Geologic Hazards Assessment
Rosemont Copper

June 2007
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# TABLE OF CONTENTS

1.0 **INTRODUCTION** ............................................................................................................... 3

2.0 **PROJECT DESCRIPTION** ................................................................................................ 4

3.0 **GEOLOGIC CONDITIONS** ............................................................................................... 5
   3.1 Regional Physiographic and Tectonic Setting ............................................................... 5
   3.2 Project Physiographic and Tectonic Setting ................................................................. 5
   3.3 Bedrock Stratigraphy and Structure .............................................................................. 6
      3.3.1 Rosemont Open Pit Area ....................................................................................... 8
      3.3.2 Plant Site Area ....................................................................................................... 8
      3.3.3 Heap Leach Pad Area .......................................................................................... 8
      3.3.4 Tailings Dry Stack Area ....................................................................................... 9
      3.3.5 PWTS Pond ....................................................................................................... 10
   3.4 Surficial Deposits ........................................................................................................... 10

4.0 **GEOLOGIC HAZARDS** .................................................................................................. 11
   4.1 Rockfall Hazards ........................................................................................................... 11
   4.2 Abandoned Mine Workings ......................................................................................... 12
   4.3 Accelerated Erosion ...................................................................................................... 12
   4.4 Seismic Hazard ........................................................................................................... 13
   4.5 Other Geologic Hazards .............................................................................................. 13

5.0 **SEISMIC HAZARD ANALYSIS** ..................................................................................... 15
   5.1 Arizona Historic Seismicity ......................................................................................... 15
   5.2 Earthquake Catalog .................................................................................................... 16
   5.3 Seismic Sources ........................................................................................................... 17
      5.3.1 Active Faults ......................................................................................................... 17
      5.3.2 Background Event ................................................................................................. 19
   5.4 Attenuation Relations .................................................................................................. 19
   5.5 Peak Ground Acceleration .......................................................................................... 23
   5.6 Response Spectra ....................................................................................................... 25
      5.6.1 Time Histories ...................................................................................................... 26

6.0 **CONCLUSIONS** ............................................................................................................. 27

7.0 **RECOMMENDATIONS** ................................................................................................ 29

8.0 **GENERAL INFORMATION** ......................................................................................... 30

9.0 **REFERENCES** ............................................................................................................... 31
LIST OF TABLES

Table 5.1: Project Site Earthquake Catalog ................................................................. 16
Table 5.2: Quaternary Faults Within 200 km of the Project Site........................................... 18
Table 5.3: Estimates of Peak Ground Acceleration.......................................................... 24
Table 5.4: Key Parameters Simplified Smoothed Pseudo-Acceleration Response Spectra 25

LIST OF FIGURES

Figure 1: Title Sheet and Project Location Map
Figure 2: Geology Map
Figure 3: Geologic Hazards Map
Figure 4: Historic Arizona Earthquakes
Figure 5: Location Map with Faults and Historic Earthquakes

LIST OF ILLUSTRATIONS

Illustration 3.1: Rosemont Stratigraphic Section (Anzalone 1995)............................... 7
Illustration 5.1: Focal Depth of Earthquakes (Entire WUS Catalog)................................. 21
Illustration 5.2: Focal Depth of Earthquakes (within 200 km of Project site)................... 22
Illustration 5.3: Project Site Seismic Hazard Curve (from the USGS)............................... 25
Illustration 5.4: Simplified Smoothed Pseudo-Acceleration Response Spectra ............... 26

LIST OF APPENDICES

Appendix A Photographs of Rockfall Hazard Area
Appendix B Historic Mining Areas

Tetra Tech June 2007
1.0 INTRODUCTION

This report presents the Tetra Tech Mining and Manufacturing (Tetra Tech) Geologic Hazard Assessment for the Augusta Resource Rosemont Copper Project (Project).

The Project site is located approximately 30 miles southeast of Tucson, west of State Highway 83 on the east slope of the Santa Rita Mountains. In geographical terms, the Rosemont Property location coordinates are approximately 31° 50’N and 110° 45’W. Access to the Property currently is from Interstate 10 to State Highway 83 south, then west on Forest Road (FR) 231. Figure 1 shows the general location of the Project.

This report is part of a compendium of reports presenting the feasibility-level design of the Project. The list of reports below present the results of field investigations, laboratory testing, and engineering analyses and design activities carried out in support of the Project.

- Leaching Facility Design (Tetra Tech, June 2007)
- Dry Tailings Facility Design (Tetra Tech, June 2007)
- Site Water Management Plan (Tetra Tech, June 2007)
- Geotechnical Study Report (Tetra Tech, June 2007)
- Geologic Hazards Assessment (Tetra Tech, June 2007)
- Baseline Geochemical Characterization (Tetra Tech, June 2007)
- Reclamation and Closure Plan (Tetra Tech, June 2007)
2.0 PROJECT DESCRIPTION

The Project will be developed as an open pit mine with a milling and processing plant for approximately 493 million tons (Mt) of sulfide ore concurrent with copper leaching of approximately 50 Mt of oxide ore in an approximate 19 year mine life. Tailings from the milling process will be further dewatered before being transported to a designated dry stack storage facility. Waste rock quantities of up to 1,288 Mt will be generated as part of the mining operation.

Open pit mining techniques will be used to mine and access the ore, move overburden (barren material) and other non-ore, or waste, materials. Overburden and the waste materials will be transported by haul truck to the waste rock storage area. Sulfide ores will be hauled to a crusher, crushed, and subsequently conveyed to a mill for further processing. The rougher flotation tailing and the scavenger flotation tailing are combined in a tailings thickener for water recovery. The thickener underflow slurry is then pumped to a bank of connected large drum filters where moisture is reduced from 40-50% water to 10-15% moisture. The tailings are then transported and placed by conveyor in a designated tailings storage area.

The deposition of dry tailings, waste rock, and overburden will be initiated with a series of perimeter buttresses that are designed to reduce visual impacts from State Highway 83 and surrounding areas, and allow reclamation to begin within the first year of operations. Topsoil will be salvaged as needed from pit and waste rock/tailings storage areas for use as a vegetation growth medium for reclamation. Waste rock and tailings will be deposited behind, i.e. to the west of the perimeter buttresses during the life of the mine. The dry tailings deposition will incorporate staged waste rock buttresses for screening and to improve mechanical and erosional stability of the tailings.
3.0 GEOLOGIC CONDITIONS

3.1 Regional Physiographic and Tectonic Setting

The Project site lies in the southwestern region of North America, specifically, in the Basin and Range physiographic province. The Basin and Range is characterized by relatively evenly spaced, sub-parallel mountain ranges separated by broad, thick alluviated basins, the boundaries of which are defined by high-angle extensional faults. This irregularly shaped region encompasses an area greater than 1,500 kilometers in length and up to 1,000 kilometers in width extending from the southern portions of Idaho and Oregon through the majority of Nevada, western Utah, southwestern California, western and southern Arizona, southwestern New Mexico, and northern Mexico.

Major regional tectonic activity in the southern portion of the Basin and Range Province occurred during late Jurassic to early Cretaceous time with the development of west-northwest elongated basins related to backarc, crustal extension, and rifting, which formed the oceanic crust of the Gulf of Mexico that propagated northwesterly into the continental block along the Chihauhua trough and Bisbee basin. This early extensional event was followed by compressional deformation of the late Cretaceous to early Eocene Laramide Orogeny (approximately 80 to 55 million years before present [mybp]), which resulted in crustal thickening across a wide region as well as considerable igneous activity. Eruptive centers are characterized by eroded stratovolcanic piles and ignimbritic caldera fills as well as isolated subvolcanic stocks, hypabyssal dike swarms, and more deeply eroded granitic plutons. The latest tectonic activity of the region involved a reversal in the regional stresses producing a thinning of the crust and two distinct widespread extensional phases of deformation. The onset of the first phase of extensional tectonism began approximately 37 mybp and continued until approximately 15 mybp. It was characterized by significant displacement along normal faults and arc related magmatism, characterized by andesitic to latitic lavas, and rhyodacitic to rhyolitic domes and ignimbritic sheets. The latter phase of extensional tectonism began approximately 15 mybp and continues today. Accompanied by high-angle block faulting, it is responsible for the dramatic Basin and Range topography viewed in the region today and was generally associated with basaltic volcanism related to the upwelling of mantle beneath the region (Dickinson, 1989).

3.2 Project Physiographic and Tectonic Setting

The Project site lies within the southern portion of the Basin and Range physiographic province, an extensional terrain characterized by discontinuous northwest to northeast-trending mountain ranges separated by broad, thick, fault-controlled alluvial basins. This region can be subdivided into the Sonoran Desert sub-province and Mexican Highland sub-province. Located in western and south-central Arizona, the Sonoran Desert sub-province is generally defined by low mountain ranges and broad, mostly undissected valleys, while the Mexican Highland sub-province of southeastern Arizona and southwestern New Mexico is characterized by greater average altitudes, local relief, and basin dissection. The southern portion of the Basin and Range physiographic province is separated from the Colorado Plateau by the Transitional zone, which is characterized by rugged relief, variably dissected alluvial basins, large mountain ranges, and plateau remnants. Located in the Mexican Highland sub-province, the Rosemont Project is situated in the northern portion of the Santa Rita Range, near the boundary separating the two sub-provinces (Menges and Pearthree, 1989).
The Santa Rita Range and its northern continuation, the Empire Mountains, represent an easterly to southeasterly tilted, south-southwest elongated, structural horst, which extends from the Pantano Wash south to Sonoita Creek. Its western boundary is coincident with the Santa Rita Fault, a north to northeast trending normal fault zone, which has juxtaposed Tertiary and Quaternary sediments of the Santa Cruz River Basin in its western hanging wall against Precambrian to Mesozoic units in its eastern structural footwall. This structural horst can be subdivided into three structural domains; the Southern Santa Rita Range, Northern Santa Rita Range, and Empire Mountains. Located south of the northwest trending Sawmill Canyon Fault Zone, the Southern Santa Rita Range is primarily underlain by a complex assemblage of Mesozoic sediments and volcanics cut by large Mesozoic stocks, which are unconformably overlain by Tertiary volcanics. North of the Sawmill Canyon Fault zone, the Precambrian Continental Granodiorite is unconformably overlain by a steep, east dipping succession of Paleozoic marine sediments, which are normally unconformably overlain by late Jurassic to early Cretaceous sediments of the Bisbee Group. The Bisbee Group is a thick (> 2,500 meters) succession of dominantly non-marine clastic sediments, which occupies a series of extensional fault-bounded basins throughout much of southeastern Arizona (Dickinson, 1989). A similar easterly dipping section of Paleozoic and Mesozoic sediments is exposed in the Empire Mountains, which is separated from the northern end of the Santa Rita Range by a moderately southeast tilted, complexly faulted assemblage of rhyolitic volcanics and related sediments, exposed in the late Cretaceous Mount Fagan Caldera.

