LCI
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Project Memorandum

To: Vicky Peacey
Senior Manager Permitting and Approvals
Resolution Copper Mining LLC
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From: Ross Hartleb, CEG

Date: April 29, 2020, transmitted by email

SUBJECT: **Responses to BGC's Review Comments on Assessment of Surface Faulting Investigations at the Skunk Camp TSF Location**
LCI Project No. 1885.001

1.0 INTRODUCTION

In their Project Memorandum dated 18 March 2020, BGC Engineering USA (BGC) provided review comments and questions on geologic and fault investigations performed by Klohn Crippen Berger (KCB) and Lettis Consultants International (LCI) for the proposed Skunk Camp Tailings Storage Facility (TSF) in southern Arizona. The purpose of our current Project Memorandum is to provide specific responses to those review comments directed to LCI. Specifically, BGC's comments to LCI pertain to LCI report *"Site-*Specific *Seismic Hazard Analysis and Development of Time Histories for Resolution Copper's Proposed Skunk Camp Tailings Storage Facility, Southern Arizona"*, prepared for Resolution Copper Mining LLC (RCM) dated 6 January 2020.

The LCI (2020) report describes our site-specific probabilistic (PSHA) and deterministic (DSHA) seismic hazard analyses for the Skunk Camp TSF site. In support of those seismic hazard analyses, LCI performed desktop and field-based geologic investigations of the area surrounding the Skunk Camp TSF to evaluate evidence for and against the presence of Quaternary-active surface faults and to determine whether any site-area faults should be included in the hazard analyses.

BGC's review comments for LCI focus on the data sets, methodologies, and observations related to LCI's surface fault investigations in the Skunk Camp TSF area. Section 2.0 below summarizes BGC's review comments for LCI, and Section 3.0 provides our responses to BGC.

In addition to the clarifications provided in this memo, LCI plans to issue a revised version of the site-specific seismic hazard report, which will include some of the supplementary information provided herein.

2.0 SUMMARY OF REVIEW COMMENTS FROM BGC

BGC (2020, Section 5.0) states that they "are generally in agreement with the findings that say the presence of Quaternary-active faulting in the Project area is highly unlikely" and that their review comments are intended to "increase confidence that there are no Quaternary-active faults in the proposed Skunk Camp TSF area." Their review comments can be summarized as follows:

(1) Define the source and the resolution of the digital elevation data used in the desktop mapping and analysis.

(2) Define the extent, scale, and process used for desktop lineament mapping and evaluation.

(3) Provide additional information and field observations regarding the topographic and tonal lineament in basin-fill deposits shown in Figure 13 from LCI (2020), and discuss whether it could be related to similar features to the south in bedrock terrain.

(4) Comment on whether the absence of faults mapped by Richard and Spencer (1998) in their map unit QTs (Miocene to Pleistocene basin-fill deposits) represents strong evidence for the lack of Quaternary-active faulting in the Skunk Camp TSF site area.

3.0 RESPOSNSES TO BGC REVIEW COMMENTS

In this section we provide our specific responses to BGC's review comments. For a more comprehensive discussion of LCI's desktop and field-based fault evaluations, the reader is directed to Section 4.0 of LCI (2020).

(1) Lidar data were not used in the desktop evaluations described in our 6 January 2020 seismic hazard report. However, we have since acquired lidar for a portion of the site area in Gila County and we have performed additional desktop evaluations using the lidar data.

For the desktop evaluations described in our 6 January 2020 seismic hazard report, we relied on topographic data derived from a stereo satellite-based survey performed for RCM by PhotoSat Information Ltd. (PhotoSat, 2019). The satellite-based survey data cover the entire area of interest and we believe it was advantageous to rely on this single dataset in our study. PhotoSat used 50-cm pixel resolution stereo satellite photographs from 2010, 2013, and 2014 to produce a 3-ft stereo satellite survey and a 1.5-ft precision, grayscale orthophotograph for a large area that includes Dripping Spring Valley in the vicinity of the Skunk Camp TSF and extends northward to the Superior, AZ area. PhotoSat (2019) reports vertical accuracy of 0.63 ft (root mean square error) for this survey, and indicates that relative horizontal accuracy is generally better than 2 ft over distances of 6 miles.

