMITY

SILURIAN

Sf

Fusselman Dolomite
Gray massive cherty dolomite. 100-300 feet thick

SOfm

Fusselman and Montoya Dolomites

ORDOVICIAN

Upper Ordovician

Om

Montoya Dolomite
Light-gray dolomite, in part interlayered with dark chert; sandstone 1-16 feet thick at base. 300-350 feet thick

DISCONFORMITY

Lower Ordovician

Oe

El Paso Limestone
Light- to medium-gray, thin- to thick-bedded limestone and dolomite. 500-519 feet thick

CAMBRIAN

Upper Cambrian

OCb

Bliss Formation
Dolomitic and shaly limestone, shale, basal conglomerate locally; hematitic and glauconitic sandstone and quartzite. 140-188 feet thick

UNCONFORMITY

PRECAMBRIAN

p€

Biotite-granite gneiss

Contact
Dashed where approximately located; short dashed where indefinite; dotted where concealed

Fault, showing direction and amount of dip
Bar and ball on downthrown side. Dashed where approximately located; dotted where concealed; queried where doubtful

Reverse fault
U, *upthrown side*

Strike and dip of beds

Strike and dip of overturned beds

Horizontal beds

Strike of vertical or near vertical foliation

d

Mine and mill dumps

Landslide

---

[1] The Kneeling Nun Rhyolite Tuff was named in a thesis by Elston (1953) for the Kneeling Nun, a prominent landmark near the town of Santa Rita in the Santa Rita quadrangle. The first published mention of the name was by Kuellmer and others (1953), and the first description of the formation was given by Jicha (1954). The formation is a massive partially welded and devitrified ash flow ranging in composition from quartz latite to rhyolite, and in thickness from 200 to 600 feet. It is everywhere conformable with the underlying Sugarlump Tuffs; the upper contact is an erosional one.

[2] The Sugarlump Tuffs was named in a thesis by Elston (1953) for Sugarlump Hill, NE¼ sec. 15, T. 19 S., R. 10 W., in the Dwyer quadrangle, which adjoins the Santa Rita quadrangle to the southeast. The name was first used by Kuellmer and others (1953), and the first published description was given by Jicha (1954). The formation consists of several volcanic and clastic units: well-bedded and massive pyroclastic deposits of latitic or rhyolitic composition, volcanic conglomerates, and sandstones locally replaced by green clinoptilolite. It rests disconformably on the Rubio Peak Formation (Elston, 1957, p. 42) in the Dwyer quadrangle and on early Tertiary and older rocks in the Santa Rita quadrangle. Because it was deposited on an uneven surface, its thickness is quite variable from place to place; the maximum reported thickness is about 1,300 feet, but in the Santa Rita quadrangle the thickness ranges from 50 to about 800 feet. Owing to the lenticularity of the units no section in the Santa Rita quadrangle can be cited as typical.

[3] The Rubio Peak Formation was named in a thesis by Elston (1953) after a prominent butte at secs. 9, 10, 15, 16, T. 19 S., R. 10 W., in the Dwyer quadrangle. The first published description of the formation was given by Hernon and others (1953). The formation consists of andesite and latite flows, conglomerate, welded ash flows, volcanic conglomerate and tuffaceous sandstones. No section can be cited as typical owing to the lenticularity of the flows and other units. The formation was deposited on an irregular surface and is therefore highly variable in thickness. Elston (1957) estimated the maximum thickness in the Dwyer quadrangle to be about 5,000 feet.

On the basis of floral assemblages regarded as most probably of late Miocene or early Pliocene age collected from lake beds overlying rhyolitic tuffs believed to be correlatives of the Kneeling Nun Rhyolite Tuff, and from lake beds within beds believed to be correlatives of the upper part of the Rubio Peak Formation (Jahns and others, 1955; F. J. Kuellmer, written communication, 1960) all three formations described above are tentatively dated as Miocene(?). A major erosional disconformity separates the Rubio Peak Formation and intrusive rocks of early Tertiary age. Flows of basaltic andesite overlying the Kneeling Nun Rhyolite Tuff are older than the Gila Conglomerate of Pliocene and Pleistocene age and parts of the Santa Fe Group of middle(?) Miocene to Pleistocene(?) age.

GEOLOGY OF THE SANTA RITA QUADRANGLE NEW MEXICO - GRANT COUNTY GQ-306

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GEOLOGY OF THE SANTA RITA QUADRANGLE, NEW MEXICO

By
Robert M. Hernon, William R. Jones and Samuel L. Moore

1964

FREEPORT-MCMORAN
CHINO MINES COMPANY

Figure 3-1B Geologic Unit Explanation

Scale: As Noted	Date: 9/7/2016	Notes:
Dept. Environmental Services		
Drawn By: SMG	Checked By: RLM	

APPENDIX A

EARTHWORK COST ESTIMATE PROCESS REPORT AND RECLAMATION DESIGN DRAWINGS

9 Waste Rock Stockpile
Earthwork Cost Estimate
Process Report

Prepared for
Freeport-McMoRan
Chino Mines Company
99 Santa Rita Mine Road
Vanadium, New Mexico 88023

Prepared by

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Chino Mines Company
99 Santa Rita Mine Road
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March 2017

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1.0 INTRODUCTION

1.1 Purpose & Summary

Freeport-McMoRan Chino Mines Company (Chino) is 9 Waste Rock Stockpile where the 9 Reservoir currently located. The process and associated cost factors that will be used in the earthwork reclamation cost estimate has been prepared by Chinos Mine Company (Chino). The earthwork reclamation process is based on a template originally created by the New Mexico Energy, Minerals and Natural Resources Department, Mining and Minerals Division (MMD, 1996). The process addresses reclamation earthwork and site operations and maintenance costs.

Reclamation cost estimates are developed by first selecting an appropriate fleet of equipment and associated productivity factors, unit rates, and quantities. Equipment selection is done based on the type of operation and availability. Equipment is optimized based on capacity, productivity, size and shape, and type of operation. The amount of time a reclamation operation takes is based on volume of material, haul distance, change in elevation, and factors called productivity factors. Productivity factors are selected based on the latest Caterpillar equipment publications, and site specific conditions such as slope angle. Unit rates are referenceable current 3rd party rates for labor, equipment, fuel, and materials. Indirect rates are later added to the total direct costs. Conceptual reclamation quantities are based on the mine plan and timing considerations required by financial assurance and established reclamation criteria. The equipment, productivity factors, unit rates, and quantities are put together using the template originally created by MMD to develop the reclamation cost estimate.

1.2 Cost Estimate Assumptions

Assumptions used throughout the cost estimate include:

- **Cost estimate calculations:** Are based on the caterpillar performance handbook and the 1996 MMD cost template. Appendix A.1 provides the calculations that will be used on each calculation sheet of the cost estimate spreadsheet.

- **Labor Rates**: All labor rates are developed based on the New Mexico Department of Labor (DOL) Type H (Heavy Engineering) labor rates effective for 2016. These rates include the base, fringe benefit, and apprenticeship contribution rates. The following FICA, Medicare, Federal un-employment, State un-employment, and Workman's Compensation Insurance are added to the labor rates to obtain the total per hour labor rate.
- **Equipment Rates**: The earth-moving equipment used in the estimate would commonly be available to a contractor. The equipment unit operating costs are taken from EquipmentWatch Custom Cost Evaluator (Penton Media, Inc., 2016). All costs taken from EquipmentWatch Custom Cost Evaluator are adjusted using the local factor for Las Cruces and overhead is removed from direct costs and included in the indirect cost percentage.
- **Fuel Costs**: The off-road diesel fuel cost will be a vendor quote for delivery of dyed ultra-low sulfur diesel to Silver City, NM.
- **Revegetation Unit Costs**: The revegetation unit cost will be a vendor quote including: scarifying, discing, rangeland drill seeding, mulching, crimping, and daily per diem.
- **RipRap Production**: The riprap unit cost will be developed based on experience gained producing riprap at the McCain Springs Quarry.
- **Equipment Production Factors**: Production factors from Caterpillar (2014) for each type of equipment are presented in Table 1. Productivity curves are developed from Caterpillar (2014) and are described in Appendix A.2 and A.3.
- **Haul Distances**: Haul distances are calculated along a preferred route and assumed to originate at the approximate centroid of the source and terminate at the approximate centroid of the reclamation area. A maximum of three segments is typically used for each haul route.
- **Borrow Areas**: The cover source that will be utilized comes from the Upper South Stockpile.
- **Dozer Push Distances**: Dozer push distances represent the distance from the centroid of the cut block to the centroid of the fill block.
- **Dust Suppression and Site Maintenance:** A full time water truck and a motor grader are included as part of the fleet during reclamation. The water truck and grader time are set equal to loader time.
- **Capital Indirect Costs**: Total indirect costs of 22.5% per MMD (1996) and Office of Surface Mining (OSM, 2000) guidance based on total capital reclamation costs for Chino. The indirect costs are comprised of: Mobilization and Demobilization (1.0%), Contingencies (2.0%), Engineering Redesign Fee (2.5%), Contractor Profit and Overhead (15.0%), and Project Management Fee (2.0%). Indirect cost percentages are identical to the percentages presented to MMD and the New Mexico Environment Department (NMED) in meetings with Tyrone on September 20, 2012, and on November 2, 2012 (Table 2).
- **Operations and Maintenance Indirect Costs**: The 9 Reservoir currently has Operations and Maintenance costs (O&M) for Earthwork. No additional Earthwok O&M is recommended for the 9 Stockpile. A total

indirect costs of 17.5% for long term operations and maintenance per MMD (1996) and OSM (2000) guidance and comprise the same values and factors as the capital indirect costs with exception of Contractor Profit and Overhead will be applied for Revegetation Maintenance. Contractor Profit and Overhead for long term operations and maintenance is 10.0%, to account for the long term contract and repetitive annual work. Indirect cost percentages are identical to the percentages presented to MMD and the NMED in meetings with Tyrone on September 20, 2012, and on November 2, 2012 (Table 4).

2.0 RECLAMATION DESIGN

During operations, the 9 Stockpile will be constructed at an overall slope that will result in 3:1 (horizontal:vertical) slope after reclamation benches are cut in. The top surface constructed at a 1% minimum slope, sloping to the southeast and other flat areas will also be constructed at a 1% minimum slope. The conceptual pre-reclamation and reclaimed 9 Stockpile, including details are shown in the Drawings Sheets 1 through 7. The main reclamation activities that will occur include:

- Minor top surface grading to achieve a smooth slope following the minimum 1% top surface sloping to the southeast.
- Minor flat area grading to achieve a smooth slope following the minimum 1% slope.
- Pushing down operational stockpile benches to achieve a smooth slope.
- Hauling and grading cover material for the top surfaces.
- Completing surface water channels and benches to collect and convey storm water from the stockpile surfaces.
- Scarification and revegetation of covered areas.

The major assumptions for this cost estimate would include:

- **Regrading**: Slopes: 200-foot maximum inter-bench slope length, maximum 3H:1V inter-bench slopes, 1% minimum top surface slope. Slopes 1% minimum slope for other flat areas.
- **Outslope Channels and Benches:** 15-foot bench width, 1% to 5% cross-bench slope, <5.0% longitudinal bench slope and 3-feet of cover; channel 6-inches of gravel underlain by 2-feet of cover.
- **Channels:** maximum 2,500 feet in length, maximum 2% longitudinal slope, 3-feet of cover.
- **Downdrains:** 2.5-feet of riprap over 6-inches of filter material underlain by 2-feet of cover.

- **Cover**: 36-inch cover thickness – tops and outslopes. Trucks and loaders with dozer assist perform all cover loading and distribution. The economic optimum number of trucks per loader is used for each haul route.
- **Revegetation Maintenance**: 2% failure every year for a total of 12 years, starting the year reclamation is completed.

3.0 REFERENCES

Caterpillar, Inc. 2011. Caterpillar Performance Handbook, Edition 41. Caterpillar Inc. Peoria, Illinois. January 2011.

Caterpillar, Inc. 2014. Caterpillar Performance Handbook, Edition 44. Caterpillar Inc. Peoria, Illinois. January 2014.

MMD. 1996. [New Mexico Energy, Minerals and Natural Resources, Department, Mining and Minerals Division]. 1996. Closeout Plan Guidelines for Existing Mines, Natural Resources Department. April 30, 1996.

OSM. 2000. U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement Handbook for Calculation of Reclamation Bond Amounts. April 5, 2000.

Penton Media, Inc. 2016. Equipment Watch Custom Cost Evaluator Version 6.17.13A.

TABLES

Table 1 Equipment Production Factors

Parameter	Value	Comment/Reference
Swell Factor Stockpiles and Tailings[1]	8% Load & haul cover 0% Pushdown	Cover material volumes are calculated based on the reclaimed area and the cover depth. No virgin materials are being regraded as part of reclamation. Thus a swell factor is not applied when regrading material.
Grading (D11T CD, D11T, D9T, 16M, D6T)		
Operator Factor [1]	1.0 Stockpile coarse grading 0.75 Cover & channel fine grading	Due to large job size assume excellent operator (CPH 44, 19-55, excellent) (CPH 44, 19-55, average)
Material Factor	1.2 - Stockpile 1.2 - Cover	CPH 44, 19-55, Loose stockpile
Work Hour	50 min	(CPH 44, 19-55)
Grade Factor – Tops	1.0	(CPH 44, 19-55) 1-5% Slope
Grade Factor - Outslopes[1]	1.6 – 3H:1V Slopes	(CPH 44, 19-55) 1.6 – 3H:1V
Soil Weight	3,300 lb./cy Stockpile 3,000 lb/cy Cover	-
Production Method/ Blade Factor	1.2 – Slot 1 – Channels/Down drains/Benches	(CPH 44, 19-55, slot dozing) No correction applied for channels/ downdrains/benches
Effective Blade Width (feet)	22 D11T CD Universal Blade 14.25 D9T Semi Universal Blade 16 16M 17.5 D6T XL SU	(CPH 44, 19-49) (CPH 44, 19-47) (CPH 44, 11-17) (CPH 44, 19-43)
Speed (miles/hr)	2.5 mph D11T CD and 16M 1.0 mph D9T and D6T	-
Visibility Factor	1.0	(CPH 44, 19-55) Clear
Elevation Factor	1.0	(CPH 44, 30-5)
Transmission Factor	1.0	-
Loader (992K)		
Heaped Bucket Capacity (cy)	16.0	(CPH 44, 23-288, Standard, 3000 lb./yd3)
Loader Cycle Time (load, dump, and maneuver; min)	0.65	(CPH 44, 23-223) Avg 0.6-0.7
Bucket Fill Factor	0.875	(CPH 44, 30-1) Avg 0.85-0.90

Parameter	Value	Comment/Reference
		Loose Material 1” and over
Work Hour (min/hr)	50	(CPH 44, 19-55)
Trucks (CAT 785F)		
Struck Capacity (cy)	71.0	Equipment Watch Specification Sheet
Heaped Capacity(cy)	102.0	(CPH 41, 9-6)
Rolling Resistance (%)	2.5%	(CPH 44, 30-1) Radial tires, dirt road maintained fairly regularly, watered, flexing slightly
Truck Exchange Time (min)	0.7	(CPH 44, 10-20) Avg. 0.6-0.8
Dump/Maneuver Time (min)	1.1	(CPH 44, 10-20) Avg 1.0-1.2
Work Hour (min/hr)	50	(CPH 44, 19-55)

CPH = Caterpillar Performance Handbook Edition 35, 44(Caterpillar, Inc. 2007, 2014)

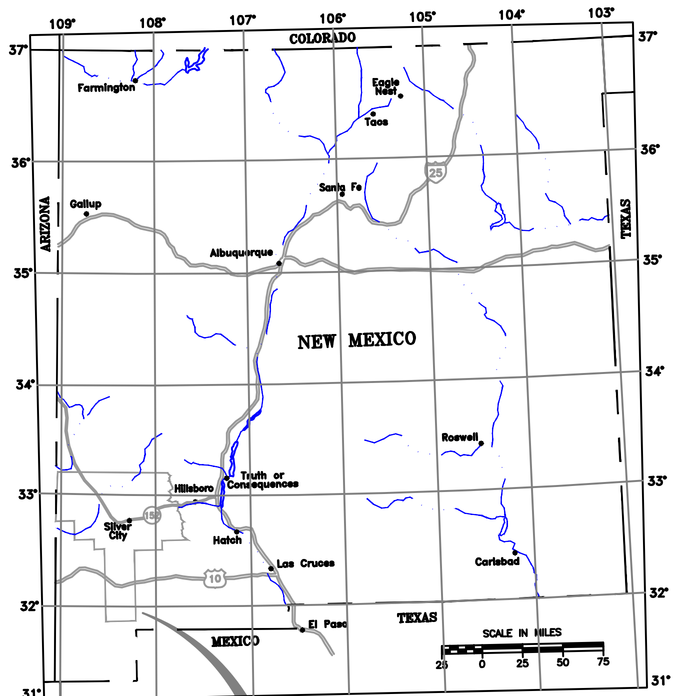
(1) The swell and operator factors used are consistent with factors presented to MMD and NMED in meetings with Tyrone on June 11, 2012, November 2, 2012, and a letter to MMD and NMED from Tyrone dated September 5, 2012.