### 3.3 Bedrock Stratigraphy and Structure

The Rosemont Project area is underlain by a north striking, steep, easterly tilted section of Cambrian to Permian miogeosynclinal marine sediments (quartzite, limestone, and dolomite). Recent evaluation of core derived from historical exploration programs at Rosemont suggests that the Bisbee Group structurally overlies the Paleozoic section within the upper plate of an east dipping, low angle fault zone. At this locality, Mesozoic sediments of the Bisbee Group include the Glance Conglomerate, Willow Canyon Formation, and the Apache Canyon Formation. The Glance Conglomerate is composed of a limestone-pebble conglomerate. It is stratigraphically overlain by a thick, monotonous succession of feldspathic sandstone and conglomerate of the Willow Canyon Formation. Arkosic clastics of the Willow Canyon Formation grade upward into the Apache Canyon Formation, a shale, and silty mudstone dominated sequence, containing subordinate amounts of interbedded dark-gray, thin-bedded, micritic limestone, and feldspathic sandstone.

A simplified stratigraphic section of the Precambrian through early Cretaceous sequence at Rosemont (Anzalone, 1995) is shown in Illustration 3.1.
The northeastern portion of the Rosemont Project area lies within the Mount Fagan Caldera, a complexly faulted, late Cretaceous dominantly rhyolitic volcanic center, which was subsequently tilted 30 to 50 degrees to the southeast by late Tertiary Basin and Range extensional tectonism. A dissected alluvial fan, exposed along the eastern flank of the Santa Rita Range, is characterized by a gently southeast tilted sequence of Miocene to Pliocene sands and gravels of the Gila Conglomerate. The Gila Conglomerate unconformably overlies Mesozoic sediments and volcanics of the Bisbee Group and Mount Fagan Caldera in the southeastern portion of the Rosemont Project area.

Proposed facilities at the Project site will overlie numerous bedrock formations. Each of the major facilities is identified in the following paragraphs, followed by a brief description of the underlying bedrock units. For completeness, repeating bedrock units are fully described for each relevant facility so that the facility description will stand alone. Published and as yet unpublished geologic mapping completed by government agencies, as well as supplemental detailed geologic mapping completed by Tetra Tech’s staff and consultants, were referenced for...
bedrock unit descriptions. The bedrock unit descriptions are brief and serve to identify the variability that can be expected in the facility foundations.

3.3.1 Rosemont Open Pit Area

Based on available information, the open pit mining activity will be located along the eastern slope of the Santa Rita Mountain range in the upper reaches of Wasp Canyon. The identified hypogene sulfide resource at Rosemont is primarily hosted by carbonate lithologies in the Pennsylvanian Horquilla Limestone, Permian Colina Limestone, and Permian Epitaph Formation. The oxide resource is mainly hosted by the mafic volcanics and clastics of the early Cretaceous Willlow Canyon Formation.

The structural setting at Rosemont is complex. A north striking, steep, easterly tilted section of Paleozoic marine sediments appears to be structurally overlain by late Jurassic to early Cretaceous Bisbee Group clastics (Glance Conglomerate and Willow Canyon Formation) within the upper plate of an east dipping, low angle fault zone. The structural setting has been further complicated by several major north-trending, steeply east dipping normal faults, which drop the stratigraphic sections to the east, as well as numerous northeast and northwest trending high angle structural zones. Most of these structures post-date the primary mineralizing event and appear to be related to late Tertiary extensional deformation.

Emplacement of late Paleocene quartz latite porphyry stocks (~56 million years) resulted in the development of large zones of copper-bearing skarn, which host the resource at Rosemont as well as several other smaller occurrences within the Rosemont-Helvetia mining district.

3.3.2 Plant Site Area

The proposed plant site is contained entirely within the region underlain by early Cretaceous clastics and mafic lavas in the Willow Canyon Formation of the Bisbee Group. This unit is characterized by a monotonous succession of interbedded medium- to coarse-grained sandstone and argillaceous sandstone with equal to subordinate amounts of vuggy, silty mudstone (Johnson and Ferguson (2006). At least three mafic lava flows occur within the Willow Canyon Formation and have been described by Johnson and Ferguson (2006) as massive to amygdaloidal, very fine-grained, mafic lavas. Individual flows range from 10 to 100 meters in thickness. A distinctive interval of volcaniclastic pebble-cobble conglomerate stratigraphically underlies the mafic volcanic flows. The total thickness of the Willow Canyon Formation is estimated to be approximately 2,200 meters.

3.3.3 Heap Leach Pad Area

The proposed heap leach pad area is underlain by early Cretaceous to Pliocene strata (deposited 144 to 1.8 mybp). Specific bedrock units as mapped by Drewes (2002), Johnson and Ferguson (2006), and Tetra Tech’s staff and consultants are described below in ascending stratigraphic order.

The oldest bedrock unit underlying the proposed heap leach pad area is the early Cretaceous Willow Canyon Formation. According to Johnson and Ferguson (2006), this unit is characterized by a monotonous succession of interbedded medium- to coarse-grained sandstone and argillaceous sandstone, containing equal to subordinate amounts of vuggy, silty mudstone. The total thickness of the Willow Canyon Formation is estimated to be approximately 2,200 meters.
The early Cretaceous Apache Canyon Formation conformably overlies the Willow Canyon Formation. The boundary between the two units is defined by a gradational contact. Johnson and Ferguson (2006) describe the Apache Canyon Formation (> 400 meters) as a sequence dominated by medium- to thick-bedded shale and laminated silty mudstone, containing subordinate amounts of interbedded, dark gray, laminated to thin-bedded, micritic limestone, and feldspathic sandstone.

Locally overlying the Cretaceous Willow Canyon and Apache Canyon formations are late Oligocene to Miocene rhyolitic to rhyodacitic lavas and pyroclastics, which are succeeded by Miocene to Pliocene Gila Conglomerate. Johnson and Ferguson (2006) describe the Gila Conglomerate as a light brown, medium- to thick-bedded, clast to matrix supported conglomerate, pebbly sandstone and sandstone. Clasts range from rounded to subangular and consist of sandstone, carbonate, argillite, hornfels, marble, granitic lithologies, quartz-feldspar porphyry and crystal-rich, welded ash flow tuff. Test pit excavations performed by Tetra Tech personnel demonstrate that the composition of the Gila Conglomerate ranges from non-cemented to strongly cemented sands and gravels. Its thickness locally exceeds 200 meters.

### 3.3.4 Tailings Dry Stack Area

The proposed tailings dry stack areas will overlie most of the northeastern part of the Rosemont property. These areas are underlain by early Cretaceous to Pliocene strata (deposited 144 to 1.8 mybp). Specific bedrock units as mapped by Drewes (2002) and Johnson and Ferguson (2006) are described below in ascending stratigraphic order.

The oldest bedrock unit underlying the proposed tailings dry stack area is the early Cretaceous Willow Canyon Formation. According to Johnson and Ferguson (2006), this unit is characterized by a monotonous succession of interbedded medium- to coarse-grained sandstone and argillaceous sandstone, containing equal to subordinate amounts of vuggy, silty mudstone. At least three mafic lava flows occur within the Willow Canyon Formation and have been described by Johnson and Ferguson (2006) as massive to amygdaloidal, very fine-grained, mafic lavas. Individual flows range from 10 to 100 meters in thickness. The total thickness of the Willow Canyon Formation is estimated to be approximately 2,200 meters.

The early Cretaceous Apache Canyon Formation conformably overlies the Willow Canyon Formation. The boundary between the two units is defined by a gradational contact. Johnson and Ferguson (2006) describe the Apache Canyon Formation (> 400 meters) as a sequence dominated by medium- to thick-bedded shale and laminated silty mudstone, containing subordinate amounts of interbedded dark gray, laminated to thin-bedded, micritic limestone, and feldspathic sandstone.

The late Cretaceous Mount Fagan Rhyolite mantles early Cretaceous sediments of the Bisbee Group in the northeastern portion of the Project area. Johnson and Ferguson (2006) describe this unit as a phenocryst-rich, ash flow tuff, containing 1 to 5% lithic lapilli within a welded to non-welded, light colored matrix. Lapilli chiefly consists of feldspathic sandstone and argillite derived from the underlying Bisbee Group and fine-grained andesitic lavas. Zones within the Mount Fagan Rhyolite, containing more than 30% lithic clasts exceeding one meter in size, have been designated as megabreccia. The thickness of the Mount Fagan Rhyolite is estimated to be greater than 1,000 meters.

Late Oligocene to Miocene rhyolitic and rhyodacitic lavas and pyroclastics locally overlie the Mount Fagan Rhyolite and are succeeded by Miocene to Pliocene Gila Conglomerate. Johnson and Ferguson (2006) describe the Gila Conglomerate as a light brown, medium- to thick-bedded, clast to matrix supported conglomerate, pebbly sandstone and sandstone. Clasts
range from rounded to subangular and consist of sandstone, carbonate, argillite, hornfels, marble, granitic lithologies, quartz-feldspar porphyry and crystal-rich, welded ash flow tuff. Test pit excavations performed by Tetra Tech personnel demonstrate that the composition of the Gila Conglomerate ranges from non-cemented to strongly cemented sands and gravels. Its thickness locally exceeds 200 meters.

### 3.3.5 PWTS Pond

The proposed PWTS Pond embankment and reservoir will lie entirely over early Cretaceous clastics of the Willow Canyon Formation. This unit is characterized by a monotonous succession of interbedded medium- to coarse-grained sandstone and argillaceous sandstone, containing equal to subordinate amounts of vuggy, silty mudstone (Johnson and Ferguson (2006). The total thickness of the Willow Canyon Formation is estimated to be approximately 2,200 meters.

### 3.4 Surficial Deposits

Paleozoic, Mesozoic, and Tertiary-age units across the Project site are locally mantled by unconsolidated Quaternary (younger than 1.8 mybp) talus, colluvium and alluvial deposits, as well as disturbed areas resulting from human activities. The natural surficial deposits were derived through slope wash, natural landscape degradation, and other erosional processes (Hardy, 1997). Four independent Quaternary age units identified in Figure 2 include Older Alluvium, Colluvium and Talus, Younger Alluvium, and Disturbed Areas.

The Older Alluvium unit is characterized by terraces comprised of medium- to thick-bedded, sandy, weakly consolidated gravel with scattered cobbles and boulders derived from the upslope bedrock units. This geologic unit is generally incised between four to twelve meters and locally forms steep cliffs and ledges up to 3 meters high (Johnson and Ferguson, 2006).

Colluvium and talus is characterized by angular to subangular pebbles, cobbles, and boulders derived through slope wash and natural landscape degradation of the steep terrain, which is pervasive throughout the western portion of the Rosemont Project area (Johnson and Ferguson, 2006). This unit typically defines the toe of the steeper western terrain.