A digital terrain model (DTM) with a 14-ft grid size was created from the PhotoSat satellite survey data. From the DTM we created hillshade and slope maps of the Skunk Camp TSF site area and, together with the PhotoSat orthophotograph and Google Earth imagery, these were used to visually evaluate geomorphic evidence for and against Quaternary faulting. Given the sparse development and lack of significant tree canopy in the site area, we found this DTM provided a high-resolution and accurate depiction of the ground surface that was useful for our desktop and field-based evaluations.

In response to BGC's (2020) recommendation, we acquired publicly available lidar data for a portion of the site area that is in Gila County (Figure 1). Unfortunately, lidar data are not available for adjacent Pinal County, where most of the Dripping Spring and Ransome faults are located (AGIC, 2020). The Gila County lidar data were collected in 2018–2019 by the U.S. Geological Survey for the Federal Emergency Management Agency (FEMA) and are designated as Quality Level 2 (QL-2) (USGS, 2018, 2019). Absolute vertical accuracy for QL-2 data is ≤0.3 ft (root mean square error) (Heidemann, 2018). We created a DTM with 8-ft grid size from the lidar data, and developed hillshade and slope maps to visually evaluate the geomorphology of the area shown in Figure 1. We observed no evidence suggestive of active faulting in the lidar coverage area.

(2) The approximate extents of our desktop evaluations are shown in Figure 1. The green polygon shows the extent of desktop evaluations performed using satellite survey data from PhotoSat (2019). The blue polygon shows the extent of desktop evaluations using lidar data from Gila County.

The extent of the desktop evaluations performed using PhotoSat (2019) data is coincident with a series of map sheets we developed at 1:10,000 scale prior to our field work. Multiple versions of these maps were produced with various combinations of hillshade imagery, slope imagery, and orthophotography from PhotoSat (2019), as well as geologic mapping from Peterson (1961), Cornwall *et al.* (1971), Cornwall and Krieger (1978), and Richard and Spencer (1998). These map sheets served two main purposes. First, they were used in our desktop evaluations to identify tonal and topographic lineaments and other geomorphic features to be visited in the field. Second, they were used in the field to help with navigation and for taking notes and observations.

Our desktop evaluations of the PhotoSat (2019) data were performed at various scales within the extent shown in Figure 1. In general, our 1:10,000 scale map sheets were used to identify gross or obvious features in the landscape. Because of the digital nature of these map sheets, we were able to zoom-in on selected features and locations as needed. For example, the tonal and topographic lineament in Figure 13 from LCI (2020) is shown at a scale of 1:8,000. The high quality of the PhotoSat base-layer data allowed us to zoom-in even more closely to scales of 1:5,000 or better during desktop evaluations without significant loss of resolution at this and other locations.

The lidar data cover only an approximately 5-mi-long section of the Dripping Spring fault at its southeastern end, and do not cover the Ransome fault (Figure 1). Our evaluations of the lidar were performed at various scales from 1:10,000 to 1:5,000 or better. We observed no geomorphic evidence suggestive of active faulting in the lidar coverage area, including along the southeastern section of the Dripping Spring fault.

We did not develop a comprehensive map of all tonal and topographic lineaments for the extents shown in Figure 1. Instead, our desktop evaluations focused on Tertiary and younger geologic units and geomorphic surfaces. We also focused on previously mapped faults in the site area such as the Dripping Spring and Ransome faults. Where our desktop evaluations of the PhotoSat (2019) data suggested areas of interest, such as possible positive or negative evidence for Quaternary faulting or canyon-wall fault exposures, we identified these as locations to be visited as part of our geologic field reconnaissance.