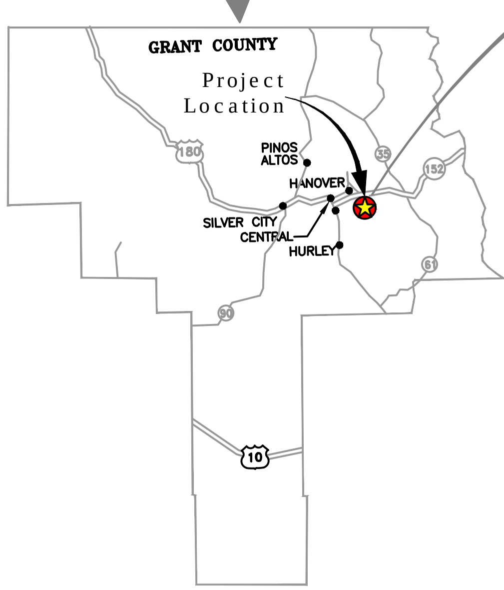
(2) Equipment Watch did not have recent information for Caterpillar 785F performance. The Komatsu HD1500-5 has the same performance specifications as the Caterpillar 785F. Thus, the Equipment Watch costs for the Komatsu HD1500-5 were used as an equivalent for the Caterpillar 785F.

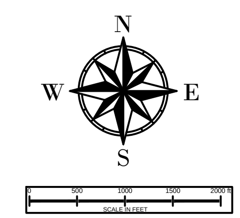
DRAWINGS

PROPOSED RECLAMATION PLAN FOR THE 9 STOCKPILE

ISSUED FOR FINANCIAL ASSURANCE RECLAMATION COST ESTIMATE







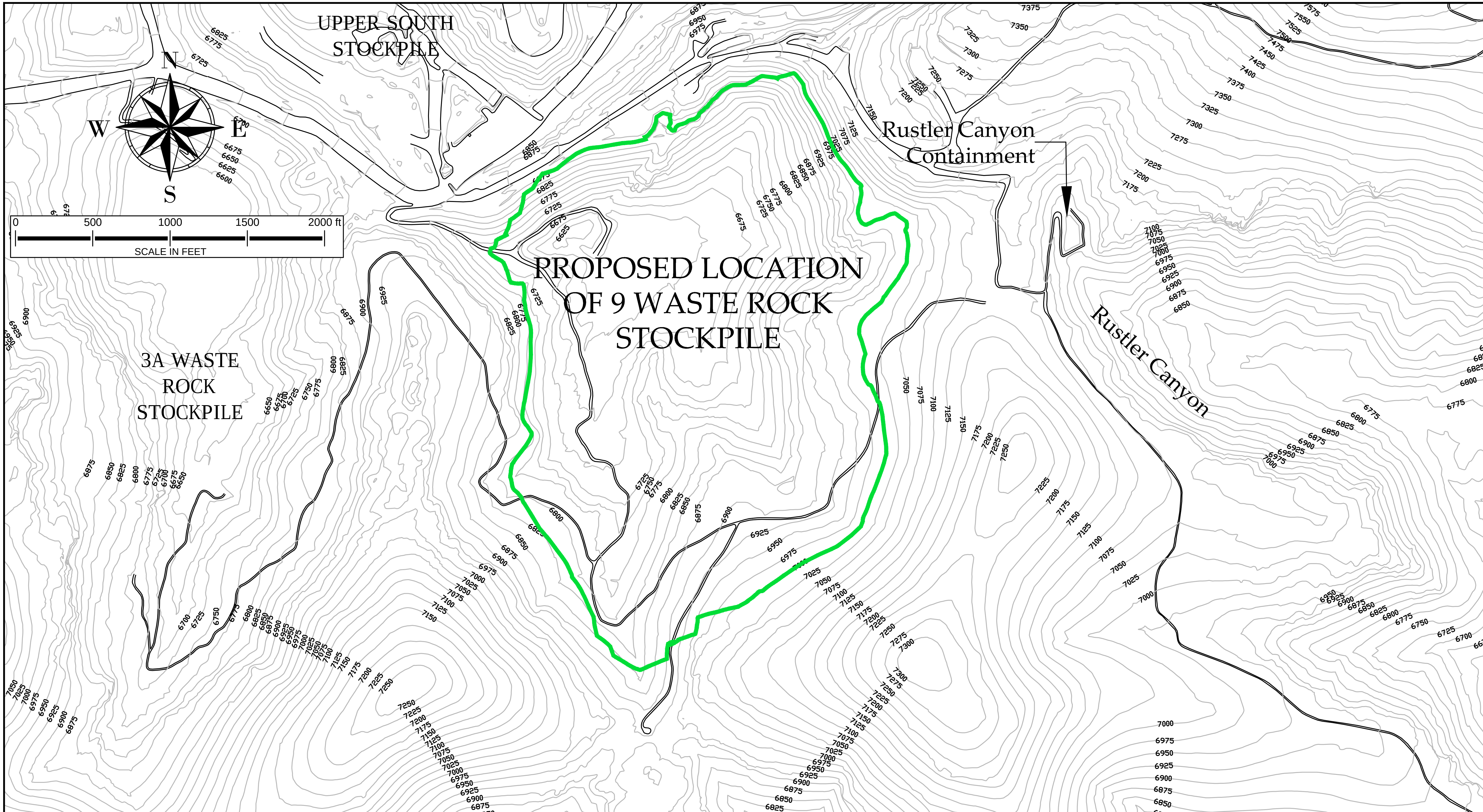
Sheet List Table

Sheet Number	Sheet Title
1	COVER SHEET
2	EXISTING TOPOGRAPHY
3	CONCEPTUAL PRE-RECLAMATION STOCKPILE
4	CONCEPTUAL RECLAIMED STOCKPILE
5	CROSS SECTIONS
6	DETAILS
7	CONCEPTUAL HAUL PATHS

FREEPORT-MCMORAN
CHINO MINES COMPANY

Sheet: 1 Cover Sheet

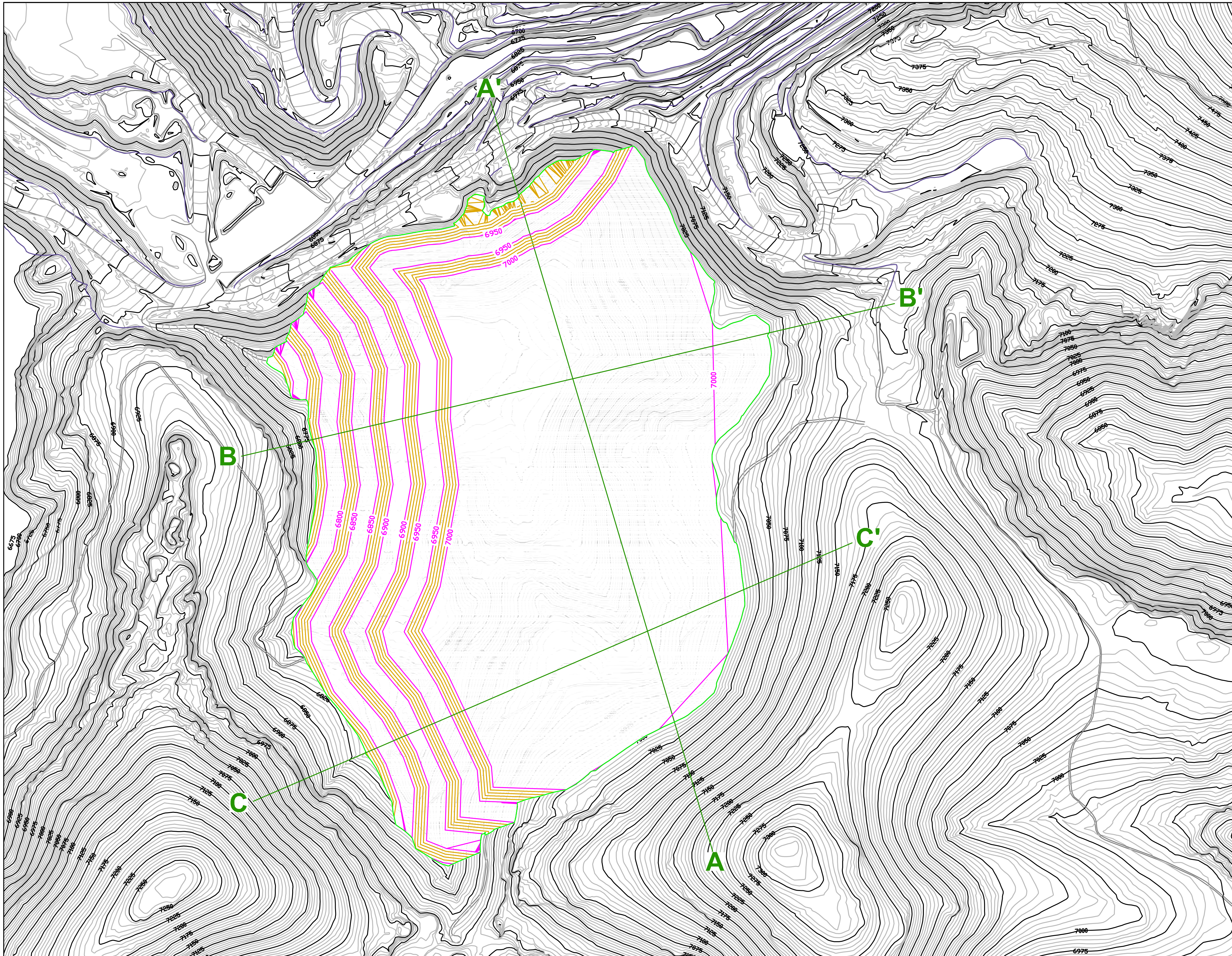
Scale: As Noted	Date: 10/19/2016	Notes:
Dept. Environmental Services		
Drawn By: SMG	Checked By: RLM	



FREEPORT-McMoRAN
CHINO MINES COMPANY

Sheet: 2 Existing Topography

Scale: As Noted	Date: 11/17/2016	Notes:
Dept. Environmental Services		Base Map: 2014 Topography
Drawn By: SMG	Checked By: RLM	



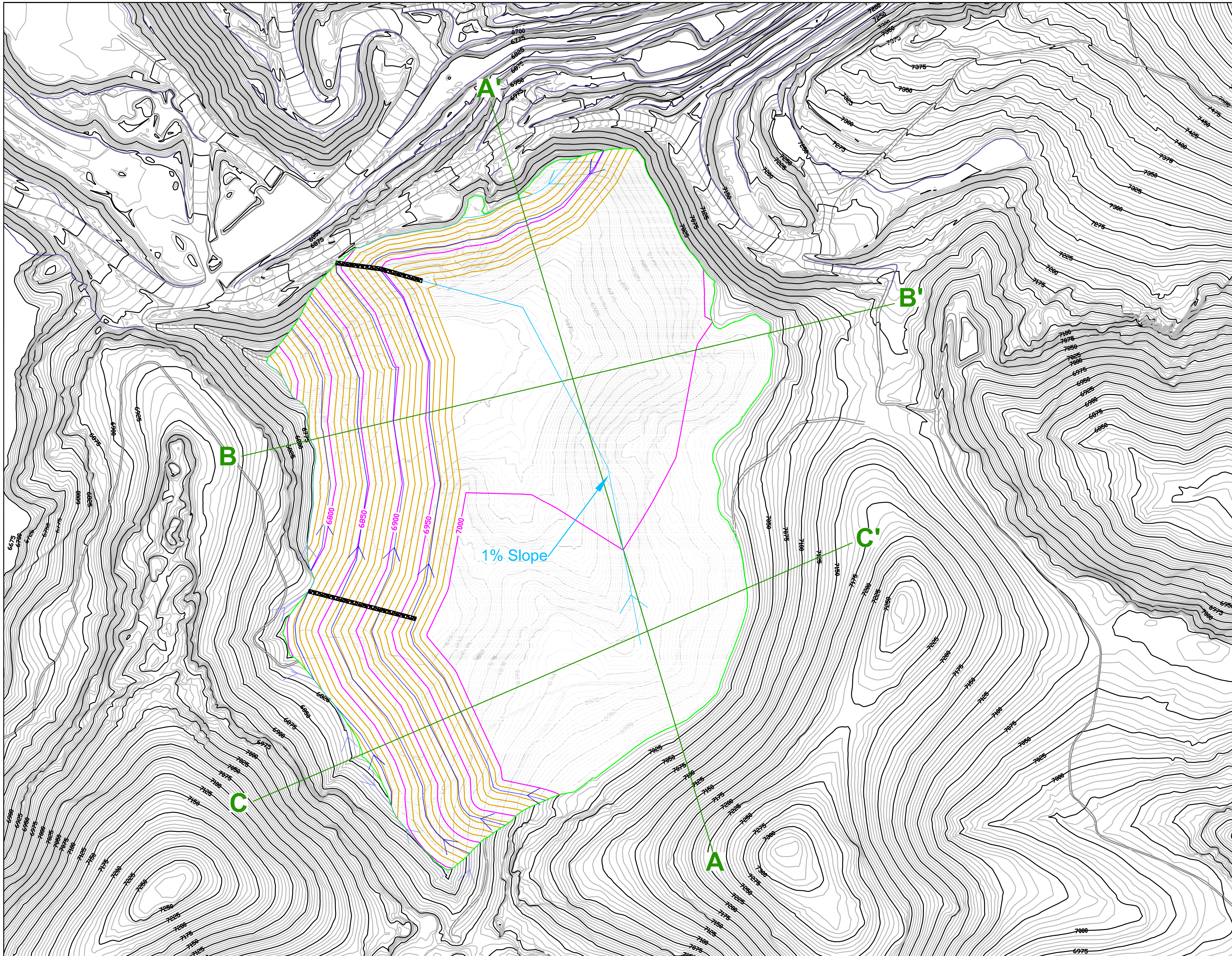
Legend

- 7000 Major Contours (25ft)
- Minor Contours (5ft)
- 6900 Operational Major Contours (50ft)
- Operational Minor Contours (10ft)
- Stockpile Boundary
- A — A' Cross-Section Lines
- Roads

FREEPORT-McMoRAN COPPER & GOLD

Sheet 3: Conceptual Pre-Reclamation Stockpile

Scale: As Noted	Date: 10-19-2016	Notes:
Dept. Reclamation		
Drawn By: MJL	Checked By: MJL	



Legend

- Major Contours (25ft)
- Minor Contours (5ft)
- Reclaimed Major Contours (50ft)
- Reclaimed Minor Contours (10ft)
- Stockpile Boundary
- A—A' Cross-Section Lines
- Downdrains
- Outslope Channels
- Surface Channels
- Off-Site Channels
- Roads