Younger alluvium is confined to active stream channels and washes and generally includes flood plain terraces incised less than 3 meters.

Holocene age disturbed areas include mine dumps, road cuts and fills, and slag deposits. This unit primarily defines areas that have undergone reworking of the native soil and rock materials through human activities. Important disturbed areas include a set of heavily vegetated dumps, located downslope from the Naragansett mine and an old smelter slag dump, located west of Rosemont Junction.
4.0 GEOLOGIC HAZARDS

The following terms are used in this report and are integral to understanding its contents.

**Geologic Hazard** – a geologic condition, natural or man-made, that poses a potential danger to life and/or property.

**Risk** – potential or chance of economic loss or injury resulting from a hazard. Degree of risk normally governs decisions involving a known hazard.

**Uncertainty** – the estimated amount by which an observed condition, calculated value, or opinion may differ from the true condition or value; condition of being uncertain; doubt.

Rockfalls are geologic hazards characterized by free falling rock masses. Normally, if rockfalls are present in an area, constraints on design and construction may be necessary to minimize risk. The degree of risk posed by rockfalls to the proposed development is variable, ranging from low (very old, well drained, gentle slopes) to high (overhanging rocky cliffs with loose rock material on steep slopes and poorly consolidated surficial deposits). In most cases the risk of future movement can be reduced by appropriate design and construction practices (engineered excavation and grading) and by active mitigation techniques, such as: control of surface and subsurface drainage; rock tieback anchors, rock scaling, and buttressing.

A large rockfall hazard area has been identified within the bounds of the Project site. The geologic hazards map presented with this report and the following text specifically address these and other geologic hazards.

4.1 Rockfall Hazards

The mapped rockfall areas indicated in Figure 3 include both the source and runout areas of rockfall. In general, most of the rockfall source areas consist of bare or nearly bare rock outcrops in the Mesozoic to Precambrian assemblage on steep slopes above the western wall of the proposed Rosemont open pit, and include areas of observed loose rocks on the surface and talus areas. Rockfalls typically descend the steep portion of the indicated slopes and come to rest where the terrain flattens. Rockfalls can also extend farther downslope where steep, incised alluvial channels exist.

Additional small areas of localized rockfall, many insignificant on the map scale, exist particularly in steeply incised alluvial valleys. Two specific areas are illustrated in Figure 3 on materials of the Gila Conglomerate to the south and Mt. Fagan Rhyolite in the north. The source material of these rockfall areas is not generally bare rock, as described above, but rather loosely consolidated deposits where rockfall results from differential weathering between cobbles or boulders and matrix material.

The rockfall zone depicted along the western wall of the proposed Rosemont open pit presents a high rockfall risk to the proposed Project and will require engineered mitigations to prevent rockfalls into the pit.

Appendix A contains photos of typical rockfall source and runout areas.
4.2 Abandoned Mine Workings

The Project site and the general area have been the subject of historic mining activities. None of these previous activities, however, has matched the scale of the proposed mining Project. Prior mining activities range from simple, shallow prospector borrow pits no more that a few feet in diameter and several feet in depth to well developed mine adits that extend tens of feet or more into the subsurface. Additionally, one slag deposit and an historic ore leaching building exist on the Project site. In order to inventory these previous mine workings, Tetra Tech researched the Abandoned Mine Lands database available on the World Wide Web through the USGS.

This database available at: http://mrdata.usgs.gov/website/MRData-US/viewer.htm was searched for all known Abandoned Mine Lands (AML) located in Pima County and then further restricted to the general area surrounding the Project site. Additionally, six historic mine workings, absent from the USGS database, were discovered during field investigations. These six additional mine workings plus the AML sites revealed through the USGS database and located within the Rosemont Project boundaries are illustrated in Figure 3 with the general pick and shovel symbol. A geologist was also sent to the property to photographically document each AML site and provide a general description of the workings. AML sites revealed through the USGS database are labeled with a waypoint number in Figure 3. AML sites discovered during field investigations are labeled Shaft 1 through Shaft 6 in Figure 3. Appendix B presents the USGS database entries for each AML site contained within the site as well as annotated photographs of all noted historic mine working sites.

Many of the AML sites present a negligible risk of mine subsidence hazards to the proposed Rosemont mine facilities. Other AML sites will require further investigations and possibly active engineered mitigation to reduce risks associated with mine subsidence. Possible mitigation efforts include backfilling, bridging, or complete avoidance of AML sites. Classifications of these mine workings, and the efforts necessary to reduce risks, should be handled during final design efforts.

4.3 Accelerated Erosion

The National Resources Conservation Service (NRCS) of the U.S. Department of Agriculture provides soils maps and soils classifications in an online database available at the following internet address: http://websoilsurvey.nrcs.usda.gov/app/. This database was searched in particular to evaluate potential soil erosion hazards as well as engineering, chemical, and physical characteristics of the mapped site soils. Specifically, the NRCS classifies soil erodibility with a K-factor. The K-factor is further subdivided into whole-rock and fine-earth fractions. The K-factor is a number on a scale from 0.02 to 0.69, with 0.69, generally speaking, indicating the highest potential for erosion. According to this scale, three divisions were made for categorizing soil erosion at the Project site, namely: 0.02 to 0.24 being low erosion potential; 0.25 to 0.47 being moderate erosion potential; and 0.48 to 0.69 being high erosion potential. If conflicting values for the whole-rock versus fine-earth K-factors were indicated, the larger of the two values was used to determine the hazard classification. Accelerated erosion is most likely during short intense periods of rainfall. Soil erosion due to wind is not a credible hazard at the Project site.

Figure 3 illustrates areas of low erosion potential, based on classifications by the NRCS and independent field observations by Tetra Tech engineering geologists. The remaining Project site is comprised of soils of moderate erosion potential. There are no areas of high erosion potential. K-factors assigned by the NRCS consider the soil and/or rock material in its natural state. Modifications to the natural soil and rock states due to construction activities may lead to
accelerated erosion of the native soils/rock. Accelerated erosion due to construction modifications can be prevented by active engineered controls of stormwater runoff, including but not limited to: silt fences surrounding active construction areas, erosion control blankets, and revegetation of disturbed areas during construction, surface water diversions around Project facilities, etc.

4.4 Seismic Hazard

The Arizona Department of Environmental Quality (ADEQ, 2004) has published guidelines for mining Project design criteria in a publication entitled “Arizona Mining Guidance Manual, BADCT.” This manual sets forth recommendations for minimum standard design criteria with the interest of protecting the groundwater aquifers in the State of Arizona. Accordingly, the BADCT manual recommends design criteria for seismic hazards as follows:

“The minimum design earthquake is the maximum probable earthquake (MPE). The MPE is defined as the maximum earthquake that is likely to occur during a 100-year interval (80% probability of not being exceeded in 100 years) and shall not be less than the maximum historical event. This design earthquake may apply to structures with a relatively short design life (e.g., 10 years) and minimum potential threat to human life or the environment.

Where human life is potentially threatened, the maximum credible earthquake (MCE) should be used. MCE is the maximum earthquake that appears capable of occurring under the presently known tectonic framework.”

In accordance with these recommendations, two distinct levels of ground motion are defined for the Project site: 1) the MPE, for heap leach pads, operational solution collection ponds, diversion ditches, etc. provided their useful life does not exceed 10 years; and, 2) the MCE for waste rock and tailings storage facilities.

A summary of Arizona seismicity and estimated Project ground motions is provided in Section 4.0 of this report.

4.5 Other Geologic Hazards

Soil material derived from clayey units of the Gila Conglomerate and the Bisbee Group may contain clays that on wetting can swell, causing damage to structures. Although the anticipated loadings from the proposed Rosemont mine facilities will be relatively large, foundation designs should be based on results of laboratory swell/consolidation testing.

Old, small earthen dams assumed to be used for livestock watering are scattered across the property. The area behind (upstream) of these dams may contain soft soils with significant organic material that on loading may prove susceptible to collapse and/or differential settlement.

Precambrian to Cenozoic bedrock units across the Project site may contain radioactive minerals that on decay may produce radon gas. The presence of radon gas in structures has been identified as a potential health risk. The evaluation of risk due to the natural occurrence of radon gas at this stage of investigation is beyond the scope of this report. In general, Tetra Tech believes the risk across the Project site is not unusually high and can be mitigated by monitoring and ventilation, if required, of any subsurface confined spaces. Additional consideration can be given to this potential problem once building sites have been selected.
Precambrian to Cenozoic bedrock units across the Project site are known to generate arsenic a naturally occurring element in rock and soil. The State of Arizona recognizes the presence of Arsenic in most of the groundwater aquifers statewide. If domestic water use is planned for the proposed Rosemont mine facilities, testing for unacceptable levels of Arsenic is required. The evaluation of risk due to unacceptable levels of Arsenic in drinking water wells is beyond the scope of this report. In general, Tetra Tech believes the risk across the Project site is not unusually high and can be mitigated by testing and monitoring, if required, of any developed drinking water wells. Additional consideration can be given to this potential problem once water well sites have been selected.

Although there are limestone units mapped in the western Project area, there is no visible evidence of karst terrain. Therefore, subsidence due to karst does not pose a credible risk to construction operations at the Project site.

The Project area is not located in any published flood zone. Furthermore, the general Project area is not contained in any mapped subsidence area. In Arizona, particularly in the southern half of the state, excessive groundwater pumping has resulted in depletion, or lowering, of the groundwater table. This lowering of the groundwater table in areas of high agricultural use or rapid population growth has resulted in consolidation of the alluvial materials present in the intermountain basins. Consolidation of particularly clayey zones in the groundwater aquifers manifests itself through ground subsidence and often earth fissures. The nearest potentially high subsidence area is west-northwest of the Project site on the western side of the Santa Rita mountain range and is part of the Tucson basin. The Tucson basin is a subdivision of the Santa Cruz river basin. The area containing the Rosemont site is not contained within the Tucson basin. In order to determine the risks associated with subsidence hazards, a site specific study evaluating well pumping rates and groundwater level drawdown is recommended. However, based on the available information to date, the relatively small areal extent of the basin containing the Rosemont site and the relative absence of population and agriculture in the general Project area, Tetra Tech considers the risk of hydraulic subsidence to be low at this time.

According to soil maps prepared by the National Resources Conservation Service of the U.S. Department of Agriculture most of the on-site soils contain low concentrations of soluble salts (i.e., calcareous and gypsiferous soils). However, soils derived from on-site limestone units contain as much as 40 to 60% calcium carbonate in the near surface soils. Soluble salts present deleterious effects to concrete; therefore, on-site materials should be evaluated for potential alkali-aggregate reaction. Soils with high soluble salt concentrations are also susceptible to collapse upon loading. Foundation designs should be guided by results of swell/consolidation laboratory testing.