(3) The 1-km-long tonal and topographic lineament shown in Figure 13 from LCI (2020) was identified in our desktop evaluations of the PhotoSat (2019) data. The lineament is located outside the area of lidar coverage. Because it is a relatively prominent feature in the landscape, we visited this feature as part of our geologic field reconnaissance. In the field we attempted to trace the basal contact of the Tertiary basin-fill conglomerate (Tcg) at multiple locations across the lineament to evaluate whether the contact could be faulted. Unfortunately, we were not able to confidently identify and follow this contact because the grass- and desert scrub-covered slopes provided poor geologic exposure. This observation is consistent with Richard and Spencer (1998), who note that the basal contact of basin-fill deposits is poorly exposed in northern Dripping Spring Valley.

Several lines of evidence suggest that this lineament is not related to active faulting. First, the preponderance of Quaternary-active faults in the region are dipping normal or normal-oblique faults. If the lineament is a fault, it would have to be very steeply dipping to vertical, based on its linear trace that crosses moderate- to high-relief topography. Second, the lineament is quite short and appears to terminate abruptly to the north. BGC (2020) suggests that the lineament may extend a short distance to the south into bedrock terrain where several sub-parallel but not colinear lineaments are evident. We note, however, that these bedrock lineaments appear to be associated more with bedrock contacts than with faults in bedrock, based on mapping by both Cornwall *et al.* (1971) and Richard and Spencer (1998). Third, during field reconnaissance we did not observe any micro-geomorphic features along the lineament such as offset drainages, scarps, or moletracks suggestive of active faulting. Based on its geometry and lack of micro-geomorphic features, it is our opinion that this lineament is not related to active faulting and is an erosional feature associated with the geologic contact between Precambrian diabase (db) and Tertiary basin-fill conglomerate (Tcg).

(4) Richard and Spencer's (1998) 1:24,000 scale geologic map of the Ray-Superior area is a compilation and reinterpretation of previous geologic maps, including Peterson's (1963) map of the Pinal Ranch quadrangle and Cornwall *et al.*'s (1971) map of the Sonora quadrangle and other maps. A primary goal of Richard and Spencer's (1998) reinterpretation was to provide a better understanding of the distribution and origin of mineral deposits in the area southwest of the Skunk Camp TSF. Their main focus was on older rocks and structures, as opposed to possible Quaternary faults in basin fill deposits. As such, it could be inferred that Richard and Spencer's (1998) map does not provide strong evidence for the lack of Quaternary active faulting in the site area.

Prior to our field work we contacted Dr. Jon Spencer of the Arizona Geological Survey. He recalled mapping in the Mill Creek area, approximately 2 km north of the Skunk Camp TSF, where Cornwall *et* *al.* (1971) map a short section of the Dripping Spring fault as a solid line in basin fill deposits. Dr. Spencer did not recall observing evidence for Quaternary faulting at this location or elsewhere in the vicinity of the Skunk Camp TSF, consistent with what is shown in Richard and Spencer (1998). Although they focused on older bedrock terrain, Richard and Spencer (1998) did map and perform field checks of younger deposits in Dripping Spring Valley. We conclude that the lack of faults mapped in basin-fill deposits by Richard and Spencer (1998) provides at least supporting evidence for the lack of Quaternary faults in the Skunk Camp TSF site area. The field investigation program conducted by KCB and detailed in their site investigation report (KCB, 2019) provides additional strong evidence for the lack of Quaternary faults in the Skunk Camp TSF area.

4.0 CLOSURE

We appreciate the detailed and thoughtful review comments from BGC on our 6 January 2020 report that documents a site-specific seismic hazard analysis for the Skunk Camp TSF. In addition to the responses provided in this memorandum, LCI will issue to RCM a revised version of its site-specific seismic hazard report for the Skunk Camp TSF site, which will include some of the information provided herein.

Sincerely,
Lettis Consultants International, Inc.

Ross D. Hartleb

Ross Hartleb, CEG
Principal Geologist

REFERENCES

Arizona Geographic Information Council (AGIC), 2020, Arizona Lidar Coverage Explorers – Existing Lidar Datasets, last accessed 2 April 2020 at http://gis.azgeo.az.gov/lidarcoverage/.