NORTH

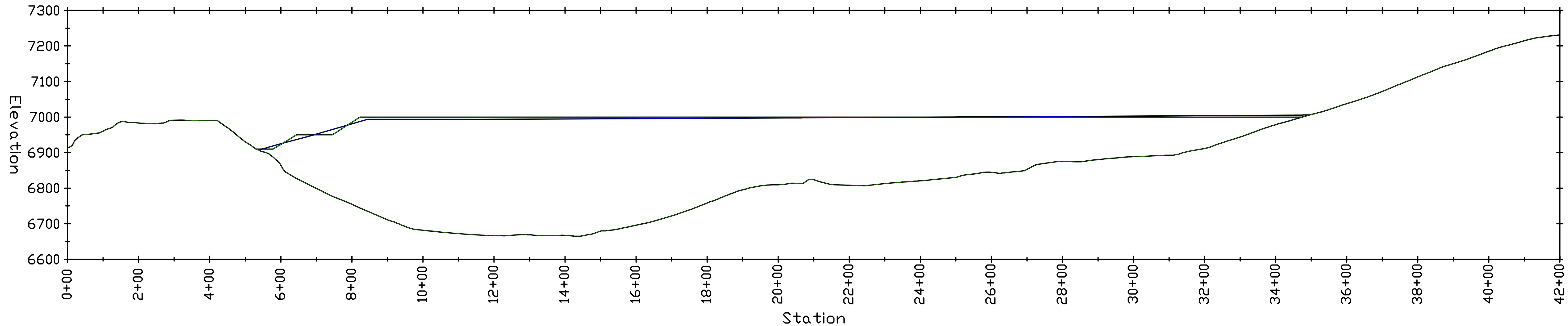
0 500 Feet

FREEPORT-McMoRAN COPPER & GOLD

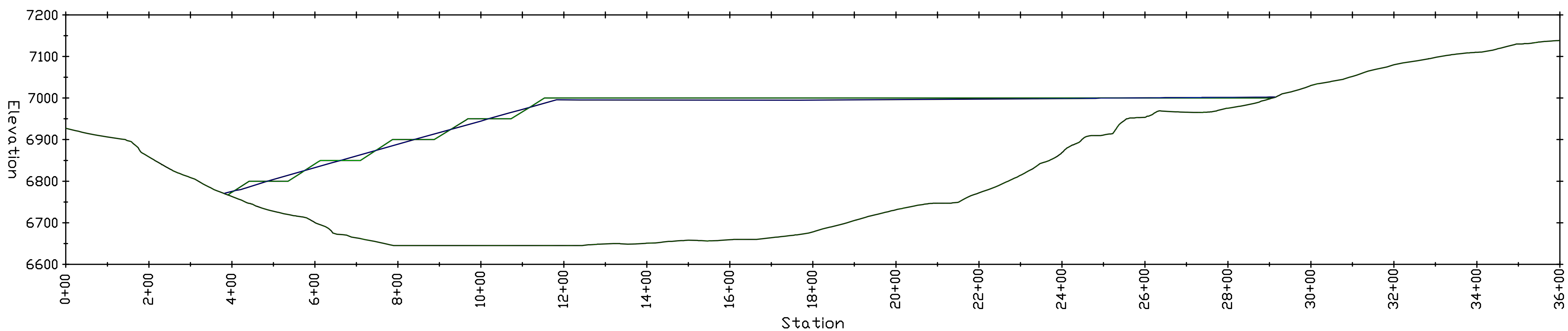
Sheet 4: Conceptual Reclaimed Stockpile

Scale: As Noted	Date: 10-19-2016	Notes:
Dept. Reclamation		
Drawn By: MJL	Checked By: DV	

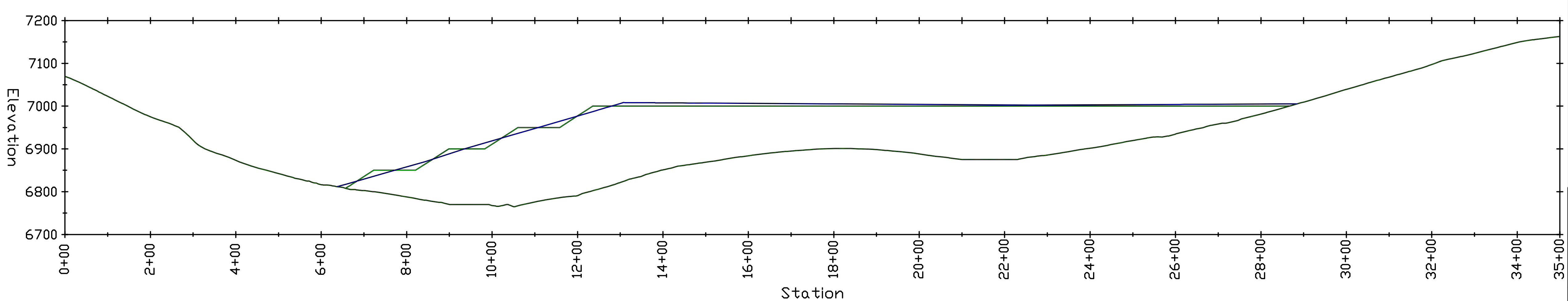
Profile View A-A' (Stations in 200ft)



Profile View B-B' (Stations in 200ft)



Profile View C-C' (Stations in 200ft)



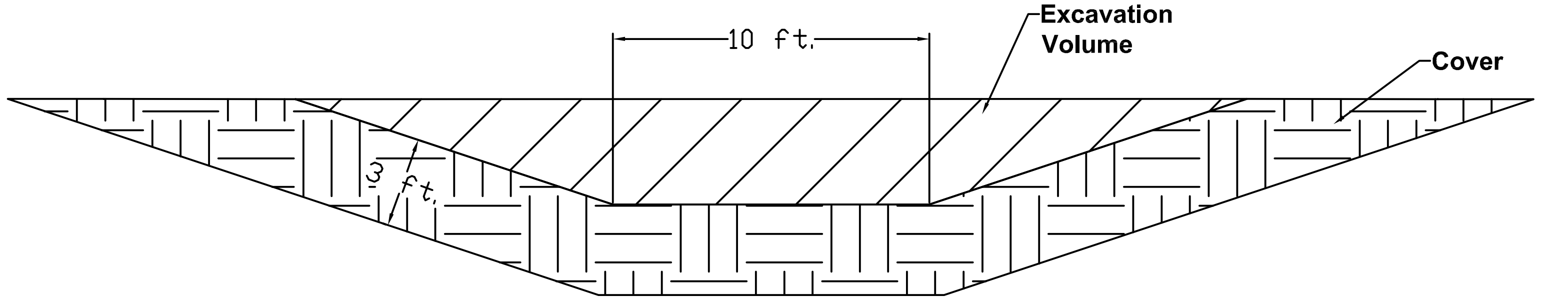
Legend

- Existing Topo
- Operational Stockpile
- Reclaimed Stockpile

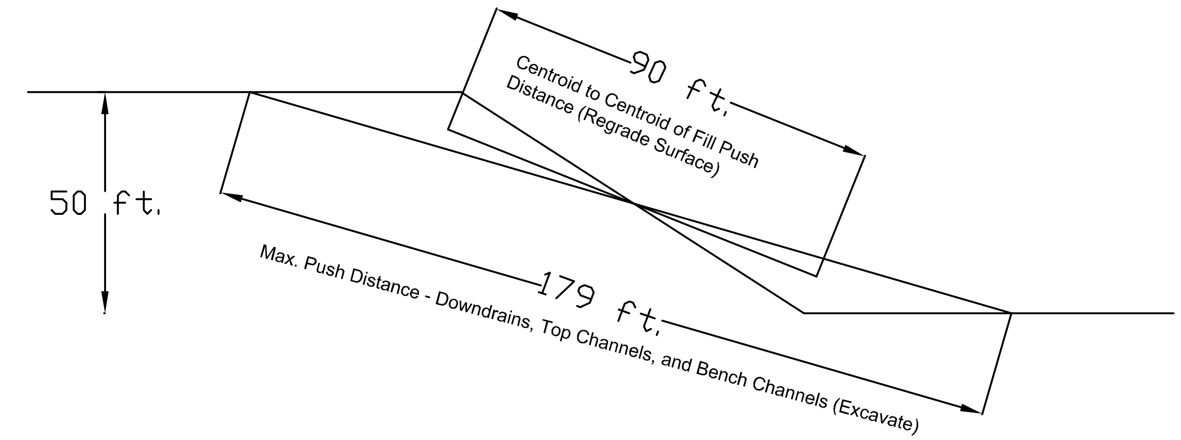
FREEPORT-MCMORAN COPPER & GOLD

Sheet 5: Cross Sections

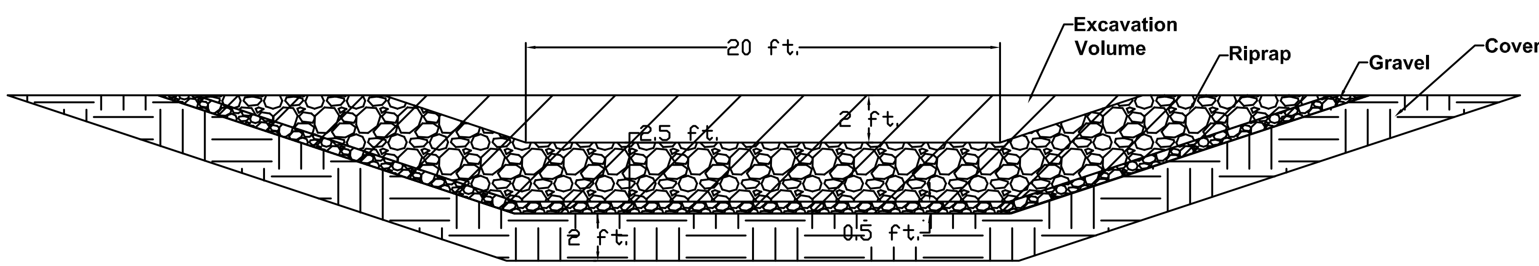
Scale: As Noted	Date: 10-19-2016	Notes:
Dept. Reclamation		
Drawn By: MJL	Checked By: MJL	



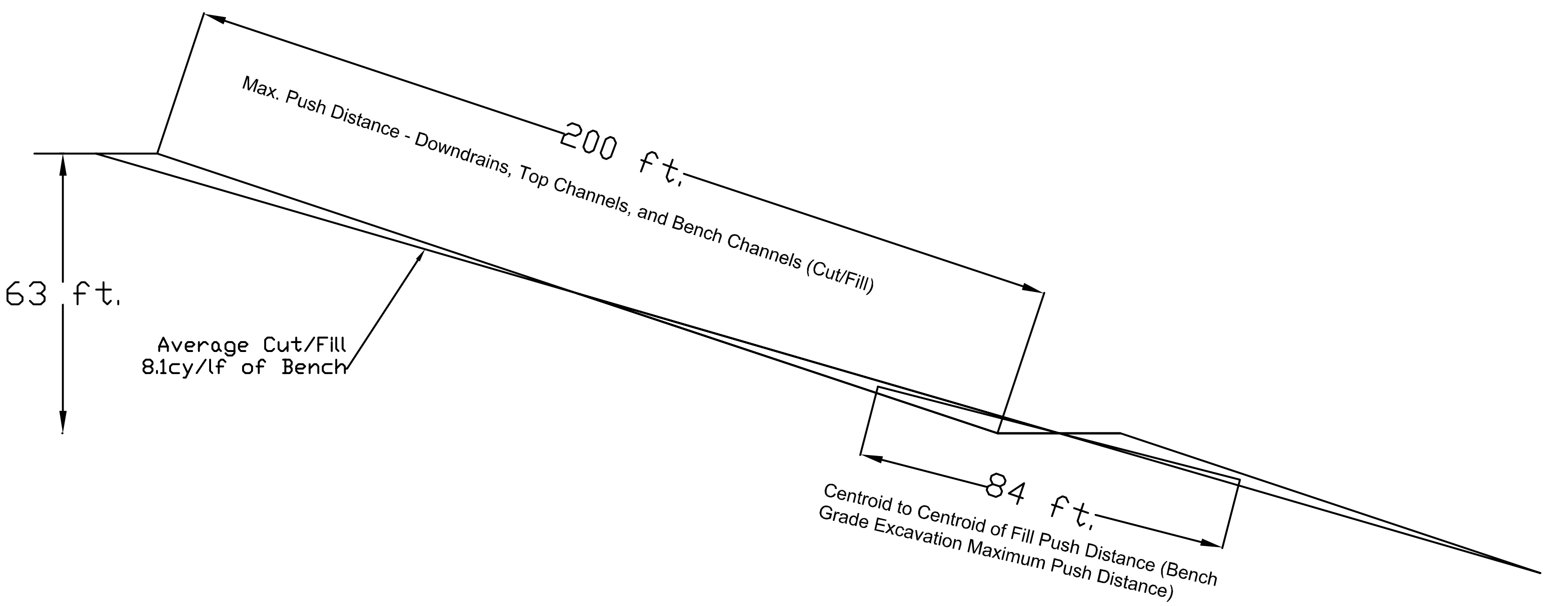
Typical Top Channel (Reclamation Area)



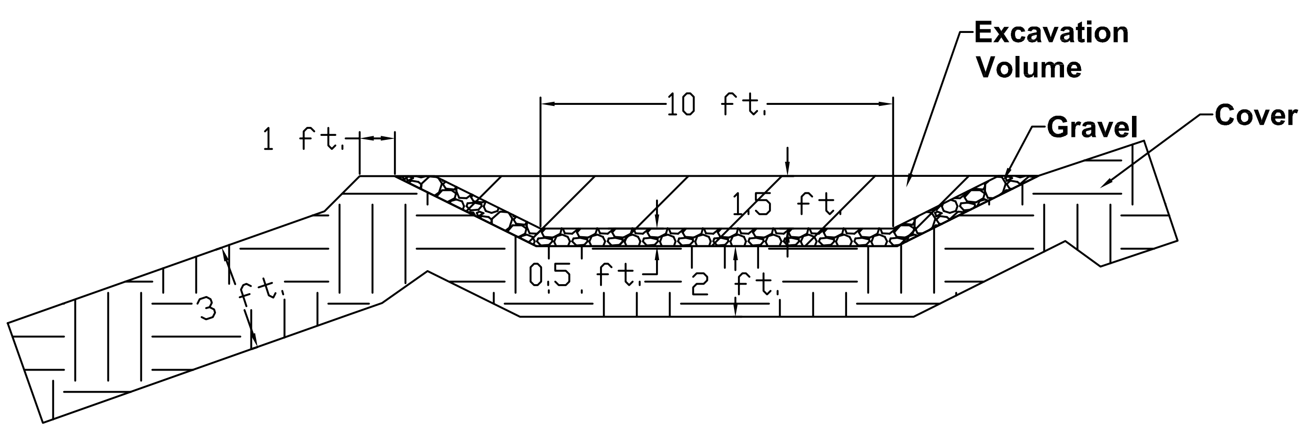
Typical Operational Bench Regrade for 3.5H:1V



Typical Down Chute/ Down Drain Channel



Typical Reclamation Outslope Bench for 3.5H:1V

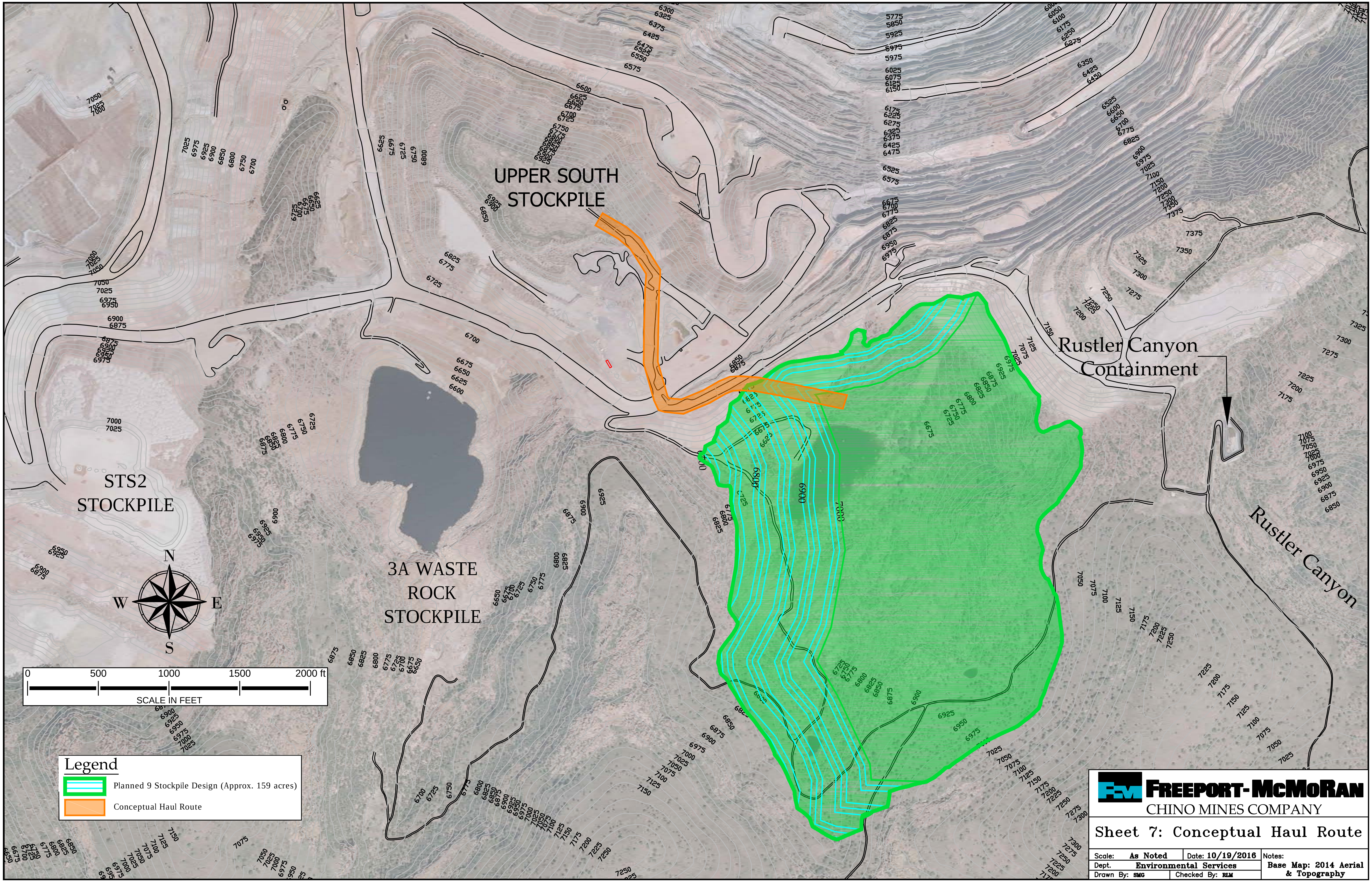


Outslope Terrace Channel

FREEPORT-McMoRAN COPPER & GOLD

Sheet 6: Details

Scale: As Noted	Date: 10-19-2016	Notes: NTS
Dept. Reclamation		
Drawn By: MJL	Checked By: DV	