Tetra Tech did not conduct an environmental assessment of the property. Accordingly, this report does not purport to address potential hazards or risks associated with environmental contamination from previous land uses.
5.0 SEISMIC HAZARD ANALYSIS

Seismic hazard analyses are typically conducted using one of two readily available methods: (1) probabilistic analysis or (2) deterministic analysis. Probabilistic analysis is commonly used in areas of diffuse historic seismicity where large regions of similar historic seismicity are assigned characteristic ground motions and associated probabilities of occurrence or non-exceedance. In these areas of low seismic activity, deterministic analyses tend to overestimate seismic risk, whereby the maximum credible earthquake is typically placed directly beneath the site resulting in overly conservative ground motions. Conversely, in areas of high seismic activity where the earthquakes occur in conjunction with known structures, deterministic analyses are usually more appropriate. Although the Project site is located in an area of relatively low seismic activity, development of ground motions associated with maximum credible earthquakes is required for design purposes. Probabilistic methods are incapable of producing MCE ground motions as there is no probability associated with a maximum credible earthquake. Accordingly, deterministic methods are necessary to develop all Project design ground motions.

There are four key elements to performing seismic hazard analyses for use in Project design, namely: (1) determination of seismogenic structures; (2) definition of associated earthquake magnitude; (3) the distance between the Project site and the seismogenic source, and; (4) selection of an appropriate attenuation function, or functions to estimate ground motions at the Project site. The following sections outline these key elements and discuss the assumptions and methodologies employed in determining each for the current study.

5.1 Arizona Historic Seismicity

Arizona earthquake history does not reflect the active tectonism seen in other parts of the Basin and Range physiographic province. The earthquake search area for this study was limited to a rectangular region enclosed by: upper latitude 37°N; lower latitude 31.3°N; eastern longitude 109°W; and western longitude 114.8°W. This rectangular area includes all of the State of Arizona but also includes small portions of northern Mexico, eastern California and southwestern Utah. Because Arizona is not defined by a perfect rectangle, greater accuracy was not practical. The historic record for Arizona indicates 366 recorded earthquakes in the nearly 68 year period from 30 January 1939 to the writing of this report. Of these 366 recorded earthquakes, 271 (74%) were below $M_W=4$. The majority of these earthquakes are confined to the north-northwestern part of the state along the boundary between the Mexican Highlands and Colorado Plateau section of the Basin and Range physiographic province. Figure 4 illustrates the locations of all recorded earthquakes in the State of Arizona since 1939 plus some supplemental earthquakes recorded just below the Arizona border with Mexico coincident with the area surrounding the Bavispe, Mexico earthquake.

The most notable event in the Arizona earthquake record is the 1887 Bavispe, Mexico earthquake located approximately 180 kilometers southwest of the Project site. This event reportedly caused great destruction near its epicenter. The towns of Nogales and Guaymas, Mexico, Benson and Tucson, Arizona, and even Albuquerque, New Mexico reported building damage related to this earthquake. The USGS estimates the magnitude of this earthquake at $M_W=7.4$ (Earthquake Information Bulletin, 1970) based on a Modified Mercalli Intensity (MMI) of XII at the epicenter. Felt reports in the region surrounding the site range from MMI=VII to VIII. Of particular interest are the published felt reports from St. David, Cochise County, Arizona (approximately 49 kilometers north-northeast of the Rosemont site) where it was reported that “Women and children ran into the streets screaming with terror, and great confusion prevailed…” and “…When we looked up we could see the house going one way and the
chimney going the other.” The town of St. David was assigned a similar Modified Mercalli Intensity as the area proposed for the site at MMI=VIII. Other nearby towns with similar reported Modified Mercalli Intensities due to the 1887 Bavispe, Mexico earthquake were Total Wreck, Arizona (reported MMI=VII) located approximately 7.5 kilometers northeast of the Rosemont site and Pantano, Arizona (reported MMI=VII) located approximately 25 kilometers northeast of the Rosemont mine site (DuBois, et al., 1982).

The largest earthquake to occur within the political borders of Arizona was the 21 July 1959 Fredonia, Arizona earthquake located near the Arizona-Utah border. Ground shaking from this event caused minor building damage in Fredonia, Arizona and Kanab, Utah. Furthermore, a rockslide was triggered at Mather Point in the Grand Canyon. The USGS has assigned $M_w=5.6$ and a Modified Mercalli Intensity VI to this event (Stover and Coffman, 1993).

### 5.2 Earthquake Catalog

The seismic hazard evaluation developed for use in design of critical structures at the Project site included a review of historic earthquake records from the United States Geological Survey (USGS) seismic hazard program for the entire Western United States (WUS). The catalog compiled by the USGS was used for the current study because it is a refined earthquake catalog. For their study the USGS removed repeat occurrences from different reporting stations as well as aftershocks and foreshocks related to the primary earthquake events. The entire WUS earthquake catalog contains 2,937 historic seismic events over the period from 1749 through December 2001 for the entire region. The WUS earthquake database was searched within a 200 kilometer target radius around the Project site. This refined, project specific, search adopted the central location coordinates of 31.83°N latitude and 110.73°W longitude.

Since the USGS study was completed in 2002 their earthquake database does not have any earthquake information more recent than 2001. In order to supplement the WUS catalog a search of the National Earthquake Information Center database, also maintained by the USGS, was searched for a 200 kilometer radius surrounding the Project site for the period January 1, 2002 to May 7, 2007. This supplemental search resulted in no additional earthquakes. Results of the Project specific WUS database search, defined as the project earthquake catalog, are presented as Table 5.1.

### Table 5.1: Project Site Earthquake Catalog

(data from USGS NEIC database, site coordinates: 31.83°N, 110.73°W, search radius=200 km)

<table>
<thead>
<tr>
<th>Mag. ($M_w$)</th>
<th>Long. (deg. E)</th>
<th>Lat. (deg. N)</th>
<th>Distance (km)</th>
<th>Depth (km)</th>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Catalog</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.4</td>
<td>-109.25</td>
<td>30.8</td>
<td>181.40</td>
<td>0</td>
<td>1887</td>
<td>5</td>
<td>3</td>
<td>USHIS\par</td>
</tr>
<tr>
<td>4.7</td>
<td>-112.5</td>
<td>32.4</td>
<td>178.23</td>
<td>0</td>
<td>1961</td>
<td>6</td>
<td>18</td>
<td>USHIS\par</td>
</tr>
<tr>
<td>4.1</td>
<td>-110.7</td>
<td>33.2</td>
<td>152.46</td>
<td>33</td>
<td>1963</td>
<td>9</td>
<td>11</td>
<td>SRA\par</td>
</tr>
<tr>
<td>4.4</td>
<td>-111.4</td>
<td>32.2</td>
<td>75.31</td>
<td>33</td>
<td>1965</td>
<td>3</td>
<td>13</td>
<td>SRA\par</td>
</tr>
<tr>
<td>4.1</td>
<td>-112.7</td>
<td>31.8</td>
<td>186.01</td>
<td>33</td>
<td>1965</td>
<td>11</td>
<td>26</td>
<td>PDE\par</td>
</tr>
<tr>
<td>4.4</td>
<td>-110.6</td>
<td>33.4</td>
<td>175.10</td>
<td>15</td>
<td>1969</td>
<td>12</td>
<td>25</td>
<td>USHIS\par</td>
</tr>
<tr>
<td>4.5*</td>
<td>-110.49</td>
<td>32.75</td>
<td>104.88</td>
<td>0</td>
<td>1972</td>
<td>3</td>
<td>9</td>
<td>PDE\par</td>
</tr>
<tr>
<td>4.4</td>
<td>-109.23</td>
<td>31.02</td>
<td>168.52</td>
<td>5</td>
<td>1977</td>
<td>6</td>
<td>8</td>
<td>PDE\par</td>
</tr>
<tr>
<td>4.2</td>
<td>-109.33</td>
<td>30.77</td>
<td>177.20</td>
<td>5</td>
<td>1988</td>
<td>6</td>
<td>11</td>
<td>PDE\par</td>
</tr>
<tr>
<td>4.4</td>
<td>-109.33</td>
<td>30.85</td>
<td>172.11</td>
<td>5</td>
<td>1989</td>
<td>5</td>
<td>25</td>
<td>PDE\par</td>
</tr>
<tr>
<td>4.5</td>
<td>-110.75</td>
<td>30.75</td>
<td>119.90</td>
<td>5</td>
<td>1999</td>
<td>10</td>
<td>16</td>
<td>PDE\par</td>
</tr>
</tbody>
</table>

*Note: this event was not contained in the WUS catalog but was found in the site specific search.*
Based on the project earthquake catalog, a total of 11 seismic events have been recorded within a 200 kilometer radius of the site above a threshold magnitude of $M \geq 4$, all of which have either measured or estimated magnitude values. The largest earthquake in the 200 kilometer record, the Bavispe, Mexico earthquake occurred on 3 May 1887 with a reported moment magnitude ($M_w$) of 7.4. The search radius would need to be expanded to greater than 700 km to produce an historic earthquake with a magnitude equal to or greater than the $M_w = 7.4$, Bavispe, Mexico earthquake. Earthquakes occurring at these great distances are unlikely to control design considerations. Figure 5 presents the Project location and locations of historic earthquakes recorded within the 200 kilometer radius Project area.

### 5.3 Seismic Sources

Assessment of seismic hazards for the Project site requires consideration of potential earthquake source zones, either identifiable seismogenic faults or fault zones with common seismogenic characteristics. Once source zones have been identified, maximum earthquakes can be assigned based on synthesis of geologic and seismologic data. In the following sections, specific fault sources and a probable background event are identified. These seismogenic sources are considered in site specific seismic hazards analysis. Considering there are numerous Quaternary active faults in the State of Arizona and surrounding states, and ground motions resulting from earthquakes with source-to-site distances greater than about 200 kilometers are relatively small, the study area for this hazard assessment was restricted to those faults lying within 200 kilometers of the site.

#### 5.3.1 Active Faults

The USGS reports Quaternary active faults as faults that displace Quaternary (younger than about 1.6 million years) sediments. The State of Arizona has defined an active fault as one having shown evidence of movement during the current geologic setting or the last 35,000 years. Where fault specific studies have been completed, the USGS further defines the age of activity, typically with a maximum age of most recent movement. In 1992 the Arizona Department of Transportation completed a seismic hazards study for the State of Arizona (Euge and Lam, 1992). For this study the authors subdivided the Quaternary into five units as follows: late to mid Holocene, younger than 5,000 years before present time (yBP); early Holocene to latest Pleistocene, between 5,000 and 20,000 yBP; late Pleistocene, 20,000 to 150,000 yBP; mid Pleistocene, between 150,000 and 700,000 yBP; and, late Quaternary undifferentiated, less than 500,000 yBP. Tetra Tech believes these age definitions to be appropriate for use in the present study and has accordingly adopted these age ranges. An obvious problem is the considerable span of the time represented by the late Pleistocene; since the Arizona definition of active (35,000 years or younger) falls in the lower part of the age range. As a conservative approach to the current analysis, any fault that has shown to have or is suspected of having ruptured within the late Pleistocene age, or younger, is considered active.