BGC Engineering USA, Inc. (BGC), 2020, Resolution Copper Project EIS – Assessment of Surface Faulting Investigations at the Skunk Camp TSF Location – Draft: Project Memorandum to SWCA Environmental Consultants, 18 March 2020, 12 p.

Cornwall, H.R., Banks, N.G., and Phillips, C.H., 1971, Geologic Map of the Sonora Quadrangle, Pinal and Gila Counties, Arizona: U.S. Geological Survey, Geological Quadrangle Map GQ-1021, 1:24,000 scale.

Cornwall, H.R. and Krieger, M.H., 1978, Geologic Map of the El Capitan Mountain Quadrangle, Gila and Pinal Counties, Arizona: U.S. Geological Survey, Geological Quadrangle Map GQ-1442, 1:24,000 scale.

Heidemann, H.K., Lidar Base Specification (version 1.3, February 2018): United States Geological Survey Techniques and Methods, Book 11, Chapter B4, 101 p.

Klohn Crippen Berger (KCB), 2019, Skunk Camp Site Investigation: Report prepared for Resolution Copper Mining LLC, KCB doc. # CCC.03-81600-EX-REP-00012 – Rev. 0.

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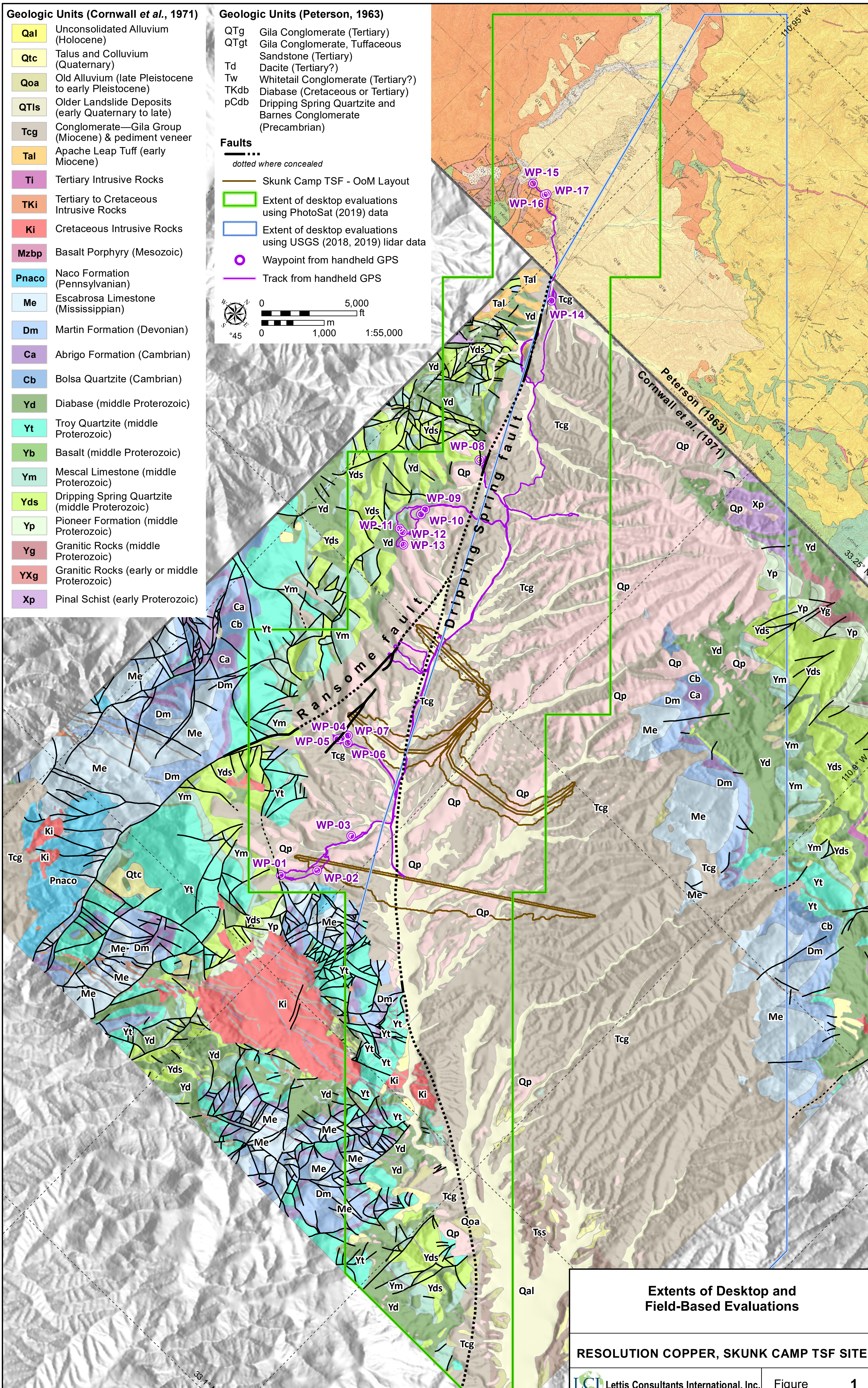
Peterson, N., 1961, Geology of the Pinal Ranch Quadrangle, Arizona: U.S. Geological Survey, Bulletin 1141-H, 1:24,000 scale.