UPPER SOUTH STOCKPILE
STS2 STOCKPILE
3A WASTE ROCK STOCKPILE
Rustler Canyon Containment
Rustler Canyon
N
E
S
W
0
500
1000
1500
2000 ft
SCALE IN FEET
Legend
Planned 9 Stockpile Design (Approx. 159 acres)
Conceptual Haul Route
FREEPORT-MCMORAN
CHINO MINES COMPANY
Sheet 7: Conceptual Haul Route
Scale: As Noted
Date: 10/19/2016
Notes:
Dept. Environmental Services
Base Map: 2014 Aerial & Topography
Drawn By: SMG
Checked By: RLM

APPENDIX A
SUPPORTING DOCUMENTATION

APPENDIX A.1

CALCULATION DOCUMENTATION

EQUATIONS USED IN CAPITAL COST SPREADSHEET

Sheet #2 Earthwork:

Bank Volume (bcy) = $Area\ (acre) * Cover\ Depth\ (in) * \frac{43{,}560\left(\frac{ft^2}{acre}\right)}{\left(12\left(\frac{in}{ft}\right)\right)} * \frac{1}{27\left(\frac{ft^3}{cy}\right)}$

Loose or Stockpile Volume (lcy) = Bank or stockpile Volume (cy) * [1 + Swell Factor]

Sheet #3 Grading:

Normal Production (cy/hr) = 159372.008958 * Maximum Push Distance (ft)$^{-0.862481}$
(Caterpillar Performance Handbook Edition 41 D11T CD 1-53)

Productivity (cy/hr) =

$$Normal\ Production\ \left(\frac{cy}{hr}\right) * Operator * Material * Work\ Hour\left(\frac{min}{hr}\right) * Grade\ Factor * \frac{2{,}300\left(\frac{lbs}{cy}\right)}{SoilWeight\left(\frac{lbs}{cy}\right)} * Prod.Method * Visibility * Elev. * Drive\ Trans.$$

Total Task Time (hr) = $\frac{Loose\ or\ Stockpile\ Volume(cy)}{Productivity\left(\frac{cy}{hr}\right)}$

Grade (Dozing Factor) = -0.02 * Grade (%) + 1
(Curve Fit Cat Handbook Ed 44 19 - 55)

Sheet #4 Loader&Truck:

Total Haul Distance (ft) = ∑ Segment Haul Distance (ft)

Haul Distance Segment (m) = Haul Distance (ft) * 0.3048 (m / ft)

Haul Effective Grade (%) = (Haul Grade (%) + Rolling Resistance (%))(unless < 0 then 0)

Return Effective Grade (%) = (Rolling Resistance (%) - Haul Grade (%))(unless < 0 then 0)

Truck Segment Travel Time Loaded (min/ m) =

-1.6825 * Haul Effective Grade Segment (%)^3 + 0.4592 * Haul Effective Grade Segment (%)^2
* 0.0079* Haul Effective Grade Segment (%) + 0.0009

Truck Segment Travel Time Empty (min/ m) =

-6.2135 * Return Effective Grade Segment (%)^4 + 1.0448 * Return Effective Grade Segment (%)^3 + 0.1016 * Return Effective Grade Segment - 0.0035* Return Effective Grade Segment (%) + 0.0009

(Curve Fit Cat Handbook Ed 41 9 - 42)

Loader (cycles / truck) = $Maximum[\frac{Struck\ Capacity(cy)}{Loader\ Net\ Bucket\ Capacity(cy)}, \frac{Heaped\ Capacity(cy)}{Loader\ Net\ Bucket\ Capacity(cy)}]$

Haul Time (min) = ∑(Segment Travel Time Loaded (min/ m) * Segment Haul Dist (m))

Return Time (min) = ∑(Segment Travel Time Empty (min/ m) * Segment Haul Dist (m))

Loading Time (min) = Loader Cycle Time (min) * Loader (cycles / truck)

Task Time (hr) = $Maximum[\frac{Volume(cy)}{Productivity(\frac{cy}{hr})}, Loader\ Task\ Time\ (Hr)]$

Truck Cycle Time (min) =

Haul Time (min) + Return Time (min) + Loading Time (min) + Load / Maneuver Time (min) + Dump Maneuver Time (min)

Productivity (cy / hr) =

$$Work\ Hour\left(\frac{min}{hr}\right) * Loader\left(\frac{cycles}{truck}\right) * Loader\ Net\ Bucket\ Capacity(cy) * \left(\frac{Optimum\ Number\ of\ Trucks}{Truck\ Cycle\ Time(\mathrm{min})}\right)$$

Net Bucket Capacity (cy) = Heaped Bucket Capacity (cy) * Bucket Fill Factor

Productivity (cy / hr) = $\left(\frac{\mathrm{Net\ Bucket\ Capacity(cy)} * \mathrm{Work\ Hour}\left(\frac{\mathrm{min}}{\mathrm{hr}}\right)}{\mathrm{Loader\ Cycle\ Time}(min)}\right)$

Task Time (hr) = $\frac{Volume(cy)}{Productivity(\frac{cy}{hr})}$

Sheet #5 Earth Sum:

Direct Cost ($) = [Owning & Operating Cost ($ / hr) + Labor Cost ($ / hr)] * Time Required (hr) * Number of Units of Equipment

Unit Cost ($ / unit) = $\frac{Direct\ Cost(\$)}{Total\ Production(unit)}$

Earthwork Total Direct Cost ($) = ∑(Total Cost ($))

Sheet #6 Veg:

Direct Cost ($) = Area (acres) * Unit Cost ($ / acre)

Veg Total Direct Cost ($) = ∑(Direct Costs ($))

Sheet #7 Other:

Direct Cost ($) = Quantity (units) * Unit Cost ($ / unit)

Other Total Direct Cost ($) = ∑(Direct Cost ($))

Sheet #1 General:

Subtotal Direct Cost ($) = Earthmoving Total Direct Cost ($) + Vegetation Total Direct Cost ($) + Other Total Direct Cost ($)

Subtotal Indirect Costs ($) = $Subtotal\ Direct\ Cost(\$) * \frac{Various\ Indirect\ Costs(\%)}{100}$

Total Cost ($) = Subtotal Direct Cost ($) + Subtotal Indirect Cost ($)

OPTIMIZATION EQUATIONS:

Each Equation for number of trucks (n) from 2 to 25.

Productivity Sheet:

Productivity (cy / hr) =

$$Work\ Hour\left(\frac{min}{hr}\right) * Loader\left(\frac{cycle}{truck}\right) * Loader\ Net\ Bucket\ Cap\ (cy) * \frac{Number\ Of\ Trucks(n)}{Truck\ Cycle\ Time\ (min)}$$

Time Sheet:

Time (hr) = $Maximum[\frac{Volume\ (cy)}{Productivity\left(\frac{cy}{hr}\right)}, Loader\ Task\ Time\ (hr)$

Truck Cost Sheet:

Truck Cost ($) =

Time (hr) * Number of Trucks[n] * (Owning & Operating Cost ($ / hr) + Labor Cost ($ / hr).

Loader Cost Sheet:

Loader Cost for Number of Trucks[n] ($) =

Time (hr) * (Owning & Operating Cost ($ / hr) + Labor Cost ($ / hr))

Total Cost Sheet:

Total Cost Number of Trucks[n] ($) = Truck Cost ($) + Loader Cost ($)

Minimum Cost = Minimum (Total Cost for Number of Trucks[n]($))

Optimum Number of Trucks:

Number of Trucks[n] =

when (Minimum Cost ($) > or = Total Cost for Number of Trucks[n].

then use Number of Trucks[n]; if not, use 0

Optimum Number of Trucks = $\sum_{n=2}^{25} \text{Number of Trucks } [n]$

APPENDIX A.2

EQUIPMENT PRODUCTIVITY
CURVE FITS

CATERPILLAR PERFORMANCE HANDBOOK

a publication by Caterpillar Inc., Peoria, Illinois, U.S.A.

JANUARY 2011

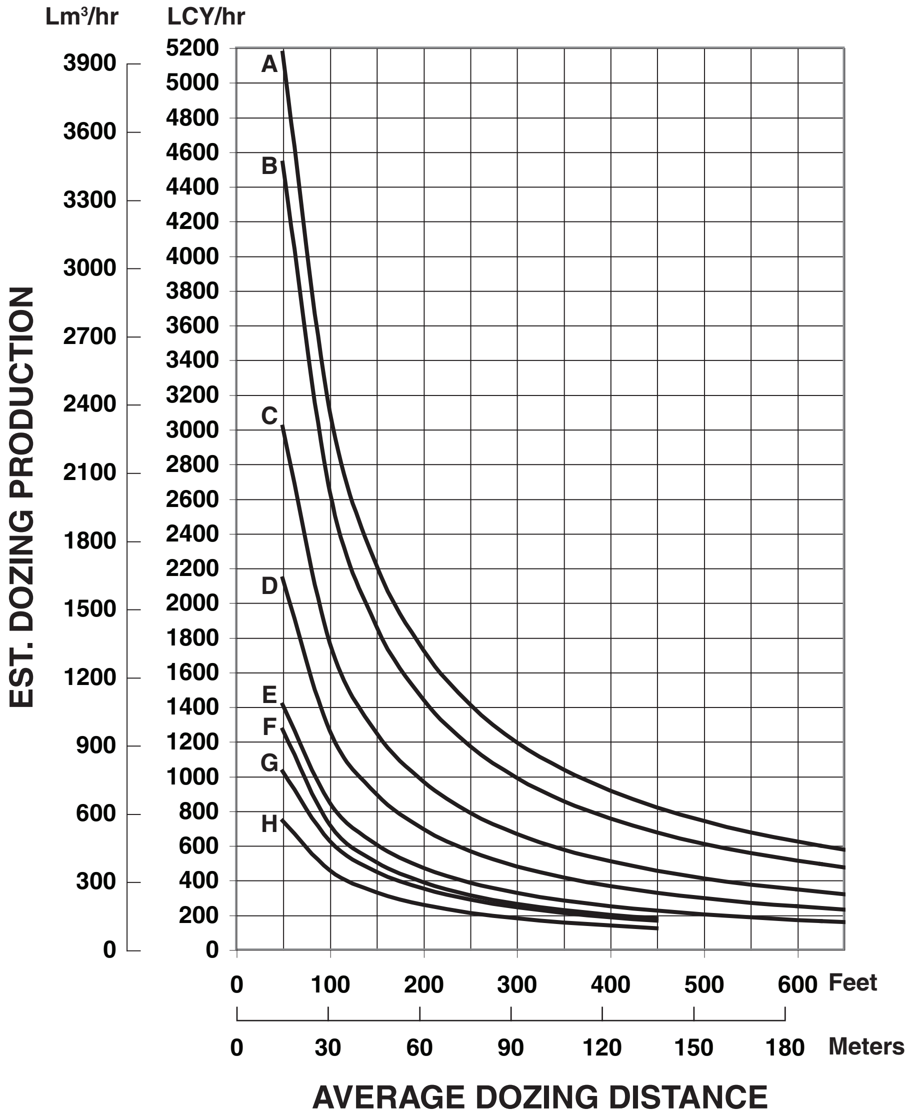
To be removed from the Caterpillar Performance Handbook subscription list, to change your mailing address, or to change the quantity of books you receive, please call 309-266-0942 or 800-566-7782 (Option 3) or email Media Logistics Services at Media_Logistics@cat.com.

Performance information in this booklet is intended for estimating purposes only. Because of the many variables peculiar to individual jobs (including material characteristics, operator efficiency, underfoot conditions, altitude, etc.), neither Caterpillar Inc. nor its dealers warrant that the machines described will perform as estimated.

NOTE: Always refer to the appropriate Operation and Maintenance Manual for specific product information.

Materials and specifications are subject to change without notice.

ESTIMATED DOZING PRODUCTION ● Universal Blades ● D7G through D11T CD

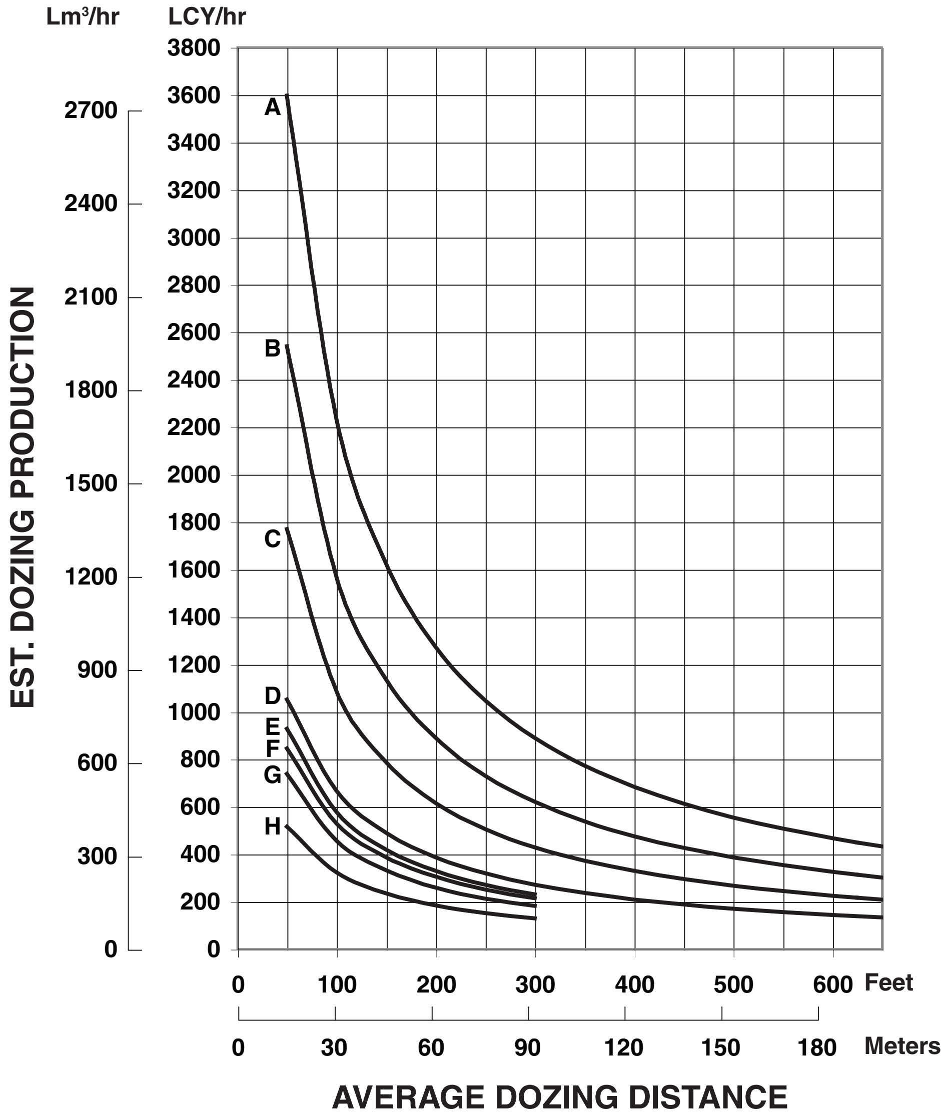


KEY

A — D11T CD
B — D11T
C — D10T
D — D9T
E — D8T
F — D7E
G — D7R Series 2
H — D7G

NOTE: This chart is based on numerous field studies made under varying job conditions. Refer to correction factors following these charts.