Based on regional seismological assessment studies completed, several hundred faults, considered active, were included in the 2002 update to the USGS seismic hazard mapping program. Twenty seven (27) of these faults lie within the 200 kilometer target radius surrounding the site. Table 5.2 lists the 27 Quaternary faults listed in the USGS Quaternary Fault and Fold database within the 200 kilometer target radius surrounding the Project site. Graphical representation of these faults is also illustrated in Figure 5.
### Table 5.2: Quaternary Faults Within 200 km of the Project Site
(data from USGS Quaternary Fault and Fold Database)

<table>
<thead>
<tr>
<th>Fault Source</th>
<th>USGS Quaternary Fault DB ID</th>
<th>Length (km)</th>
<th>Sense of Movement</th>
<th>Age of Latest Rupture(^3)</th>
<th>Closest Horizontal Distance to Fault (km)(^1)</th>
<th>MCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washburn Ranch fault zone</td>
<td>2092</td>
<td>12</td>
<td>Normal</td>
<td>H</td>
<td>172.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Safford fault zone, northern section</td>
<td>936a</td>
<td>15</td>
<td>Normal</td>
<td>H</td>
<td>129.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Safford fault zone, southern section</td>
<td>936b</td>
<td>16</td>
<td>Normal</td>
<td>H</td>
<td>129.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Animas Valley faults</td>
<td>2093</td>
<td>20</td>
<td>Normal</td>
<td>H</td>
<td>173.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Gillespie Mountain fault</td>
<td>2096</td>
<td>22</td>
<td>Normal</td>
<td>H</td>
<td>180.9</td>
<td>6.6</td>
</tr>
<tr>
<td>Pitaycachi fault</td>
<td>MX-126</td>
<td>128</td>
<td>Normal</td>
<td>H</td>
<td>158.2</td>
<td>7.5</td>
</tr>
<tr>
<td>Pearson Mesa faults</td>
<td>2091</td>
<td>5</td>
<td>Normal</td>
<td>L</td>
<td>184.3</td>
<td>5.9</td>
</tr>
<tr>
<td>California Wash fold and faults</td>
<td>933</td>
<td>6</td>
<td>Normal</td>
<td>L</td>
<td>43.7</td>
<td>6.0</td>
</tr>
<tr>
<td>Rimrock fault</td>
<td>2090</td>
<td>8</td>
<td>Normal</td>
<td>L</td>
<td>181.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Santa Rita fault zone</td>
<td>934</td>
<td>52</td>
<td>Normal</td>
<td>L</td>
<td>11.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Lang Canyon fault</td>
<td>2025</td>
<td>1</td>
<td>Normal</td>
<td>M</td>
<td>181.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Buena Vista fault</td>
<td>938</td>
<td>4</td>
<td>Normal</td>
<td>M</td>
<td>153.5</td>
<td>5.8</td>
</tr>
<tr>
<td>South Swisshelm fault</td>
<td>930</td>
<td>8</td>
<td>Normal</td>
<td>M</td>
<td>116.7</td>
<td>6.1</td>
</tr>
<tr>
<td>Unnamed faults west of the Pyramid Mountains</td>
<td>2097</td>
<td>17</td>
<td>Normal</td>
<td>M</td>
<td>173.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Gray Ranch fault zone</td>
<td>2095</td>
<td>20</td>
<td>Normal</td>
<td>M</td>
<td>176.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Huachucha fault zone</td>
<td>932</td>
<td>25</td>
<td>Normal</td>
<td>M</td>
<td>63.3</td>
<td>6.7</td>
</tr>
<tr>
<td>Pedregosa fault</td>
<td>928</td>
<td>26</td>
<td>Normal</td>
<td>M</td>
<td>134.9</td>
<td>6.7</td>
</tr>
<tr>
<td>Chiricahua fault zone</td>
<td>929</td>
<td>28</td>
<td>Normal</td>
<td>M</td>
<td>153.5</td>
<td>6.8</td>
</tr>
<tr>
<td>Cactus Flats faults</td>
<td>937</td>
<td>9</td>
<td>Normal</td>
<td>M/E</td>
<td>142.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Guadalupe Canyon fault</td>
<td>926</td>
<td>5</td>
<td>Normal</td>
<td>E</td>
<td>166.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Joe Glenn Ranch faults</td>
<td>1021</td>
<td>7</td>
<td>Normal</td>
<td>E</td>
<td>132.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Outlaw Mountain fault</td>
<td>942</td>
<td>11</td>
<td>Normal</td>
<td>E</td>
<td>145.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Bunk Robinson Peak fault zone</td>
<td>927</td>
<td>14</td>
<td>Normal</td>
<td>E</td>
<td>158.0</td>
<td>6.4</td>
</tr>
<tr>
<td>North Swisshelm fault</td>
<td>931</td>
<td>18</td>
<td>Normal</td>
<td>E</td>
<td>112.8</td>
<td>6.5</td>
</tr>
<tr>
<td>Clifton faults</td>
<td>939</td>
<td>14</td>
<td>Normal</td>
<td>Q</td>
<td>181.6</td>
<td>6.4</td>
</tr>
<tr>
<td>Little Rincon Mountains fault</td>
<td>935</td>
<td>17</td>
<td>Normal</td>
<td>Q</td>
<td>56.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Whittick Wash fault</td>
<td>940</td>
<td>23</td>
<td>Normal</td>
<td>Q</td>
<td>92.4</td>
<td>6.7</td>
</tr>
<tr>
<td>Basin and Range Background Event</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.0</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1) Site to Source Distances in Red dip toward the site.
2) Safford fault zones (northern and southern sections) were combined into one 31km continuous rupture surface for conservatism.
3) **Age of Latest Rupture**
   
   - **H** - Holocene to latest Pleistocene (less than 0.02 myBP)
   - **L** - late Pleistocene (0.02 to 0.15 myBP)
   - **M** - mid Pleistocene (0.15 to 0.7 myBP)
   - **E** - early Pleistocene (0.7 to 1.6 myBP)
   - **Q** - Quaternary undifferentiated (less than 1.6 myBP)
Table 5.2 indicates that only nine of the 27 USGS Quaternary active faults have experienced movement, or are suspected of having ruptured more recently than the late Pleistocene. Therefore, the nine faults in highlighted text, plus the background event, were considered active according to the Arizona definition and for the purposes of estimating design ground motions for the Project site.

5.3.2 Background Event

Based on a review of the western United States earthquake catalog and resultant earthquake surface ruptures, dePolo (1994) established a maximum background earthquake for the Basin and Range physiographic province. This review evaluated the size of earthquakes occurring in the province that did not result in significant surface rupture versus those that resulted in surface rupture. In accordance with this research dePolo (1994) established a maximum background earthquake for the Basin and Range physiographic province at a value of $M_W=6.5$ and at a hypocentral depth of 15 km. This background, or floating, earthquake was assigned for consideration in the current seismic hazard analysis.

5.4 Attenuation Relations

Seismic hazard analyses require an attenuation relationship or a combination of weighted attenuation relationships in order to produce estimated ground motions for use in Project design. Due to the absence of abundant strong ground motion records, no specific attenuation relation(s) exist solely for Arizona; thus, attenuation relations from other areas must be considered and adopted for use at the Project site. Most recently published applicable attenuation relations are based on strong ground motion records from shallow focus California earthquakes. In general, these attenuation relations are applicable to western North America (Boore and others, 1997), including Nevada.

For the purposes of this study, five attenuation relationships were selected similar to those adopted by the USGS for the western United States in their 2002 update of the National Seismic Hazard Mapping program. The attenuation relationships, namely: Boore, et al. (1997); Sadigh, et al. (1997); Abrahamson and Silva (1997); Spudich, et al. (1999); and, Campbell and Bozorgnia (2003) were used to derive horizontal ground motion relations for peak ground acceleration and 5%-damped pseudo-acceleration response spectra. Generally, the authors advise that using their relations for source-to-site distances, $d$, of $d > 100$ km will overestimate ground motions. However, based on the site specific analysis, extending the study region out to 200 km to include the majority of regional active sources does not produce controlling ground motions. Furthermore, increased estimated ground motions generated due to extending the site-to-source distance beyond 100 km will only produce more conservative results.

Additionally, it should be noted the Spudich, et al. (1999) attenuation relation directly estimates peak ground acceleration (PGA) and pseudo-velocity response spectra (PSV). The remaining four attenuation relations used provided equations for estimating PGA and pseudo-acceleration response spectra (PSA) values at varying periods directly. Using the Spudich, et al. (1999) relations, pseudo-acceleration response spectral values for various periods or interest were derived using the following relationship:
Illustration 5.2 shows numerous earthquake records with an assigned focal depth of zero meters. Based on the data presented in Illustrations 5.1 and 5.2, a focal depth of 15 kilometers has been assigned to all active faults for the seismic hazard analysis presented herein. This results in placing the contributing earthquake closer to the site for faults dipping toward the site. Therefore, the analysis is conservative.

In order to determine the appropriate source-to-site distance for several of the applicable attenuation functions, the focal depth of the potential earthquake source must be considered. The majority of the earthquakes in the historic record has focal depths less than 15 kilometers (as presented in Illustration 5.1 for the entire WUS catalog) or have not been assigned focal depths at all (as presented in Illustration 5.2 for the Project area).

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The sense of movement is determined based on literature research and knowledge of the general tectonic framework of the Project physiographic and tectonic region. Additionally, whether the site lies on the hanging wall or footwall can be readily determined based on the location of the site with respect to the contributing fault and the dip direction of the fault. The average shear wave velocity in the upper 30 meters of the soil and bedrock profile was derived from site specific seismic refraction studies completed during the geotechnical investigations. According to these studies, the average shear wave velocity in the upper 30 meters is 618 meters per second corresponding to a National Earthquake Hazards Reduction Program (NEHRP) Site Class C, or a general rock site classification.

Each of the attenuation relations used in the current seismic hazard analysis requires specific fault parameters, namely: magnitude of earthquake; site to source distance (which varies by attenuation function); average shear wave velocity in the upper 30 meters of the foundation materials; sense of fault movement, i.e., normal, reverse or strike-slip; and, whether the site lies on the hanging wall or foot wall, in the case of normal or reverse faults. For each of the nine potentially contributing faults, plus the background event, a characteristic or maximum credible earthquake can be estimated using empirical relationships considering the known fault length. Maximum credible earthquakes for each of the nine active faults, as indicated in Table 5.2, were developed using the empirical relationship between fault length and maximum credible earthquake developed by Wells and Coppersmith (1994).