PhotoSat Information Ltd., 2019, PhotoSat Stereo Satellite Surveying Project Report for Resolution Copper Mining, Arizona: Reference No. 4039, 31 May 2019, 46 p.

Richard, S.M. and Spencer, J.E., 1998, Compilation Geologic Map of the Ray-Superior Area, Central Arizona: Arizona Geological Survey Open-File Report 98-13, 50 p. with three plates, 1:24,000 scale.

United States Geological Survey (USGS), 2018, Ground Control Survey Report – CA AZ FEMA R9 Lidar 2017 D18: contractor report prepared by Woolpert, Inc. for contract no. G16PC00022, 538 p.

United States Geological Survey (USGS), 2019, Airborne Lidar Data Report – CA AZ FEMA R9 2017 D18: contractor report prepared by Woolpert, Inc. for contract no. G16PC00022, 180 p.



Extents of Desktop and Field-Based Evaluations

RESOLUTION COPPER, SKUNK CAMP TSF SITE

Lettis Consultants International, Inc. | Figure **1**

Victoria Boyne

From: ResolutionProjectRecord
Subject: FW: RC Follow-up Response to BGC - Action Item GS-12A
Attachments: LCI Skunk Camp memo_response to BGC_rev.pdf

From: Peacey, Victoria (RC) <Victoria.Peacey@riotinto.com>
Sent: Monday, May 25, 2020 3:45 PM
To: Rasmussen, Mary C -FS <mary.rasmussen@usda.gov>
Cc: Chris Garrett <cgarrett@swca.com>; Donna Morey <dmorey@swca.com>
Subject: RC Follow-up Response to BGC - Action Item GS-12A

EXTERNAL: This email originated from outside SWCA. Please use caution when replying.

Hello Mary,

To assist in completing action item GS-12A and in response to questions from BGC (2020, Section 5.0) related to faulting in the proposed Skunk Camp TSF area, the following documents are enclosed:

Action Item

1/23/2020	GS-12 A: (BGC/SWCA/USFS): Review 2020 Site Specific Seismic report "Dripping Springs" for data validation and update a tech memo.	12A: Received 3/19/20 (BGC)

RC Response

1. Technical response memorandum from LCI to provide specific responses to BCG's review comments (Attached)
2. Updated LCI report titled *"Site-Specific Seismic Hazard Analysis and Development of Time Histories for Resolution Copper's Proposed Skunk Camp Tailings Storage Facility, Southern Arizona."* The file is too large to email (41MB). The updated file can be accessed using the link and the login below:

http://www.lettisci.com/projects/lci1/ftp/ResolutionCopper_SkunkCamp_Final_Rev2_051920.zip

Username: lci1
Password: m,&1T~!@Ld}b

Please let me know if you have any questions,

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