ESTIMATED DOZING PRODUCTION ● Semi-Universal Blades ● D6N through D11T

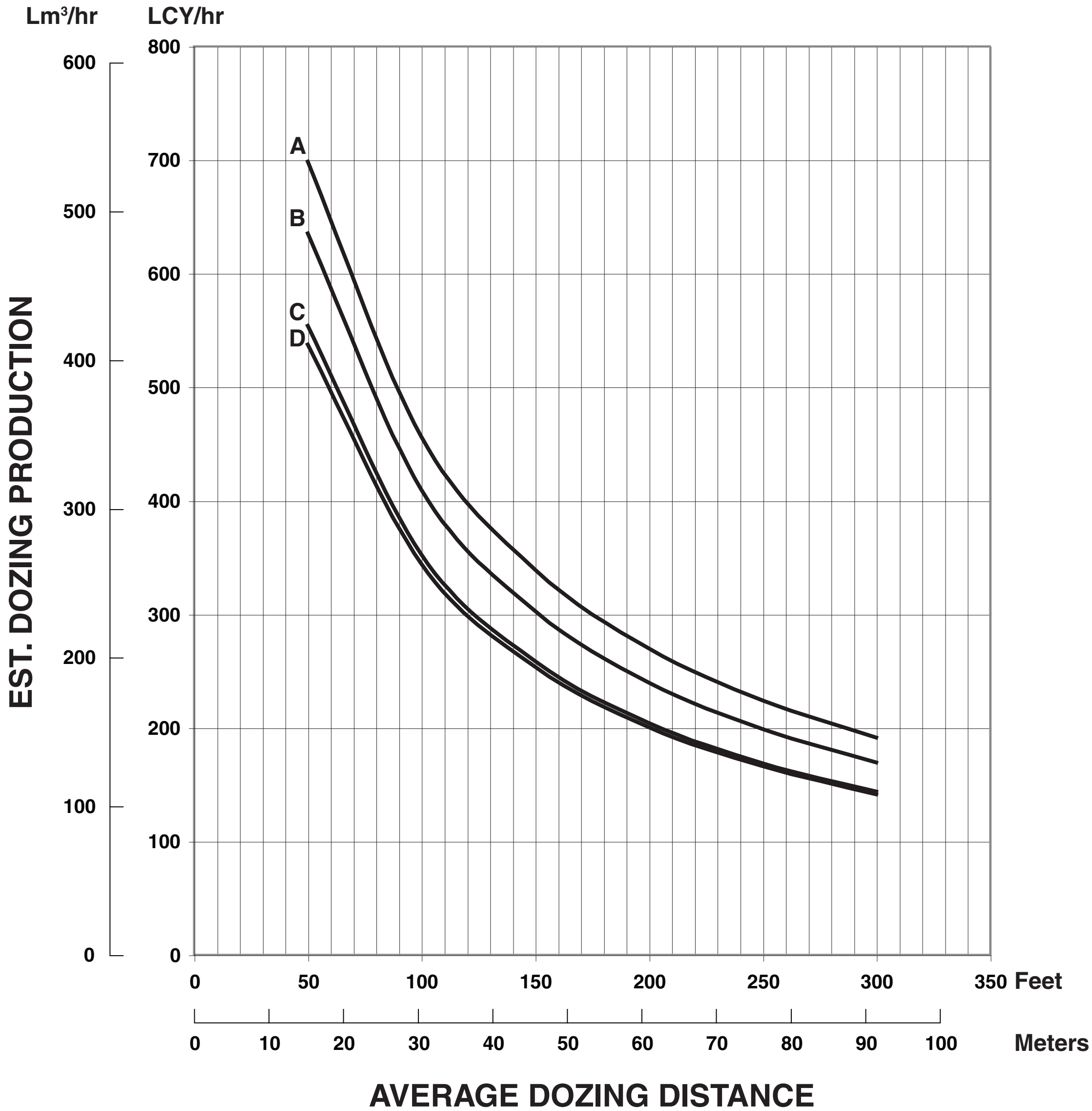


KEY

A — D11T
B — D10T
C — D9T
D — D8T
E — D7E
F — D7R Series 2
G — D6T
H — D6N

NOTE: This chart is based on numerous field studies made under varying job conditions. Refer to correction factors following these charts.

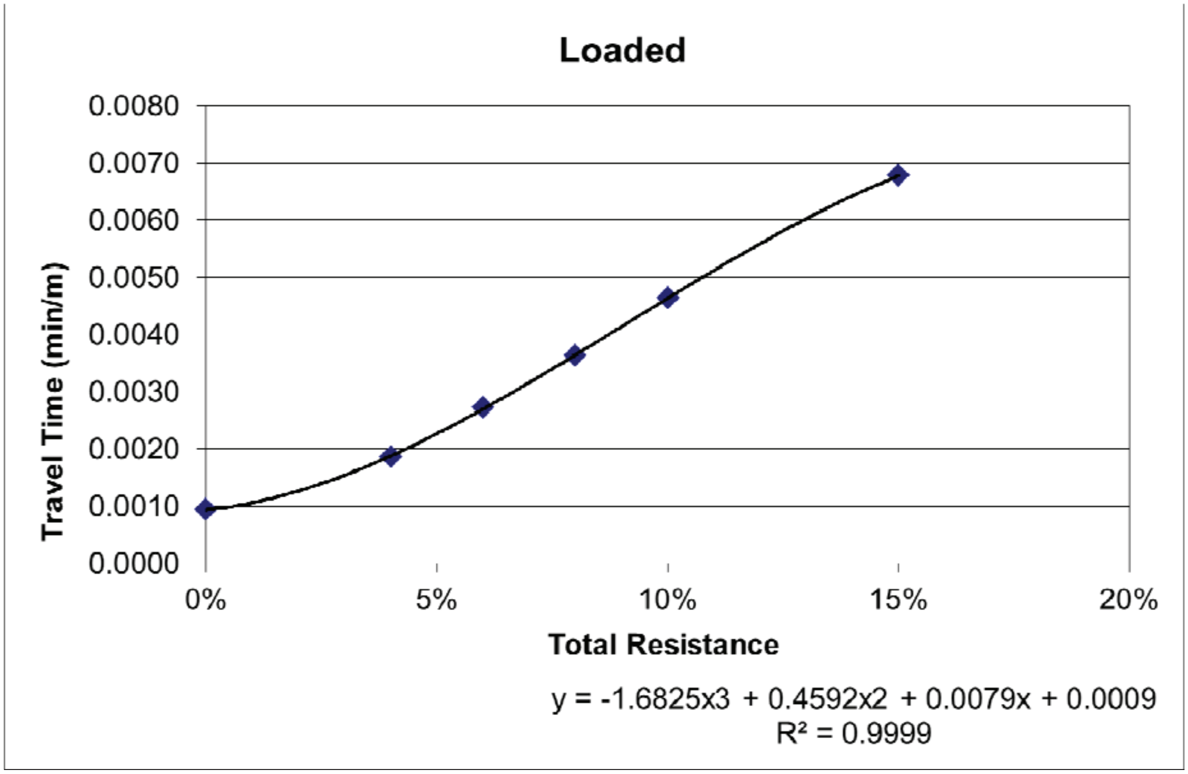
ESTIMATED DOZING PRODUCTION ● Straight Blades ● D6T through D7R Series 2

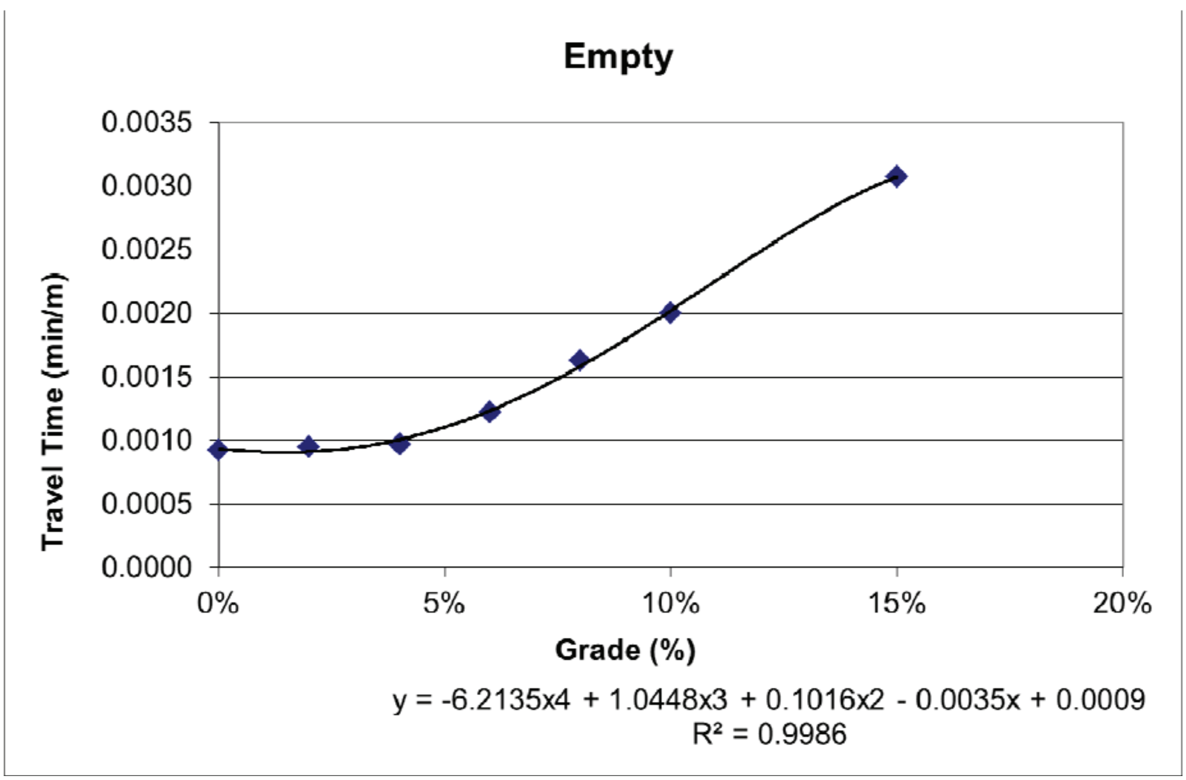


KEY
- A — D7E
- B — D7R Series 2
- C — D6T
- D — D7G

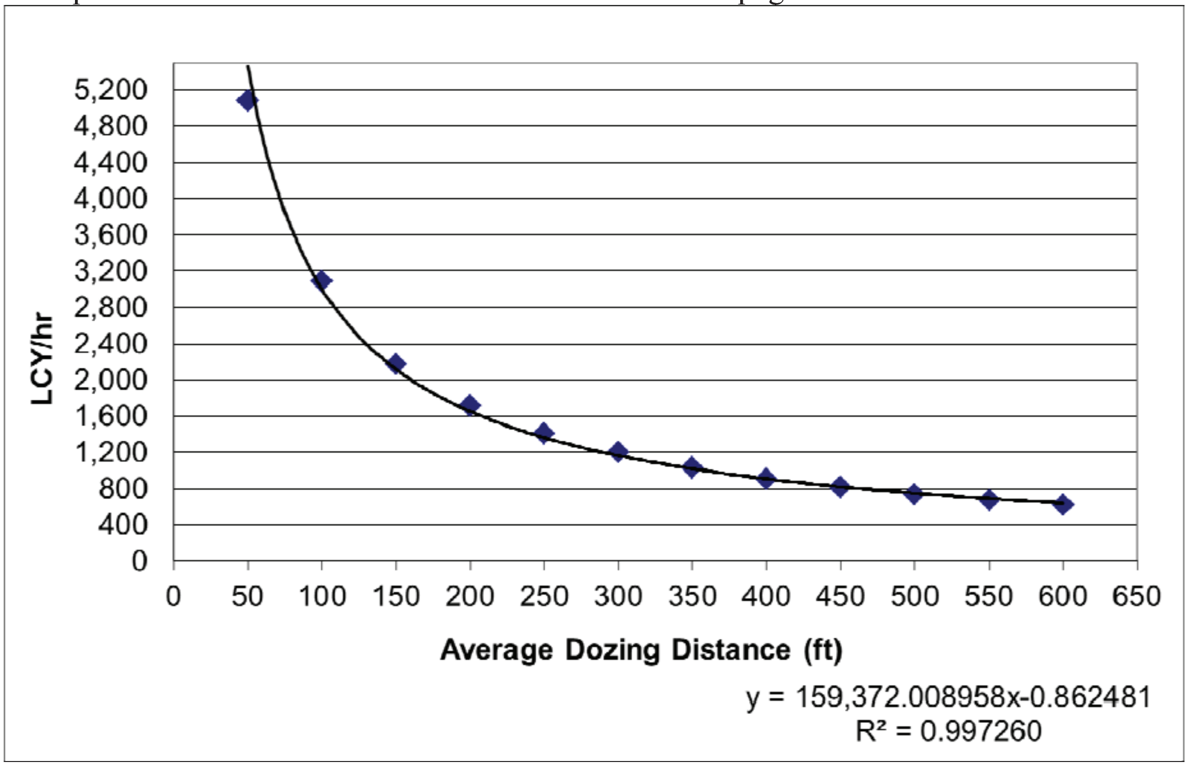
NOTE: This chart is based on numerous field studies made under varying job conditions. Refer to correction factors following these charts.