The sense of movement is determined based on literature research and knowledge of the general tectonic framework of the Project physiographic and tectonic region. Additionally, whether the site lies on the hanging wall or footwall can be readily determined based on the location of the site with respect to the contributing fault and the dip direction of the fault. The average shear wave velocity in the upper 30 meters of the soil and bedrock profile was derived from site specific seismic refraction studies completed during the geotechnical investigations. According to these studies, the average shear wave velocity in the upper 30 meters is 618 meters per second corresponding to a National Earthquake Hazards Reduction Program (NEHRP) Site Class C, or a general rock site classification.

In order to determine the appropriate source-to-site distance for several of the applicable attenuation functions, the focal depth of the potential earthquake source must be considered. The majority of the earthquakes in the historic record has focal depths less than 15 kilometers (as presented in Illustration 5.1 for the entire WUS catalog) or have not been assigned focal depths at all (as presented in Illustration 5.2 for the Project area).

Illustration 5.2 shows numerous earthquake records with an assigned focal depth of zero meters. Based on the data presented in Illustrations 5.1 and 5.2, a focal depth of 15 kilometers has been assigned to all active faults for the seismic hazard analysis presented herein. This results in placing the contributing earthquake closer to the site for faults dipping toward the site. Therefore, the analysis is conservative.

$$\frac{T}{2\pi} SA = SV = \frac{2\pi}{T} SD$$, where

- $T$ = period
- $SA$ = spectral acceleration
- $SV$ = spectral velocity; and,
- $SD$ = spectral displacement.
Illustration 5.1: Focal Depth of Earthquakes (Entire WUS Catalog)

- 57.1% of all events in WUS Catalog occur above 15 km depth.
- 86.2% of all events in WUS Catalog occur above 15 km depth.
Illustration 5.2: Focal Depth of Earthquakes (within 200 km of Project site)
5.5 Peak Ground Acceleration

The primary result of seismic hazard analysis is an estimate of peak ground acceleration (PGA) that can be expected at the site given the various geological and seismological parameters. Table 5.3 presents a comparison of estimates of PGA for all 27 potentially contributing fault sources within the 200 kilometer radius of the Project site using the attenuation functions described previously. All PGA estimates presented in Table 5.4 are for the mean value established by the respective attenuation function.

Table 5.3 indicates the attenuation functions considered resulted in a relatively narrow range of PGA estimates. Additionally, it can be seen in Table 5.3 that the faults with latest rupture ages older than the late Pleistocene do not produce controlling ground motions, so exclusion of these faults from the current study would not have produced inaccurate results. The maximum ground acceleration expected at the Project site is 0.326g associated with a maximum credible earthquake on the Santa Rita fault zone, as indicated in Table 5.3. Accordingly, the MCE design peak ground acceleration (PGA) equals 0.326g.

For determining the Project design MPE, careful consideration of the definition is necessary. Again the Arizona BADCT regulation defines the MPE accordingly:

“The minimum design earthquake is the maximum probable earthquake (MPE). The MPE is defined as the maximum earthquake that is likely to occur during a 100-year interval (80% probability of not being exceeded in 100 years) and shall not be less than the maximum historical event....”

This definition may be misleading since it could be interpreted that the MPE is the larger of the maximum historical event or one having a return period of 100 years. However, Tetra Tech interprets this definition to require the larger of the maximum historical event or one having a return period of approximately 448 years, corresponding to the 80% probability of non-exceedance event in 100 years. In order to determine the 448 year return period event, the USGS NEHRP program was researched. The USGS provided seismic hazard curves for all sites in the conterminous United States on a 0.1 x 0.1 degree grid (of longitude and latitude). Illustration 5.3 presents the seismic hazard curve for the Project site.

The plot of the seismic hazard curve for the proposed site indicates that the 80% probability of non-exceedance event in 100 years corresponds to a peak ground acceleration at the site of 0.045g. In comparison, the largest earthquake ground motion recorded in the Project area was associated with the 1887 Bavispe, Mexico event. The estimates of peak ground acceleration presented in Table 5.3 indicate that this event would result in an acceleration of 0.036g. Therefore, the design MPE for the Project site would be the greater of these two accelerations or 0.045g.
### Table 5.3: Estimates of Peak Ground Acceleration

(All Quaternary Faults within 200 km of the Project site)

<table>
<thead>
<tr>
<th>Source Characteristics</th>
<th>Estimates of PGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washburn Ranch fault zone</td>
<td>2092</td>
</tr>
<tr>
<td>Safford fault zone, northern section</td>
<td>936a</td>
</tr>
<tr>
<td>Safford fault zone, southern section</td>
<td>936b</td>
</tr>
<tr>
<td>Animas Valley faults</td>
<td>2093</td>
</tr>
<tr>
<td>Gillespie Mountain fault</td>
<td>2096</td>
</tr>
<tr>
<td>Pitaycachi fault</td>
<td>MX-126</td>
</tr>
<tr>
<td>Pearson Mesa faults</td>
<td>2091</td>
</tr>
<tr>
<td>California Wash fold and faults</td>
<td>933</td>
</tr>
<tr>
<td>Rinrock fault</td>
<td>2090</td>
</tr>
<tr>
<td>Santa Rita fault zone</td>
<td>934</td>
</tr>
<tr>
<td>Lang Canyon fault</td>
<td>2025</td>
</tr>
<tr>
<td>Buena Vista fault</td>
<td>938</td>
</tr>
<tr>
<td>South Swisshelm fault</td>
<td>930</td>
</tr>
<tr>
<td>Unnamed faults west of the Pyramid Mountains</td>
<td>2097</td>
</tr>
<tr>
<td>Gray Ranch fault zone</td>
<td>2095</td>
</tr>
<tr>
<td>Huachuca fault zone</td>
<td>932</td>
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<td>Pedregosa fault</td>
<td>929</td>
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<tr>
<td>Chiricahua fault zone</td>
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</tr>
<tr>
<td>Cactus Flats faults</td>
<td>937</td>
</tr>
<tr>
<td>Guadalupe Canyon fault</td>
<td>926</td>
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<tr>
<td>Joe Glenn Ranch faults</td>
<td>1021</td>
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<tr>
<td>Outlaw Mountain fault</td>
<td>942</td>
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<tr>
<td>Bunk Robinson Peak fault zone</td>
<td>927</td>
</tr>
<tr>
<td>North Swisshelm fault</td>
<td>931</td>
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<tr>
<td>Clifton faults</td>
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<tr>
<td>Little Rincon Mountains fault</td>
<td>935</td>
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<tr>
<td>Whitlock Wash fault</td>
<td>940</td>
</tr>
<tr>
<td>Basin and Range Background Event</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Notes:
1) Site to Source Distances in Red dip toward the site.
2) Composite PGA considers all 5 equally weighted attenuation relations.
3) Safford fault zones (northern and southern sections) were combined into one 31km continuous rupture surface for conservatism.
4) Age of Latest Rupture
   - H - Holocene to latest Pleistocene (less than 0.02 myBP)
   - L - late Pleistocene (0.02 to 0.15 myBP)
   - M - mid Pleistocene (0.15 to 0.7 myBP)
   - E - early Pleistocene (0.7 to 1.6 myBP)
   - Q - Quaternary undifferentiated (less than 1.6 myBP)
5) The estimated peak ground acceleration for the Pitaycachi fault represents the greatest historical ground motion.
Illustration 5.3: Project Site Seismic Hazard Curve (from the USGS)

5.6 Response Spectra

Using the peak horizontal ground acceleration for the Project site developed in the preceding sections, pseudo-acceleration response spectra were calculated for 0 seconds (PGA) to 2.0 seconds at 5% damping using the five equally weighted attenuation relationships described in Section 5.4. Illustration 5.4 shows a simplified smoothed pseudo-acceleration response spectra for the MCE and MPE design ground motions, suitable for design of critical structures at the proposed Rosemont mine site. Table 5.4 presents the key parameters of the simplified smoothed pseudo-acceleration response spectra.

Table 5.4: Key Parameters Simplified Smoothed Pseudo-Acceleration Response Spectra

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MCE Design Ground Motion</th>
<th>Parameter</th>
<th>MPE Design Ground Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGA</td>
<td>0.328g</td>
<td>PGA</td>
<td>0.0450g</td>
</tr>
<tr>
<td>SAmx</td>
<td>762 cm/s2</td>
<td>SDS</td>
<td>0.0816g</td>
</tr>
<tr>
<td>SVMx</td>
<td>65.8 cm/s</td>
<td>SD1</td>
<td>0.0317g</td>
</tr>
<tr>
<td>SDmax</td>
<td>20.5 cm</td>
<td>TO</td>
<td>0.0778 sec</td>
</tr>
<tr>
<td>T3</td>
<td>0.54 sec</td>
<td>TS</td>
<td>0.389 sec</td>
</tr>
<tr>
<td>T4</td>
<td>1.96 sec</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Illustration 5.4: Simplified Smoothed Pseudo-Acceleration Response Spectra

<table>
<thead>
<tr>
<th></th>
<th>DS</th>
<th>18.2 sec</th>
</tr>
</thead>
</table>

5.6.1 Time Histories

Results of deterministic seismic hazard analysis as presented in this report may be used in several ways. For example, pseudostatic-type analysis for slope stability modeling will typically use 50 to 80% of the value of the peak ground acceleration to represent average sustained loading conditions. This straightforward approach requires no further analysis other than determination of the appropriate seismic coefficient. For pseudostatic analyses for the Rosemont site, the pseudostatic coefficient has been set at 2/3 of the peak ground acceleration. For dynamic analysis of structures, such as buildings or high-risk earthen embankments, a more rigorous approach requiring earthquake acceleration time histories is required. Earthquake acceleration time histories may be generated synthetically or integrated using actual records or historic ground motions recorded at strong ground motion stations. For dynamic analysis at the Project site time histories will need to be developed, as needed, for the final design effort.
6.0 CONCLUSIONS

Based on the preceding report discussions, Tetra Tech offers the following conclusions:

1) Proposed facilities at the Rosemont site will mantle numerous bedrock and surficial deposits. The engineering properties of these differing surface and subsurface units may vary markedly, leading to the potential for differential settlements beneath structures.

2) High risk rockfall hazards exist in the western areas of the Project site. Based on Project plans developed to date, the proposed open pit will cross through the boundary of the rockfall hazard area. Constructing this facility will undoubtedly change the existing natural conditions and require engineering mitigations.

3) The Project site and the general Project area have been the subject of historic mining activities. Prior mining activities range from simple, shallow prospector borrow pits no more that a few feet in diameter and several feet in depth to well developed mine adits that extend tens of feet or more into the subsurface. Additionally, one slag deposit and an historic ore leaching tank exist on the Project site. Many of the AML sites present negligible risks of mine subsidence hazards to the proposed Rosemont mine facilities. Other AML sites will require further investigation and possibly active engineered mitigation to reduce risks associated with mine subsidence.