777F
Caterpillar Performance Handbook Edition 41 9-42

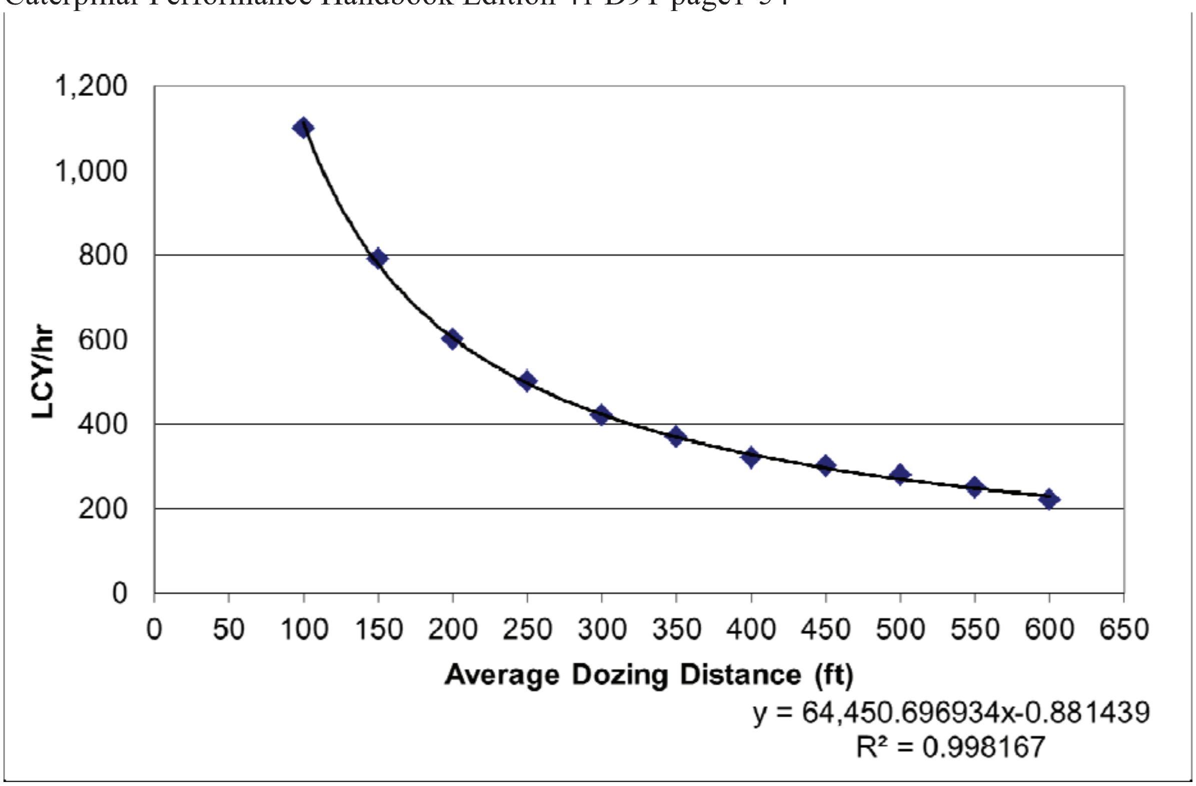




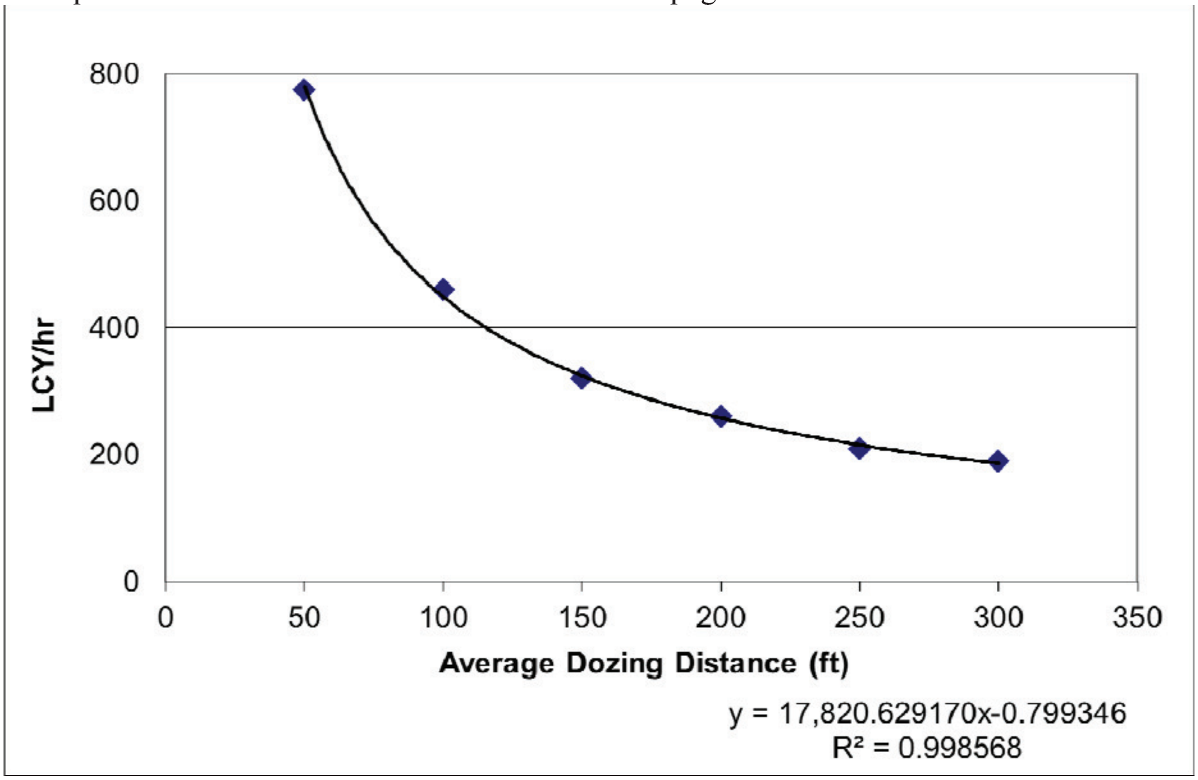
D11T CD
Caterpillar Performance Handbook Edition 41 D11T CD page1-53



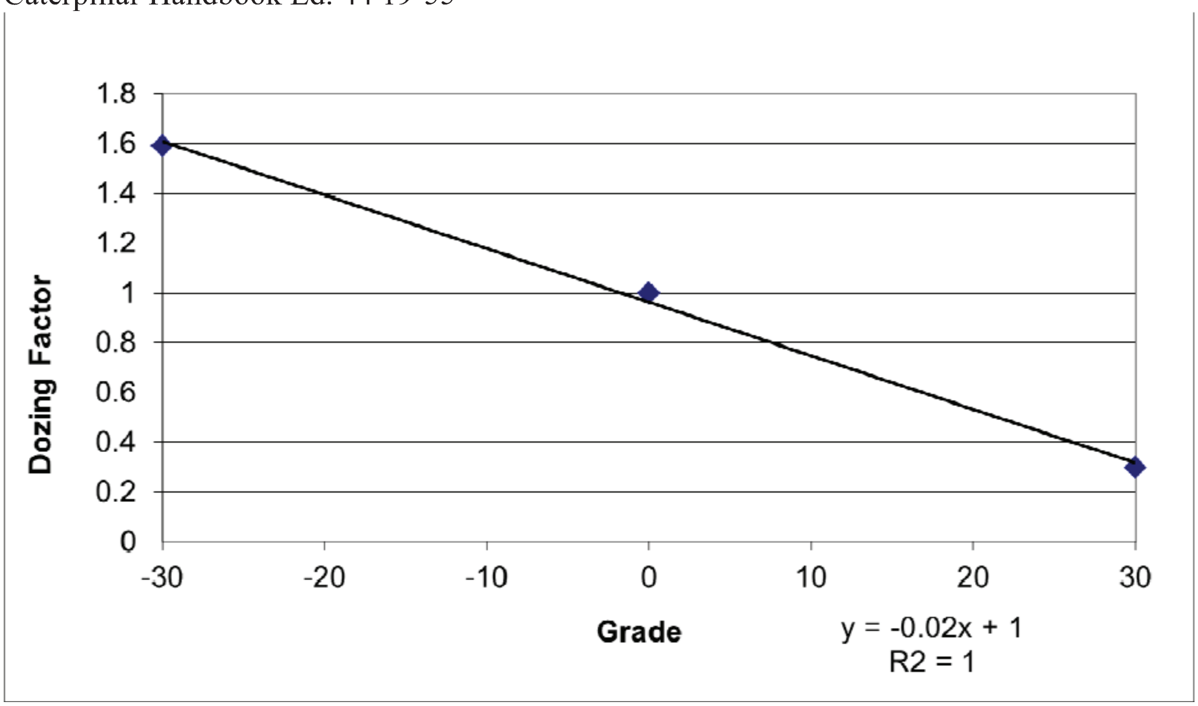
D9T
Caterpillar Performance Handbook Edition 41 D9T page1-54



D6T
Caterpillar Performance Handbook Edition 41 D6T page1-55



Dozing Factor
Caterpillar Handbook Ed. 44 19-55



APPENDIX A.3

CATERPILLAR PERFORMANCE HANDBOOK REFERENCES

CATERPILLAR PERFORMANCE HANDBOOK

a publication by Caterpillar, Peoria, Illinois, U.S.A.

JANUARY 2014

Please direct any inquiries about the Performance Handbook to the Caterpillar Performance Handbook Coordinator at *Sherman_Ashley_E@cat.com*.

Performance information in this booklet is intended for estimating purposes only. Because of the many variables peculiar to individual jobs (including material characteristics, operator efficiency, underfoot conditions, altitude, etc.), neither Caterpillar nor its dealers warrant that the machines described will perform as estimated.

NOTE: Always refer to the appropriate Operation and Maintenance Manual for specific product information.

Materials and specifications are subject to change without notice.

Printed in U.S.A. SEBD0351-44

USE OF BRAKE PERFORMANCE CURVES

The speed that can be maintained when the machine is descending a grade with retarder applied can be determined from the retarder curves in this section when gross machine weight and total effective grade are known.

Select appropriate grade distance chart that covers total downhill haul; don't break haul into individual segments.

To determine brake performance: Read from gross weight down to the percent effective grade. (Effective grade equals actual % grade *minus* 1% for each 10 kg/metric ton (20 lb/U.S. ton) of rolling resistance.) From this weight-effective grade point, read horizontally to the curve with the highest obtainable speed range, then down to maximum descent speed brakes can safely handle without exceeding cooling capacity. When braking, engine RPM should be maintained at the highest possible level without overspeeding. If cooling oil overheats, reduce ground speed to allow transmission to shift to next lower speed range.

Brake Performance Curves are made in compliance with ISO 10268 and applicable to Sea Level and 32° C (90° F) temperature. Contact Factory for Application Specific Performance.

USE OF RIMPULL-SPEED-GRADEABILITY CURVES

For best results, use Caterpillar Fleet Production and Cost Analysis (FPC) to simulate cycle time, fuel burn, and production for Application Specific Performance inquiries. Contact Factory Representative or visit catminer.cat.com/stb for more information.

(See Wheel Tractor Scraper Section)

Total Effective Grade (or Total Resistance) is grade assistance *minus* rolling resistance.

10 kg/metric ton (20 lb/U.S. ton) = 1% adverse grade.

Example —

With a favorable grade of 20% and rolling resistance of 50 kg/metric ton (100 lb/U.S. ton), find Total Effective Grade.

(50 kg/metric ton) = 50 ÷ 10 = 5% Effective Grade
(from Rolling Resistance)
100 lb/ton = 100 ÷ 20 = 5% Effective Grade
20% (grade) – 5% (resistance) =
15% Total Effective Grade

TYPICAL FIXED TIMES FOR HAULING UNITS

Wait time, delays and operator efficiency all impact cycle time. Minimizing truck exchange time can have a significant effect on productivity.

Fixed time for hauling units include:

1. Truck load time (various with loading tool)
2. Truck maneuver in load area (Truck exchange) (Typically 0.6-0.8 min.)
3. Maneuver and dump time at dump point (Typically 1.0-1.2 min.)

Total cycle time is the combination of:

1. The above fixed time
2. Hauling time (Loaded)
3. Return time (Empty)

Example — assume load tool spots hauler with full bucket

		988F	5130B
cycle times		.60	.45
First pass	(dump time)	.10 min.	.05 min.
2 passes	(full cycle)	.70	.50
3 passes	"	1.30	.95
4 passes	"	1.90	1.40
5 passes	"	2.50	1.85
6 passes	"	3.10	2.30
7 passes	"	3.70	2.75
8 passes	"	4.30	3.20
9 passes	"	4.90	3.65
10 passes	"	5.40	4.10

NOTE: Other sizes of loading tools will have different cycle times. See Wheel Loader section for **average** cycle times for truck loading.

MODEL	14M		16M		24M	
Base Power — Net	193 kW	**259 hp**	221 kW	**297 hp**	397 kW	**533 hp**
VHP Range — Net	193-204 kW	**259-274 hp**	221-233 kW	**297-312 hp**	**—**	
VHP Plus Range — Net	193-219 kW	**259-294 hp**	221-248 kW	**297-332 hp**	**—**	
Operating Weight*	21 423 kg	**47,229 lb**	27 531 kg	**60,695 lb**	62 726 kg	**138,287 lb**
Engine Model	**C11 ACERT**		**C13 ACERT**		**C18 ACERT**	
Rated Engine RPM	**1800**		**2000**		**1800**	
No. of Cylinders	**6**		**6**		**6**	
Displacement	11.1 L	**677 in³**	12.5 L	**763 in³**	18.1 L	**1104.5 in³**
Max. Torque	1422 N·m	**1049 lb-ft**	1712 N·m	**1263 lb-ft**	2713 N·m	**2001 lb-ft**
No. of Speeds Forward/Reverse	**8/6**		**8/6**		**6/3**	
Top Speed: Forward	50.4 km/h	**31.3 mph**	51.7 km/h	**32.1 mph**	43.4 km/h	**27.0 mph**
Reverse	39.8 km/h	**24.7 mph**	40.8 km/h	**25.3 mph**	41.6 kmh	**25.8 mph**
Std. Tires — Front and Rear	**16R24**		**23.5R25**		**29.5R29**	
Front Axle/Steering:						
Oscillation Angle	**32°**		**32°**		**32°**	
Wheel Lean Angle	**17.1°**		**18.2°**		**18.0°**	
Steering Angle	**47.5°**		**47.5°**		**47.5°**	
Articulation Angle	**20°**		**20°**		**25°**	
Minimum Turning Radius**	7.9 m	**25'11"**	8.9 m	**29'3"**	12.4 m	**40'9"**
No. Circle Support Shoes	**6**		**6**		**6**	
Hydraulics:						
Pump Type	**Variable Piston**		**Variable Piston**		**Variable Piston**	
Max. Pump Flow	280 L/min	**74 gpm**	280 L/min	**74 gpm**	550 L/min	**145 gpm**
Tank Capacity	60 L	**15.9 U.S. gal**	65 L	**17.2 U.S. gal**	135 L	**36 U.S. gal**
Implement Pressure: Max.	24 150 kPa	**3500 psi**	24 150 kPa	**3500 psi**	24 150 kPa	**3500 psi**
Min.	3100 kPa	**450 psi**	3100 kPa	**450 psi**	3100 kPa	**450 psi**
Interior Sound Level/SAE J919	**70 dB(A)**		**72 dB(A)**		**74 dB(A)**	
Electrical:						
System Size	**24V**		**24V**		**24V**	
Std. Battery CCA @ 0° F	**1125**		**1400**		**1500**	
Std. Alternator	**80**		**150**		**150**	
GENERAL DIMENSIONS:						
Height (to top of ROPS)	3535 mm	**139.2"**	3718 mm	**146.4"**	4452 mm	**175.3"**
Overall Length	9349 mm	**368.1"**	9963 mm	**392.2"**	14 194 mm	**558.8"**
With Ripper and Pushplate	10 896 mm	**429"**	11 672 mm	**459.5"**	16 102 mm	**633.9"**
Wheelbase	6559 mm	**258"**	6985 mm	**275"**	10 278 mm	**404.6"**
Blade Base	2840 mm	**111.8"**	3069 mm	**120.8"**	4048 mm	**159.4"**
Overall Width (at top of front tires)	2801 mm	**110.3"**	3096 mm	**121.9"**	4280 mm	**168.5"**
Standard Blade: Length	4267 mm	**14'0"**	4877 mm	**16'0"**	7315 mm	**24'0"**
Height	686 mm	**27"**	787 mm	**31"**	1025 mm	**40"**
Thickness	25 mm	**1"**	25 mm	**1"**	50 mm	**2"**
Lift Above Ground	419 mm	**16.5"**	395 mm	**15.6"**	634 mm	**25"**
Max. Shoulder Reach:***						
Frame Straight — left	2169 mm	**85.4"**	2282 mm	**90"**	3222 mm	**126.9"**
Frame Straight — right	2279 mm	**89.7"**	2587 mm	**101.9"**	3228 mm	**127.1"**
Fuel Tank Capacity	492 L	**130 U.S. gal**	534 L	**141 U.S. gal**	1326 L	**350 U.S. gal**

*__Operating Weight__ — based on standard machine configuration with full fuel tank, coolant, lubricants and operator. 24M includes ripper.
**__Minimum Turning Radius__ — combining the use of articulated frame steering, front wheel steer and unlocked differential.
***Applicable for the standard blade with hydraulic sideshift and tip control. Maximum shoulder reach is obtainable to the right.

MODEL	D6R 6S		D6R 6SU		D6R 6SU XL		D6R 6S LGP	
Gauge	—		1880 mm	**74"**	1880 mm	**74"**	2.23 m	**90"**
Type	**Straight**		**Semi-Universal**		**Semi-Universal**		**Straight**	
Blade Capacities*	3.27 m^3	**4.27 yd^3**	5.35 m^3	**6.99 yd^3**	5.35 m^3	**6.99 yd^3**	5.50 m^3	**7.20 yd^3**
Weight, Shipping** (Dozer)	2599 kg	**5717 lb**	2973 kg	**6540 lb**	2973 kg	**6540 lb**	3054 kg	**6733 lb**
Tractor and Dozer Dimensions:								
A Length (Blade Straight)	5.12 m	**16'9"**	5.08 m	**16'8"**	5.33 m	**17'6"**	5.48 m	**18'0"**
Blade Dimensions:								
B Width (including std. end bits)	3.36 m	**11'0"**	3.26 m	**10'8"**	3.26 m	**10'8"**	4.08 m	**13'4"**
C Height	1257 mm	**4'1.5"**	1411 mm	**4'8"**	1411 mm	**4'8"**	1104 mm	**3'7"**
D Max. Digging Depth	473 mm	**18.6"**	453 mm	**1'6"**	453 mm	**1'6"**	658 mm	**2'2"**
E Ground Clearance @ Full Lift	1104 mm	**3'7.5"**	1204 mm	**3'11"**	1204 mm	**3'11"**	1088 mm	**3'7"**
F Manual Tilt	689 mm	**2'3.1"**	—		—		—	
G Max. Pitch Adjustment	**+5.3 to 4.8°**		**+5.6° to –5.2°**		**+5.6° to –5.2°**		**+4.4° to –4.4°**	
H Max. Hydraulic Tilt	764 mm	**2'6.1"**	811 mm	**2'8"**	811 mm	**2'8"**	747 mm	**2'5"**
J Hydraulic Tilt (Manual Brace Centered)	420 mm	**16.5"**	455 mm	**1'6"**	455 mm	**1'6"**	421 mm	**1'5"**
K Push Arm Trunnion Width (to Ball Centers)	—		2.58 m	**8'6"**	2.58 m	**8'6"**	3.42 m	**11'5"**

MODEL	D6T 6A		D6T 6SU		D6T 6A XL		D6T 6SU XL	
Gauge	1880 mm	**74"**	1880 mm	**74"**	1.88 m	**74"**	1.88 m	**74"**
Type	**Angling**		**Semi-Universal**		**Angling**		**Semi-Universal**	
Blade Capacities*	3.64 m^3	**4.75 yd^3**	5.35 m^3	**6.99 yd^3**	3.94 m^3	**5.15 yd^3**	5.35 m^3	**6.99 yd^3**
Weight, Shipping** (Dozer)	3138 kg	**6904 lb**	2973 kg	**6540 lb**	3195 kg	**7044 lb**	2973 kg	**6540 lb**
Tractor and Dozer Dimensions:								
A Length (Blade Straight)	5.00 m	**16'5"**	5.08 m	**17'6"**	5.21 m	**17'1"**	5.33 m	**17'6"**
Length (Blade Angled)	5.83 m	**19'2"**	—		6.05 m	**19'10"**	—	
Width (Blade Angled)	3.78 m	**12'5"**	—		3.77 m	**12'5"**	—	
Width (with C-Frame only)	2.93 m	**9'8"**	—		2.99 m	**9'10"**	—	
Blade Dimensions:								
B Width (including std. end bits)	4.16 m	**13'8"**	3.26 m	**10'8"**	4.16 m	**13'8"**	3.26 m	**10'8"**
C Height	1154 mm	**3'10"**	1411 mm	**4'8"**	1154 mm	**3'10"**	1411 mm	**4'8"**
D Max. Digging Depth	506 mm	**1'8"**	453 mm	**1'6"**	511 mm	**1'8"**	453 mm	**1'6"**
E Ground Clearance @ Full Lift	1144 mm	**3'9"**	1204 mm	**3'11"**	1217 mm	**4'0"**	1204 mm	**3'11"**
G Max. Pitch Adjustment	—		**+5.6° to –5.2°**		—		**+5.6° to –5.2°**	
H Max. Hydraulic Tilt	519 mm	**1'8"**	811 mm	**2'8"**	485 mm	**1'4"**	811 mm	**2'8"**
Blade Angle	**25°**		—		**25°**		—	
J Hydraulic Tilt (Manual Brace Centered)	—		455 mm	**1'6"**	—		455 mm	**1'6"**
K Push Arm Trunnion Width (to Ball Centers)	2.58 m	**8'6"**	2.58 m	**8'6"**	2.58 m	**8'6"**	2.58 m	**8'6"**

*Blade capacities as determined by SAE J1265. Tractor and dozer dimensions variations due to SystemOne undercarriage products are negligible. Notice that the capacity of the SU-blade is the volume carried by a straight blade of the same dimensions plus the volume included in the “cup” of the SU-blade. It is intended for **relative comparisons of dozer sizes,** and not for predicting capacities or productivities in actual field conditions.

**Shipping Weight — Total Bulldozer Arrangement includes: Blade, push arms or C-frame, braces, cylinders, lines, trunnions and lift cylinder mountings.

MODEL	D9R/D9T			
	9SU		9U	
Type	Semi-U		Universal	
Blade Capacities*	13.5 m^3	**17.7 yd^3**	16.4 m^3	**21.4 yd^3**
Weight, Shipping** (Dozer)	6543 kg	**14,425 lb**	7134 kg	**15,727 lb**
Tractor and Dozer Dimensions:				
A Length (Blade Straight)	6.84 m	**22'5"**	7.18 m	**23'7"**
Blade Dimensions:				
B Width (including std. end bits)	4.35 m	**14'3"**	4.68 m	**15'4"**
C Height	1934 mm	**6'4.1"**	1934 mm	**6'4.1"**
D Max. Digging Depth	606 mm	**1'11.9"**	606 mm	**1'11.9"**
E Ground Clearance @ Full Lift	1422 mm	**4'8"**	1422 mm	**4'8"**
G Max. Pitch Adjustment	**+3.4° to 2.9°**		**+3.4° to 2.9°**	
H Max. Hydraulic Tilt	940 mm	**3'1"**	1014 mm	**3'3.9"**
J Hydraulic Tilt (Manual Brace Centered)	570 mm	**1'10.4"**	616 mm	**2'0.3"**
K Push Arm Trunnion Width (to Ball Centers)	3.17 m	**10'3"**	3.17 m	**10'3"**
Maximum Track Width Permitted	762 mm	**2'6"**	762 mm	**2'6"**
Dual Tilt Option				
G Dual Pitch Adj.	**+4.8° to 5.2°**		**+4.8° to 4.9°**	
H Dual Max. Hyd. Tilt	1139 mm	**3'8.8"**	1231 mm	**4'0.5"**

*Blade capacities as determined by SAE J1265.
Notice that the capacity of the U-blade is the volume carried by a straight blade of the same dimensions plus the volume included in the "cup" of the U-blade. It is intended for **relative comparisons of dozer sizes**, and not for predicting capacities or productivities in actual field conditions.
Notice that the capacity of the SU-blade is the volume carried by a straight blade of the same dimensions plus the volume included in the "cup" of the SU-blade. It is intended for **relative comparisons of dozer sizes,** and not for predicting capacities or productivities in actual field conditions.
**Shipping Weight — Total Bulldozer Arrangement includes: Blade, push arms or C-frame, braces, cylinders, lines, trunnions and lift cylinder mountings.

MODEL	D11T 11SU		D11T 11U		D11T 11 CD	
Type	**Semi-U**		**Universal**		**CarryDozer**	
Blade Capacities*	27.2 m^3	**35.5 yd^3**	34.4 m^3	**45.0 yd^3**	43.6 m^3	**57.0 yd^3**
Weight, Shipping**						
Standard Dozer	14 813 kg	**32,658 lb**	17 296 kg	**38,131 lb**	24 085 kg	**53,099 lb**
Abrasion Dozer	16 192 kg	**35,698 lb**	18 823 kg	**41,498 lb**	—	
Tractor and Dozer Dimensions:						
A Length	8.38 m	**27'6"**	8.83 m	**28'11"**	8.34 m	**26'8"**
Width	5.60 m	**18'4"**	6.35 m	**20'10"**	6.71 m	**22'0"**
Blade Dimensions:						
B Width (including std. end bits)	5.58 m	**18'4"**	6.35 m	**20'10"**	6.71 m	**22'0"**
C Height	2.77 m	**9'1"**	2.77 m	**9'1"**	2.74 m***	**9'0"*** **
D Max. Digging Depth	766 mm	**2'6.2"**	766 mm	**2'6.2"**	688 mm	**2'3"**
E Ground Clearance @ Full Lift	1533 mm	**5'0.4"**	1533 mm	**5'0.4"**	1850 mm	**6'1"**
G Max. Pitch Adjustment	**+2.1° to 2.2°**		**+2.1° to 2.2°**		—	
H Max. Hydraulic Tilt	1184 mm	**3'10.6"**	1344 mm	**4'4.9"**	1800 mm	**5'11"**
J Hydraulic Tilt (Manual Brace Centered)	886 mm	**2'10.9"**	1006 mm	**3'3.6"**	—	
K Push Arm Trunnion Width (to Ball Centers)	4.18 m	**13'9"**	4.18 m	**13'9"**	4.18 m	**13'9"**
Maximum Track Width Permitted	914 mm	**3'0"**	914 mm	**3'0"**	914 mm	**3'0"**
Dual Tilt Option	**+7.5° to 7.6°**		**+7.5° to 7.6°**			
	or		or			
G Dual Pitch Adjustment	**+0° to 13°**		**+0° to 13°**		**+47.8° to 10.4°**	
H Dual Max. Hyd. Tilt	1706 mm	**5'7.2"**	1938 mm	**6'4.3"**	—	

*Blade capacities as determined by SAE J1265.
Notice that the capacity of the U-blade is the volume carried by a straight blade of the same dimensions plus the volume included in the "cup" of the U-blade. It is intended for **relative comparisons of dozer sizes,** and not for predicting capacities or productivities in actual field conditions.
Notice that the capacity of the SU-blade is the volume carried by a straight blade of the same dimensions plus the volume included in the "cup" of the SU-blade. It is intended for **relative comparisons of dozer sizes,** and not for predicting capacities or productivities in actual field conditions.
**Shipping Weight — Total Bulldozer Arrangement includes: Blade, push arms or C-frame, braces, cylinders, lines, trunnions and lift cylinder mountings.
***Blade height with cutting edge at 53°.

All dimensions are approximate.

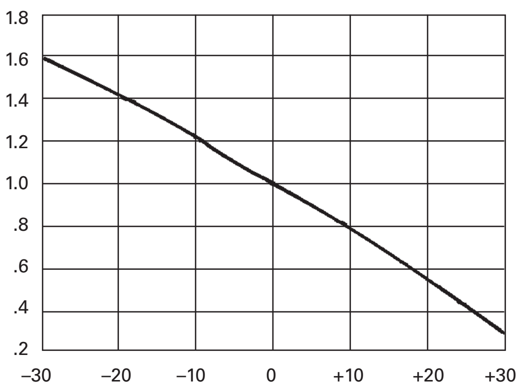
JOB CONDITION CORRECTION FACTORS

	TRACK-TYPE TRACTOR
OPERATOR —	
Excellent	1.00
Average	0.75
Poor	0.60
MATERIAL —	
Loose stockpile	1.20
Hard to cut; frozen —	
with tilt cylinder	0.80
without tilt cylinder	0.70
Hard to drift; "dead" (dry, non-cohesive material) or very sticky material	0.80
Rock, ripped or blasted	0.60-0.80
SLOT DOZING	1.20
SIDE BY SIDE DOZING	1.15-1.25
VISIBILITY —	
Dust, rain, snow, fog or darkness	0.80
JOB EFFICIENCY —	
50 min/hr	0.83
40 min/hr	0.67
BULLDOZER*	
Adjust based on SAE capacity relative to the base blade used in the Estimated Dozing Production graphs.	
GRADES — See following graph.	

***NOTE:** Angling blades and cushion blades are not considered production dozing tools. Depending on job conditions, the A-blade and C-blade will average 50-75% of straight blade production.

% Grade vs. Dozing Factor

(–) Downhill
(+) Uphill



ESTIMATING DOZER PRODUCTION OFF-THE-JOB

Example problem:

Determine average hourly production of a D8T/8SU (with tilt cylinder) moving hard-packed clay an average distance of 45 m (150 feet) down a 15% grade, using a slot dozing technique.

Estimated material weight is 1600 kg/Lm^3 (2650 lb/LCY). Operator is average. Job efficiency is estimated at 50 min/hr.

Uncorrected Maximum Production — 458 Lm^3/h (600 LCY/hr) (example only)

Applicable Correction Factors:

Hard-packed clay is "hard to cut" material . . .–0.80
Grade correction (from graph) . . . .–1.30
Slot dozing . . . .–1.20
Average operator . . . .–0.75
Job efficiency (50 min/hr) . . . .–0.83
Weight correction. . . . . (2300/2650)–0.87

Production = Maximum Production × Correction Factors
= (600 LCY/hr) (0.80) (1.30) (1.20) (0.75) (0.83) (0.87)
= 405.5 LCY/hr

To obtain production in metric units, the same procedure is used substituting maximum uncorrected production in Lm^3.

= 458 Lm^3/h × Factors
= 309.6 Lm^3/h

	Minutes added (+) or Subtracted (–) From Basic Cycle
Machine	
— Material handler	–.05
Materials	
— Mixed	+.02
— Up to 3 mm (1/8 in)	+.02
— 3 mm (1/8 in) to 20 mm (3/4 in)	–.02
— 20 mm (3/4 in) to 150 mm (6 in)	.00
— 150 mm (6 in) and over	+.03 and Up
— Bank or broken	+.04 and Up
Pile	
— Conveyor or Dozer piled 3 m (10 ft) and up	.00
— Conveyor or Dozer piled 3 m (10 ft) or less	+.01
— Dumped by truck	+.02
Miscellaneous	
— Common ownership of trucks and loaders	Up to –.04
— Independently owned trucks	Up to +.04
— Constant operation	Up to –.04
— Inconsistent operation	Up to +.04
— Small target	Up to +.04
— Fragile target	Up to +.05

Using actual job conditions and the above factors, total cycle time can be estimated. Convert total cycle time to cycles per hour.

$$\text{Cycles per hour at 100\% Efficiency} = \frac{60 \text{ min}}{\text{Total Cycle Time in Minutes}}$$

Job efficiency is an important factor in machine selection. Efficiency is the actual number of minutes worked during an hour. Job efficiency accounts for bathroom breaks and other work interruptions.

$$\text{Cycles per hour at 50 minutes per hour (83\% efficiency)} = \text{Cycles per hour at 100\% efficiency} \times \frac{50 \text{ min actual work time}}{60 \text{ min hour}}$$

TRUCK LOADING

Average loader cycle times

914G2-962H	0.45-0.50 min
966H-980H	0.50-0.55 min
988H-990H	0.55-0.60 min
992K-994H	0.60-0.70 min

3. Required Payload Per Cycle

Required payload per cycle is determined by dividing required hourly production by the number of cycles per hour.

4. Bucket Selection

After required payload per cycle has been calculated, the payload should be divided by the loose cubic yard (meter) material weight to determine number of loose cubic yards (meters) required per cycle.

The bulk of material handled does not weigh 1800 kg/m^3 (3000 lb/yd^3), so a reasonable knowledge of material weight is necessary for accurate production estimates. The Tables Section has average weight for certain materials when actual weights are not known.

The percentage of rated capacity a bucket carries in various materials is estimated below. The bucket size required to handle the required volume per cycle is found with the aid of the percentage of rated bucket capacity called "Bucket Fill Factor."

The bucket size needed is determined by dividing loose cubic meters (or yards) required per cycle by the bucket fill factor.

$$\text{Bucket size} = \frac{\text{Volume Required/Cycle}}{\text{Bucket Fill Factor}}$$

BUCKET FILL FACTORS

The following indicates the approximate amounts of material as a percent of rated bucket capacity which will actually be delivered per bucket per cycle. This is known as "Bucket Fill Factor."

Loose Material	Fill factor
Mixed moist aggregates	95-100%
Uniform aggregates up to 3 mm (1/8 in)	95-100
3 mm (1/8 in) to 9 mm (3/8 in)	90-95
12 mm (1/2 in) to 20 mm (3/4 in)	85-90
24 mm (1.0 in) and over	85-90

992K — Standard

Up to specified density for 100% fill factor

Bucket Volume		Material Density	
m³	**yd³**	**kg/m³**	**lb/yd³**
12.2	**16**	1780	**3000**
11.5	**15**	1890	**3200**
10.7	**14**	2030	**3430**

992K — High Lift

Up to specified density for 100% fill factor

Bucket Volume		Material Density	
m³	**yd³**	**kg/m³**	**lb/yd³**
12.2	**16**	1560	**2630**
11.5	**15**	1560	**2630**
10.7	**14**	1560	**2630**

993K — Standard

Up to specified density for 100% fill factor

Bucket Volume		Material Density	
m³	**yd³**	**kg/m³**	**lb/yd³**
15.3	**20**	1780	**3000**
14.5	**19**	1870	**3160**
13.8	**18**	1970	**3330**

993K — High Lift

Up to specified density for 100% fill factor

Bucket Volume		Material Density	
m³	**yd³**	**kg/m³**	**lb/yd³**
14.5	**19**	1720	**2890**
13.8	**18**	1810	**3060**
13.0	**17**	1920	**3240**

TABLES

SWELL — VOIDS — LOAD FACTORS

SWELL (%)	VOIDS (%)	LOAD FACTOR
5	4.8	0.952
10	9.1	0.909
15	13.0	0.870
20	16.7	0.833
25	20.0	0.800
30	23.1	0.769
35	25.9	0.741
40	28.6	0.714
45	31.0	0.690
50	33.3	0.667
55	35.5	0.645
60	37.5	0.625
65	39.4	0.606
70	41.2	0.588
75	42.9	0.571
80	44.4	0.556
85	45.9	0.541
90	47.4	0.526
95	48.7	0.513
100	50.0	0.500

BUCKET FILL FACTORS

Loose Material	Fill Factor
Mixed Moist Aggregates	95-100%
Uniform Aggregates up to 3 mm (1/8")	95-100
3 mm-9 mm (1/8"-3/8")	90-95
12 mm-20 mm (1/2"-3/4")	85-90
24 mm (1") and over	85-90
Blasted Rock	
Well Blasted	80-95%
Average Blasted	75-90
Poorly Blasted	60-75
Other	
Rock Dirt Mixtures	100-120%
Moist Loam	100-110
Soil, Boulders, Roots	80-100
Cemented Materials	85-95

NOTE: Loader bucket fill factors are affected by bucket penetration, breakout force, rackback angle, bucket profile and ground engaging tools such as bucket teeth or bolt-on replaceable cutting edges.