4) Figure 3 illustrates areas of low erosion potential. The remaining Project site comprises soils of moderate erosion potential. There are no areas of high erosion potential. Modifications to the natural soil and rock due to construction activities may lead to accelerated erosion of the native soils/rock. Accelerated erosion due to construction modifications can be prevented by active engineered controls of stormwater runoff, including but not limited to: silt fences surrounding active construction areas, erosion control blankets and re-vegetation of disturbed areas during construction, surface water diversions around Project facilities, etc.

5) Seismic hazards for the Project site are defined by the MPE and the MCE design events and correlated to specific engineered structures based on the level of risk and life of a particular facility. The MPE=0.045g and the MCE=0.326g. Simplified, smoothed pseudo-acceleration response spectra are provided in the text.

6) Soil material derived from clayey units of the Gila Conglomerate and the Bisbee Group may contain clays that on wetting can swell, causing damage to structures.

7) Old, small earthen dams assumed to be used for livestock watering are scattered across the property. The area behind (upstream) these dams may contain soft soils with significant organic material that on loading may prove susceptible to collapse and/or differential settlement.

8) Precambrian to Cenozoic bedrock units across the Project site may contain radioactive minerals that on decay may produce radon gas. Tetra Tech believes the risk across the Project site is not unusually high and can be mitigated by monitoring and ventilation, if required, of any subsurface confined spaces.

9) Precambrian to Cenozoic bedrock units across the Project site are known to generate Arsenic a naturally occurring element in rock and soil. Tetra Tech believes the risk across the site is not unusually high and can be mitigated by testing and monitoring, if required, of any developed drinking water wells.
10) Although there are limestone units mapped in the western Project area, there is no visible evidence of karst terrain. Therefore, subsidence due to karst does not pose a credible risk to construction operations at the site.

11) The Project area is not located in any published flood zone.

12) The general Project area is not contained in any mapped subsidence area. At this time, Tetra Tech considers the risk of hydraulic subsidence to be low.

13) Most of the on-site soils contain low concentrations of soluble salts (i.e., calcareous and gypsiferous soils). Soils with high soluble salt concentrations are susceptible to collapse upon loading.
7.0 RECOMMENDATIONS

1) Site-specific engineering designs and rockfall mitigation measures will be necessary to ensure the safety of both infrastructure and personnel in mapped rockfall areas. Slope stability studies and, where appropriate, rockfall stability analyses should be completed for structures proposed in the rockfall hazard area.

2) Site specific engineering designs and mitigation measures should be developed to control the flow of surface water.

3) Although the anticipated loadings from the proposed Rosemont mine facilities will be relatively large, foundation designs should be based on results of laboratory swell/consolidation testing.

4) If proposed development plans change from those presented by Tetra Tech in this June 2007 report, a representative of Tetra Tech should be contacted to review the changes in light of the conclusions and recommendations presented.

5) If dynamic analyses of structures for the proposed Rosemont mine are determined to be necessary, site specific time histories will need to be developed for the MPE and MCE design ground motions.
8.0 GENERAL INFORMATION

Information contained within this report is intended to provide an assessment of geological conditions for the Project site. The report is based on review of geologic literature, limited field investigations and our general understanding of geologic processes in the Project area. Variations can and do occur in geological materials, and departures from conditions presented in this report are possible. The conclusions and recommendations presented herein are within the limits described by the State of Arizona and have been prepared in accordance with generally accepted professional engineering principles and practices.
9.0 REFERENCES


FIGURES
APPENDIX A

PHOTOGRAPHS OF ROCKFALL HAZARD AREAS
INDEX OF PHOTOGRAPHS

1. Typical rockfall hazard area (in background of photo) along the western boundary of the site. This photo shows the Gunsight Pass area.

2. Typical rockfall hazard area along the western boundary of the site. The rock outcroppings to the right and at the top of the photo are source zones, while the talus deposit (center of photo) and the loose rocks on the surface represent rockfall deposits.

3. Close-up of a talus deposit along the western site boundary.

4. Typical rockfall in a steeply incised canyon. This type of rockfall occurs where steep rock outcrops exist along the alluvial valleys used as roadways. This photo was taken in the valley to the north of the slag pile and east of the pit area.

5. Rockfall area in a steeply incised valley southeast of the pit area. At this location, there is no road at the bottom of the valley as pictured in the previous photo.
1. Typical rockfall hazard area (in background of photo) along the western boundary of the site. This photo shows the Gunsight Pass area.

2. Typical rockfall hazard area along the western boundary of the site. The rock outcroppings to the right and at the top of the photo are source zones, while the talus deposit (center of photo) and the loose rocks on the surface represent rockfall deposits.
3. Close-up of a talus deposit along the western site boundary.
4. Typical rockfall in a steeply incised canyon. This type of rockfall occurs where steep rock outcrops exist along the alluvial valleys used as roadways. This photo was taken in the valley to the north of the slag pile and east of the pit area.
5. Rockfall area in a steeply incised valley southeast of the pit area. At this location, there is no road at the bottom of the valley as pictured in the previous photo.
APPENDIX B

HISTORIC MINING AREAS
INDEX

IMG_1335
IMG_1336
IMG_1337
IMG_1338
IMG_1339
IMG_1340
IMG_1341
IMG_1342
IMG_1344
IMG_1345
IMG_1346
IMG_1347
IMG_1348
IMG_1349
IMG_1350
IMG_1351
IMG_1352
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IMG_1360
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IMG_1363
IMG_1366
IMG_1367
IMG_1368
IMG_1370
IMG_1371
IMG_1372
IMG_1373
IMG_1374
IMG_1376
IMG_1377
IMG_1380
IMG_1382
IMG_1383
Waypoint 2
Sweet Bye and Bye Mine. Small 4’x4’x12’ cut (adit) in N wall of Arroyo. Not visible from above. No or minimal dumps.
Waypoint 2
Sweet Bye and Bye Mine. Small 4’x4’x12’ cut (adit) in N wall of Arroyo. Not visible from above. No or minimal dumps.

Waypoint 3
Graded terrace 50’x50’ due W of Sweet Bye and Bye Mine.
Waypoint 2
(Just above and W) looking E Showing Arroyo. Workings are concealed at bottom left center photo

Waypoint 4
Pickwick Prospect??? Uncertain. Appears to be series of three 10'x20' cuts into arkose at North side of Arroyo. No or minimal dumps, gravel size arkose.
Waypoint 4

Pickwick Prospect??? Uncertain. Appears to be series of three 10'x20' cuts into arkose at North side of Arroyo. No or minimal dumps, gravel size arkose.
Helvetia East. Same coordinates as Augusta DDH 2054. Site disturbance from drilling makes old workings identification difficult. Possible cuts into N wall and possible dumps in wash (mod to well sorted arkose gravel). Large detention basin w/water is 75’ S
Waypoint 5

Helvetia East. Same coordinates as Augusta DDH 2054. Site disturbance from drilling makes old workings identification difficult. Possible cuts into N wall and possible dumps in wash (mod to well sorted arkose gravel). Large detention basin w/water is 75’ S
Waypoint 5

Helvetia East. Same coordinates as Augusta DDH 2054. Site disturbance from drilling makes old workings identification difficult. Possible cuts into N wall and possible dumps in wash (mod to well sorted arkose gravel). Large detention basin w/water is 75’ S
Waypoint 5

Helvetia East. Same coordinates as Augusta DDH 2054. Site disturbance from drilling makes old workings identification difficult. Possible cuts into N wall and possible dumps in wash (mod to well sorted arkose gravel). Large detention basin w/water is 75’ S

Waypoint 6

East Helvetia Deposit. Small cut along vein trending NE. Leads to three terraces below, largest is 50’x200’ (Waypoint 7). Fair amount of gravel size dumps composing terraces. Lowest terrace is location of Augusta DDH AR-2044.
Waypoint 6
East Helvetia Deposit. Small cut along vein trending NE. Leads to three terraces below, largest is 50’x200’ (Waypoint 7). Fair amount of gravel size dumps composing terraces. Lowest terrace is location of Augusta DDH AR-2044.

Waypoint 7
Close-up
Waypoint 6

East Helvetia Deposit. Small cut along vein trending NE. Leads to three terraces below, largest is 50’x200’ (Waypoint 7). Fair amount of gravel size dumps composing terraces. Lowest terrace is location of Augusta DDH AR-2044.
Waypoint 6

East Helvetia Deposit. Small cut along vein trending NE. Leads to three terraces below, largest is 50'x200' (Waypoint 7). Fair amount of gravel size dumps composing terraces. Lowest terrace is location of Augusta DDH AR-2044.
Location (all identical) given for eighteen old workings. Little evidence of workings preserved. No shafts, adits, or evident dumps observed. Reclaimed or likely exact location was unknown and section center used. Very close to leaching tank (Waypoint 34). Abundant gravel size arkose, mod to well sorted suggesting possible dumps.
Location listed looking W for 18 of the old workings.

Waypoint 9
Unknown workings. Shaft 5'x5'x30' S side of arroyo. Possible adit trending N, partially backfilled (debris). No evident dumps.
Waypoint 9
Unknown workings. Shaft 5'x5'x30' S side of arroyo. Possible adit trending N, partially backfilled (debris). No evident dumps.

Waypoint PAPSHFT
Old Pap. Shaft, 10'x10'x40'. Possibly partially backfilled, unknown adits. No evident dumps.
Waypoint PAPSHFT
Old Pap. Shaft, 10'x10'x40'. Possibly partially backfilled, unknown adits. No evident dumps.
Waypoint 20
Large cut 20'x20'x50' into W flank of hillside. Gravel to small boulder size dumps.
Waypoint 20
Large cut 20’x20’x50’ into W flank of hillside.
Gravel to small boulder size dumps.

Waypoint 21
Small 6’x6’x6’ pit. Unknown if backfilled. No dumps.
Waypoint 21
Small 6'x6'x6' pit. Unknown if backfilled. No dumps.

Waypoint 22
Dump, 30'x15' QMP
Waypoint 24
Shaft, 6’x’6x20’ E side of arroyo. At bottom adit bearing E. No or minimal dumps.

Waypoint 25
Shaft 8’x’8x20’ possibly backfilled. Dumps, gravel size, about 50’ long to the W.
Waypoint 26

Shaft 7’x9’x~50’(?). Adit trending S. Waypoint 26 is also location for large shelf 50’x125’ cut into QMP hillside. Adit 30’ to the east of Waypoint 26 at ground level bearing S into hillside.
Waypoint 26
Shaft 7’x9’x~50’(?). Adit trending S. Waypoint 26 is also location for large shelf 50’x125’ cut into QMP hillside. Adit 30’ to the east of Waypoint 26 at ground level bearing S into hillside.
Waypoint 27
Pickwick Mine. Terrance 20’x100’ just above Waypoint 26.

Waypoint 27
Pickwick Mine. Terrance 20’x100’ just above Waypoint 26.
Waypoint 27
Pickwick Mine. Terrance 20’x100’ just above Waypoint 26.

Waypoint 28
Cut ~40’ diameter with recently backfilled adit trending N at N wall bottom. No dumps.
Waypoint 28
Cut ~40’ diameter with recently backfilled adit trending N at N wall bottom. No dumps.

Waypoint M-G M
Muheim-Grafen Mine, No evident workings at coordinates. Possibly reclaimed or incorrect location, just very orange oxidized soil.
Waypoint 29
Four adits, trending N, all backfilled. Dumps/disturbance ~75' surrounding site.
Waypoint 29
Four adits, trending N, all backfilled.
Dumps/disturbance ~75’ surrounding site.
Waypoint 29
Four adits, trending N, all backfilled. Dumps/disturbance ~75' surrounding site.

Waypoint 30
Adit 5'x4'xUkn' trending W into hillside. Little evidence of dumps.
Waypoint 30
Adit 5'x4'xUkn' trending W into hillside. Little evidence of dumps.

Waypoint 31
Probable adit, backfilled. 15'x30' cut into hillside. Small dump and timber pile.
Waypoint 31
Probable adit, backfilled. 15’x30’ cut into hillside. Small dump and timber pile.

Waypoint 32
Old Pap-Put? Cut 10’x10’x6’ with adit (4’x5’xUnk) at W end trending W into hillside.
Waypoint 32
Old Pap-Put? Cut 10'x10'x6' with adit (4'x5'xUnk) at W end trending W into hillside.
Waypoint 33
Adit 4’x5’xUnk’ partially backfilled trending SW into hillside. No dumps.
Waypoint 34
Old leaching tank for acid soluble Cu. 20'x40'x6'
Waypoint 58

Small prospect pit (cut) on the NW slope of ridge. Measures 20'x15'x10'. Well-bedded and jointed (4" to 12") crystal lithic tuff. Has a small dump composed of gravel to boulder size debris.
Waypoint 58
Small prospect pit (cut) on the NW slope of ridge. Measures 20’x15’x10’. Well-bedded and jointed (4” to 12”) crystal lithic tuff. Has a small dump composed of gravel to boulder size debris.
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Waypoint 58

Small prospect pit (cut) on the NW slope of ridge. Measures 20'x15'x10'. Well-bedded and jointed (4" to 12") crystal lithic tuff. Has a small dump composed of gravel to boulder size debris.

Waypoint 59

Short tunnel (entrance 5'x3') on east slope of ridge, extending approximately 10 feet into Cretaceous andesite of Willow Canyon Formation.
Waypoint 59

Short tunnel (entrance 5’x3’) on east slope of ridge, extending approximately 10 feet into Cretaceous andesite of Willow Canyon Formation.
Waypoint 59

Short tunnel (entrance 5' x 3') on east slope of ridge, extending approximately 10 feet into Cretaceous andesite of Willow Canyon Formation.

Waypoint 60

Small prospect pit (cut) on NW slope of ridge with small dump. Measures 10' x 10' x 10'. Bedrock is arkosic sediments of Cretaceous Willow Canyon Formation.
Waypoint 60
Small prospect pit (cut) on NW slope of ridge with small dump. Measures 10’X10’X10’. Bedrock is arkosic sediments of Cretaceous Willow Canyon Formation.

Waypoint 60
Small prospect pit (cut) on NW slope of ridge with small dump. Measures 10’X10’X10’. Bedrock is arkosic sediments of Cretaceous Willow Canyon Formation.
Waypoint 61

Small adit (1’x1’) in hillside. Its entrance is almost completely buried by debris. Bedrock is Cretaceous andesite in Willow Canyon Formation.
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<th>Site</th>
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<th>Ore Minerals</th>
<th>Other Materials</th>
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<th>Location</th>
<th>Workings</th>
<th>Orebody</th>
<th>Structures</th>
<th>Region</th>
<th>Alteration</th>
<th>Latitude</th>
<th>Longitude</th>
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<th>Form</th>
<th>Process</th>
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<th>Production</th>
<th>Status</th>
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<td>Sweet Bye And Bye</td>
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<td>Silver, Lead</td>
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<td>Mine Group, Operations Center</td>
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<td>Arizona</td>
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<td>COPPER, SILVER, LEAD</td>
<td>10113598</td>
<td>3</td>
<td>10283576</td>
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</tr>
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<td>3</td>
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<td>1918</td>
<td>100205</td>
<td>Silver, Lead</td>
<td>Copper, Zinc</td>
<td>Unknown Small Past Production</td>
<td>Underground</td>
<td>Coronado Nf, Part 12, Santa Rita Mt</td>
<td>U.S. Grant</td>
<td>Mine Group, Operations Center</td>
<td>1925 1969 0</td>
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<td>Arizona</td>
<td>Pima M</td>
<td>COPPER, SILVER, LEAD</td>
<td>10113208</td>
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</tr>
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<td>5</td>
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<td>1918</td>
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<td>Copper, Zinc</td>
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<td>Coronado Nf, Part 12, Santa Rita Mt</td>
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<td>Arizona</td>
<td>Pima M</td>
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<td>3</td>
<td>10039405</td>
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<td>6</td>
<td>Oregon Copper, Chicago &amp; Coconino</td>
<td>1918</td>
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<td>Copper, Zinc</td>
<td>Unknown Small Past Production</td>
<td>Underground</td>
<td>Coronado Nf, Part 12, Santa Rita Mt</td>
<td>U.S. Grant</td>
<td>Mine Group, Operations Center</td>
<td>1925 1969 0</td>
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<td>Arizona</td>
<td>Pima M</td>
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<td>3</td>
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<td>1918</td>
<td>100209</td>
<td>Silver, Lead</td>
<td>Copper, Zinc</td>
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<td>Underground</td>
<td>Coronado Nf, Part 12, Santa Rita Mt</td>
<td>U.S. Grant</td>
<td>Mine Group, Operations Center</td>
<td>1925 1969 0</td>
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<td></td>
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<td>Arizona</td>
<td>Pima M</td>
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</tr>
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<td>1918</td>
<td>100211</td>
<td>Silver, Lead</td>
<td>Copper, Zinc</td>
<td>Unknown Small Past Production</td>
<td>Underground</td>
<td>Coronado Nf, Part 12, Santa Rita Mt</td>
<td>U.S. Grant</td>
<td>Mine Group, Operations Center</td>
<td>1925 1969 0</td>
<td>124</td>
<td></td>
<td>31.8331 -110.7591</td>
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<td>Arizona</td>
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<td>COPPER, SILVER, LEAD</td>
<td>10162330</td>
<td>3</td>
<td>10162330</td>
<td>Picture 12</td>
</tr>
<tr>
<td>12</td>
<td>Hesperia East</td>
<td>1918</td>
<td>100214</td>
<td>Silver, Lead</td>
<td>Copper, Zinc</td>
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<td>Underground</td>
<td>Coronado Nf, Part 12, Santa Rita Mt</td>
<td>U.S. Grant</td>
<td>Mine Group, Operations Center</td>
<td>1925 1969 0</td>
<td>124</td>
<td></td>
<td>31.8334 -110.7610</td>
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<td>United States</td>
<td>Arizona</td>
<td>Pima M</td>
<td>COPPER, SILVER, LEAD</td>
<td>10026900</td>
<td>3</td>
<td>10162330</td>
<td>Picture 12</td>
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### APPENDIX B - TABLE OF ABANDONED MINE LANDS WITHIN THE PROPOSED ROSEMONT MINE SITE

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Country</th>
<th>State</th>
<th>County</th>
<th>Minerals Found</th>
<th>Previous Owners</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermountain Field Operations Center (IFOC) 000</td>
<td>Cow Creek 31.8383 -110.7560 NA United States Arizona Pima M Copper, Gold, Silver</td>
<td>Cow Creek 31.8383 -110.7560 NA United States Arizona Pima M Copper, Gold, Silver</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>ID #</td>
<td>Commod.</td>
<td>Workings</td>
<td>County</td>
<td>Host Rock</td>
<td>Ore Minerals</td>
<td>Structures</td>
<td>Tectonic</td>
<td>Alteration</td>
<td>Ore Controls</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>----------</td>
<td>--------</td>
<td>-----------</td>
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<td>----------</td>
<td>------------</td>
<td>--------------</td>
</tr>
<tr>
<td>10113205</td>
<td>Silver, Copper, Lead</td>
<td>Silver Spur Mine</td>
<td>Pima</td>
<td>M</td>
<td>Silver, Copper, Lead</td>
<td>Underground</td>
<td>Open Pit</td>
<td>Open Folds In S.</td>
<td>Extensive Faulting In N.</td>
</tr>
<tr>
<td>10234887</td>
<td>Zinc, Silver, Lead</td>
<td>Ridley Mine</td>
<td>Pima</td>
<td>M</td>
<td>Silver, Copper, Lead</td>
<td>Underground</td>
<td>Open Pit</td>
<td>Open Folds In S.</td>
<td>Extensive Faulting In N.</td>
</tr>
<tr>
<td>2524450</td>
<td>Zinc, Silver, Lead</td>
<td>Malachite, Pyrite, Sphalerite, Powellite</td>
<td>Pima</td>
<td>M</td>
<td>Silver, Copper, Lead</td>
<td>Underground</td>
<td>Open Pit</td>
<td>Open Folds In S.</td>
<td>Extensive Faulting In N.</td>
</tr>
<tr>
<td>2523655</td>
<td>Zinc, Silver, Lead</td>
<td>Copper, Silver</td>
<td>Pima</td>
<td>M</td>
<td>Silver, Copper, Lead</td>
<td>Underground</td>
<td>Open Pit</td>
<td>Open Folds In S.</td>
<td>Extensive Faulting In N.</td>
</tr>
<tr>
<td>10039628</td>
<td>Zinc, Silver, Lead</td>
<td>Broad Top Mine</td>
<td>Pima</td>
<td>M</td>
<td>Silver, Copper, Lead</td>
<td>Underground</td>
<td>Open Pit</td>
<td>Open Folds In S.</td>
<td>Extensive Faulting In N.</td>
</tr>
</tbody>
</table>

**Notes:**
1. This table presents all of the Abandoned Mine Lands located within the Rosemont project footprint identified through the USGS database for Pima County, Arizona. Tetra Tech and its subcontractors attempted to locate each of the sites listed above and collected photographic documentation of each site. Some of the sites were not found as they were either not located in the database or did not result in a sufficiently obvious mining activity.
2. Sites labeled with "Waypoint" or "Shaft" are sites that were visited and photographed by Tetra Tech, and their locations can be determined through the USGS database of Abandoned Mine Lands in the United States.
3. The latitude and longitude data presented in this table are approximate and may not be precise enough to accurately locate the mine sites. Not all listed AML sites were found in these feasibility studies.