NOTE: For bucket fill factors for hydraulic excavators, see bucket payloads in the hydraulic excavator section.

TYPICAL ROLLING RESISTANCE FACTORS

Various tire sizes and inflation pressures will greatly reduce or increase the rolling resistance. The values in this table are approximate, particularly for the track and track + tire machines. These values can be used for estimating purposes when specific performance information on particular equipment and given soil conditions is not available. See Mining and Earthmoving Section for more detail.

UNDERFOOTING	ROLLING RESISTANCE, PERCENT*			
	Tires		Track	Track
	Bias	Radial	**	+Tires
A very hard, smooth roadway, concrete, cold asphalt or dirt surface, no penetration or flexing	1.5%*	1.2%	0%	1.0%
A hard, smooth, stabilized surfaced roadway without penetration under load, watered, maintained	2.0%	1.7%	0%	1.2%
A firm, smooth, rolling roadway with dirt or light surfacing, flexing slightly under load or undulating, maintained fairly regularly, watered	3.0%	2.5%	0%	1.8%
A dirt roadway, rutted or flexing under load, little maintenance, no water, 25 mm (1") tire penetration or flexing	4.0%	4.0%	0%	2.4%
A dirt roadway, rutted or flexing under load, little maintenance, no water, 50 mm (2") tire penetration or flexing	5.0%	5.0%	0%	3.0%
Rutted dirt roadway, soft under travel, no maintenance, no stabilization, 100 mm (4") tire penetration or flexing	8.0%	8.0%	0%	4.8%
Loose sand or gravel	10.0%	10.0%	2%	7.0%
Rutted dirt roadway, soft under travel, no maintenance, no stabilization, 200 mm (8") tire penetration and flexing	14.0%	14.0%	5%	10.0%
Very soft, muddy, rutted roadway, 300 mm (12") tire penetration, no flexing	20.0%	20.0%	8%	15.0%

*Percent of combined machine weight.

**Assumes drag load has been subtracted to give Drawbar Pull for good to moderate conditions. Some resistance added for very soft conditions.

ANGLE OF REPOSE OF VARIOUS MATERIALS

MATERIAL	ANGLE BETWEEN HORIZONTAL AND SLOPE OF HEAPED PILE	
	Ratio	Degrees
Coal, industrial	1.4:1—1.3:1	35-38
Common earth, Dry	2.8:1—1.0:1	20-45
Moist	2.1:1—1.0:1	25-45
Wet	2.1:1—1.7:1	25-30
Gravel, Round to angular	1.7:1—0.9:1	30-50
Sand & clay	2.8:1—1.4:1	20-35
Sand, Dry	2.8:1—1.7:1	20-30
Moist	1.8:1—1.0:1	30-45
Wet	2.8:1—1.0:1	20-45

ALTITUDE DERATION

PERCENT FLYWHEEL HORSEPOWER AVAILABLE AT SPECIFIED ALTITUDES

MODEL	0-760 m (0-2500')	760-1500 m (2500-5000')	1500-2300 m (5000-7500')	2300-3000 m (7500-10,000')	3000-3800 m (10,000-12,500')	3800-4600 m (12,500-15,000')
D3K XL	100	100	100	100	88	85
D3K LGP	100	100	100	100	88	85
D4K XL	100	100	100	100	88	85
D4K LGP	100	100	100	100	88	85
D5K XL	100	100	100	100	88	85
D5K LGP	100	100	100	100	88	85
D5N XL & LGP	100	100	100	100	100	100
D6K XL & LGP	100	100	100	100	N/A	N/A
D6N XL & LGP	100	100	100	100	N/A	N/A
D6N XL & LGP**	100	100	100	100	100	100
D6G	100	100	100	100	94	87
D6G Series 2 XL	100	100	100	94	87	80
D6G Series 2 LGP	100	100	100	94	87	80
D6R	100	100	100	100	92	84
D6R Series 3 (All)	100	100	100	100	92	84
D6T (Tier 4 Interim/Stage IIIB)	100	100	100	100	100	88
D7E	100	100	100	98	95	88
D7G	100*	100*	100*	94	86	80
D7G Series 2	100	100	100	100	100	94
D7R Series 2 (All)	100	100	100	100	100	96
D8R	100	100	100	93	85	77
D8T	100	100	100	100	100	93
D9R	100	100	100	93	85	77
D9T U.S. EPA Tier 4 Final	100	100	100	100	100	100
D9T Tier 3 equivalent NACD Std. Altitude	100	100	100	99	92	83
D9T Tier 3 equivalent NACD High Altitude	100	100	100	100	100	100
D9T EU Stage IIIA equivalent	100	100	100	98	91	80
D9T Tier 2 equivalent	100	100	100	100	99	88
D10T2 Tier 2 equivalent ***	100	100	100	100	100	100
D10T2 Tier 4 Final***	100	100	100	100	100	100
D11T/D11T CD Tier 2 equivalent****	100	100	100	100	100	86
D11T/D11T CD Tier 4 Final****	100	100	100	100	83	67
120H STD	100	100	100	100	100	100
120M	100	100	100	100	95	88
135H STD	100	100	100	100	100	98
12H STD	100	89	83	77	71	65
12M	100	100	100	100	95	88

*Refer to "Captive Vehicle Engine Fuel Specifications" microfiche at your local dealer.
**Information not available at time of printing.
***In forward gears.
****D11T — High altitude arrangement available.

CATERPILLAR PERFORMANCE HANDBOOK

a publication by Caterpillar Inc., Peoria, Illinois, U.S.A.

JANUARY 2012

Important Notice: The subscription list has been discontinued for the Caterpillar Performance Handbook (PHB). Edition 42 is the final PHB to be distributed via a subscription list. Effective immediately, all Performance Handbooks, including this current edition, can be ordered 24/7 at *https://oos.midlandcorp.com/cat*. Please direct any inquiries about the Performance Handbook to the Caterpillar Performance Handbook Coordinator at *Siegle_Toni_M@cat.com*.

Performance information in this booklet is intended for estimating purposes only. Because of the many variables peculiar to individual jobs (including material characteristics, operator efficiency, underfoot conditions, altitude, etc.), neither Caterpillar Inc. nor its dealers warrant that the machines described will perform as estimated.

NOTE: Always refer to the appropriate Operation and Maintenance Manual for specific product information.

Materials and specifications are subject to change without notice.

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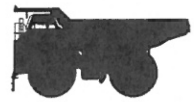
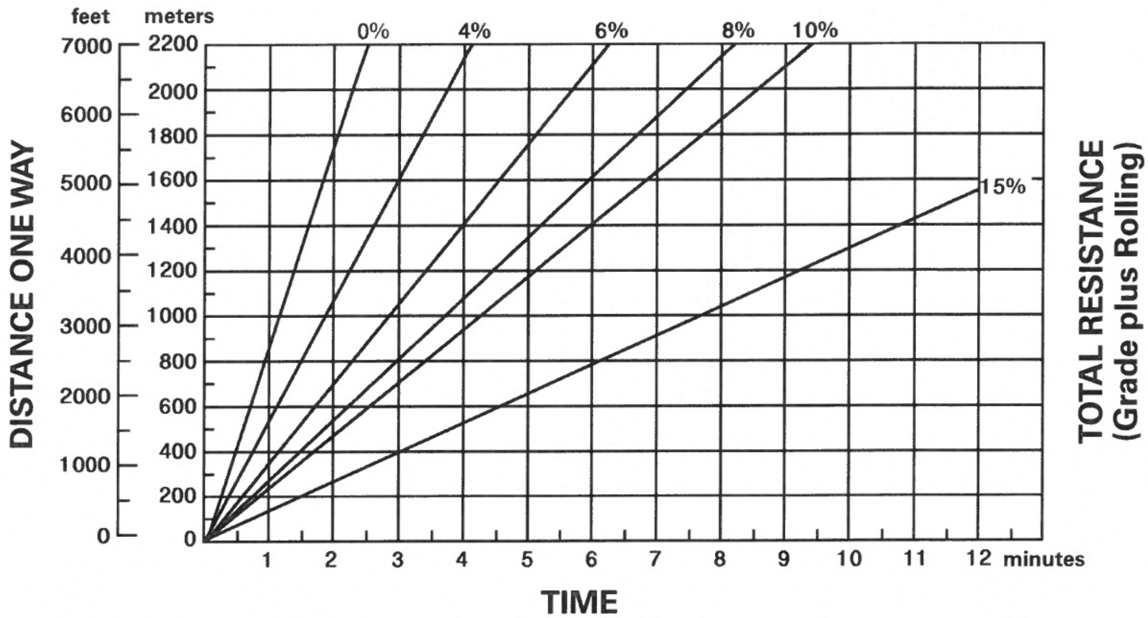


MODEL	**785C**		**785D**		**789C**	
Body Type	**Dual Slope**		**Dual Slope**		**Dual Slope**	
Target Gross Machine Weight §	249 433 kg	**550,000 lb**	249 433 kg	**550,000 lb**	317 460 kg	**700,000 lb**
Basic Machine Weight*	59 385 kg	**130,921 lb**	46 921 kg	**103,443 lb**	67 344 kg	**148,468 lb**
Attachments**	21 677 kg	**47,790 lb**	35 144 kg	**77,479 lb**	29 015 kg	**63,967 lb**
Body Weight without Liners***	22 997 kg	**50,700 lb**	22 997 kg	**50,700 lb**	27 094 kg	**59,732 lb**
Full Liner	8113 kg	**17,886 lb**	8113 kg	**17,886 lb**	9392 kg	**20,706 lb**
Operating Machine Weight	112 172 kg	**247,297 lb**	113 175 kg	**249,508 lb**	132 845 kg	**292,873 lb**
Debris (3% of Operating Machine Weight)	3365 kg	**7419 lb**	3395 kg	**7485 lb**	3985 kg	**8786 lb**
Empty Operating Weight	115 537 kg	**254,716 lb**	116 570 kg	**256,993 lb**	136 830 kg	**301,659 lb**
Target Payload §	133.9 m tons	**147.6 tons**	132.9 m tons	**146.5 tons**	180.7 m tons	**199.2 tons**
Capacity:						
Heaped (2:1) (SAE) Base Body	78 m^3	**102 yd^3**	78 m^3	**102 yd^3**	105 m^3	**137 yd^3**
Heaped (2:1) (SAE) with Std. Sideboards	91 m^3	**119 yd^3**	91 m^3	**119 yd^3**	120 m^3	**157 yd^3**
Distribution Empty:						
Front	**45.0%**		**45.5%**		**45.6%**	
Rear	**55.0%**		**54.5%**		**54.4%**	
Distribution Loaded:						
Front	**33.3%**		**33.3%**		**33.3%**	
Rear	**66.7%**		**66.7%**		**66.7%**	
Engine Model	**3512B EUI**		**3512C HD-EUI**		**3516B EUI**	
Number of Cylinders	**12**		**12**		**16**	
Bore	170 mm	**6.7"**	170 mm	**6.7"**	170 mm	**6.7"**
Stroke	190 mm	**7.5"**	215 mm	**8.46"**	190 mm	**7.5"**
Displacement	51.8 L	**3158 in^3**	58.56 L	**3574 in^3**	69 L	**4210 in^3**
Net Power	979 kW	**1313 hp**	979 kW	**1313 hp**	1335 kW	**1791 hp**
Gross Power	1082 kW	**1450 hp**	1082 kW	**1450 hp**	1417 kW	**1900 hp**
Standard Tires	**33.00R51**		**33.00R51**		**37.00R57**	
Machine Clearance Turning Circle	30.6 m	**100'5"**	33.2 m	**108'11"**	30.2 m	**99'2"**
Fuel Tank Refill Capacity	1893 L	**500 U.S. gal**	1893 L	**500 U.S. gal**	3222 L	**850 U.S. gal**
Top Speed (Loaded)	56.5 km/h	**35.1 mph**	56.5 km/h	**35.1 mph**	57.2 km/h	**35.5 mph**
GENERAL DIMENSIONS (Empty):						
Height to Canopy Rock Guard Rail	5.77 m	**18'11"**	5.68 m	**18'7"**	6.15 m	**20'2"**
Wheelbase	5.18 m	**17'0"**	5.18 m	**17'0"**	5.70 m	**18'8"**
Overall Length (Base Body)	10.62 m	**34'10"**	11.55 m	**37'9"**	12.18 m	**39'11"**
Loading Height (Base Body)	4.97 m	**16'4"**	4.97 m	**16'4"**	5.21 m	**17'1"**
Height at Full Dump	11.21 m	**36'9"**	11.81 m	**38'9"**	11.90 m	**39'1"**
Body Length (Target Length)	7.65 m	**25'1"**	7.65 m	**25'2"**	8.15 m	**26'9"**
Width (Operating)	6.64 m	**21'4"**	7.06 m	**23'2"**	7.67 m	**25'2"**
Width (Shipping)***	3.91 m	**12'10"**	3.91 m	**12'10"**	3.84 m	**12'7"**
Front Tire Tread	4.85 m	**15'11"**	4.85 m	**15'11"**	5.43 m	**17'10"**

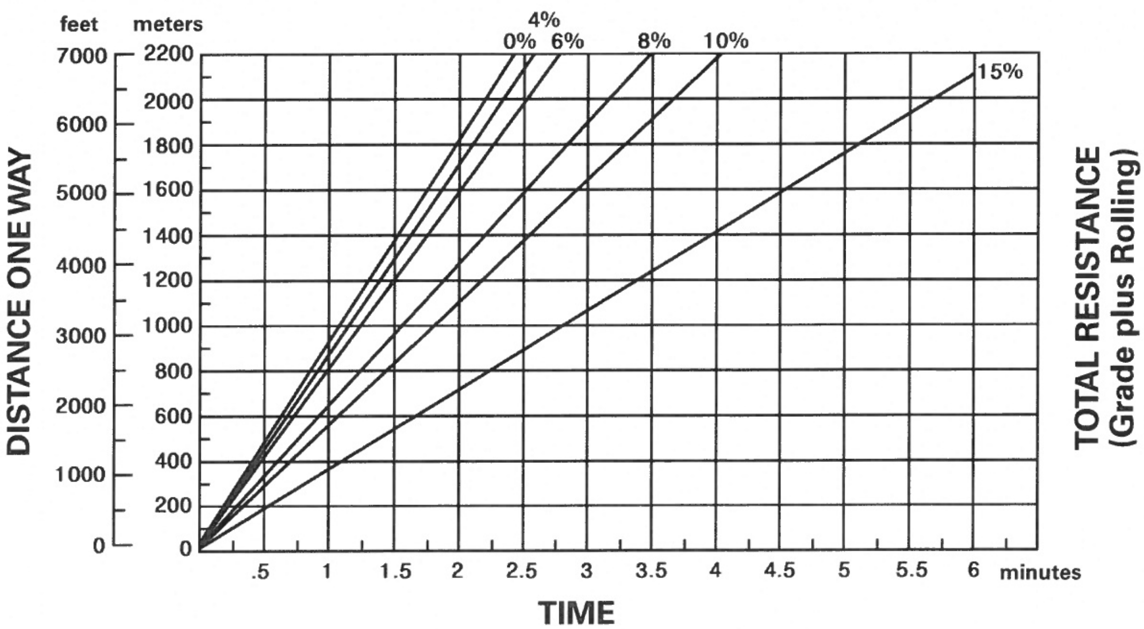
*See Weight Definitions and Relations on 9-16. Note: No mandatory or optional attachments or fuel.
**Typical selection of mandatory and optional attachments.
***Data provided is for a representative body and liner package. Several dual slope, flat floor, and mine specific design (MSD) bodies and liner packages are available. All weights, capacities, and dimensions are dependent on the machine configuration (body type, attachments, tires, and optional equipment selected).
§Reference Caterpillar's latest 10/10/20 Payload Policy for information on gross machine operating weight and target payload.
NOTE: Contact Mining Representative to use Caterpillar Weight Configurator for application specific weights.

9

LOADED



EMPTY



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