USDA Forest Service
Tonto National Forest
Arizona

October 2, 2017 (Revised October 3, 2018)

Process Memorandum to File

Tonnage of Rock Type Mined and Tailings Produced over Mine Life

This document is deliberative and is prepared by the third-party contractor in compliance with the National Environmental Policy Act and other laws, regulations, and policies to document ongoing process and analysis steps. This document does not take the place of any Line Officer's decision space related to this project.

Prepared by:
Chris Garrett
Project Manager
SWCA Environmental Consultants

Purpose of Process Memorandum

The purpose of this process memorandum is to document information received from Resolution Copper Mining, LLC (Resolution Copper) regarding the variation in the lithology of mined material over the mine life. A similar process memorandum was prepared on August 9, 2017, identifying the percentages of material. This memorandum provides the same information, but based on tonnage instead of percentages.

This memorandum was updated in October 2018, to reflect additional information provided by Resolution Copper in February 2018.

Source of Information

Information was received by email from Resolution Copper on October 2, 2017, regarding the variation in major lithologies expected to be mined from the ore deposit over time. The original email is included in Attachment 1. Additional information was received by email from Resolution Copper on February 8, 2018, with further clarifications on the amount of rock to be mined and the amount of tailings expected to be produced. The original email is also included in Attachment 1.

Variation in Tonnage of Rock Type Mined over Mine Life

The expected variation in the tonnage of major lithologies mined over time is shown in Table 1.

Table 1. Tonnage of Rock Type over Mine Life

Major Lithology	Cave Production (short tons)				Life of Mine
	Years 1–10	Years 11-20	Years 21–30	Years 31–40	
Diab	87,623,493	118,906,200	181,494,735	25,369,471	413,393,899
Qzite	31,938,727	48,740,750	59,893,483	11,223,859	151,796,819
QEP	12,647,579	100,460,409	27,821,692	62,397,916	203,327,596
Breccia	102,683,761	34,446,379	77,962,119	55,132,993	270,225,252
Mesc	9,334,941	15,019,013	25,577,113	2,563,771	52,494,838
Pzls	6,888,075	24,595,892	7,876,176	2,115,711	41,475,854
Kvs	9,865,062	90,689,051	70,729,656	17,186,503	188,470,272
Kqs	12,031,146	35,149,823	20,009,392	906,484	68,096,845
Basalt	1,430,734	4,281,949	5,181,511	64,412	10,958,606
Tw	1	0	0	8,920	8,921
TOTALS	**274,443,519**	**472,289,466**	**476,545,877**	**176,970,040**	**1,400,248,902**

Resolution Copper notes that in addition to the rock mined as shown in Table 1, 33 million tons of development rock are also expected to be run through the mill, for a total of 1.433 billion tons of material processed.

Definitions for the above major lithologies are as follows:[1]

- Diab – Diabase
- Qzite – Quartzite
- QEP – Quartz eye porphyry; rhyodacite porphyry
- Breccia – Heterolithic Breccia
- Mesc – Mescal limestone
- Pzls – Paleozoic carbonates
- Kvs – Cretaceous volcanics and sediments (undifferentiated)
- Kqs – Cretaceous quartz-rich sediments
- Basalt – Precambrian basalt
- Tw – Tertiary Whitetail Conglomerate
- Pyrite

Tailings Production over Mine Life

The General Plan of Operations (GPO) indicated that 1.5 billion tons (1.3 billion cubic yards) of tailings would be produced. This volume was used during alternatives development to guide analysis of brownfield site capacity and alternative tailing design.[2]

Resolution Copper provided refined estimates of the amount of tailings (February 8, 2018 email) and indicated that the most recent estimates are that 1.37 billion tons of tailings would be produced.

[1] Primarily based on: Appendix G of the GPO; and 4DGeo Applied Structural Geology, 2017. Summary of geological information relevant to development of the porphyry Cu-Mo Resolution deposit, Arizona. May.

[2] GPO, p. 125

ATTACHMENT 1

Email Correspondence with Resolution Copper

Chris Garrett

Sent: Flood, Cameo <Cameo.Flood@tetratech.com>
Monday, October 02, 2017 12:18 PM
To: mcrasmussen@fs.fed.us; Donna Morey; Chris Garrett
Cc: Victoria.Peacey@riotinto.com; Morissette, Mary (RC)
Subject: FW: Geochem follow-up question
Attachments: image002.wmz

Please see Andrew's table below. Let me know if you have any further questions.

Cameo Flood
Direct: 406.327.5231
Cell: 406.207.6174
Cameo.Flood@tetratech.com

From: Luke, Andrew (RC) [mailto:Andrew.Luke@riotinto.com]
Sent: Monday, October 02, 2017 11:35 AM
To: Flood, Cameo <Cameo.Flood@tetratech.com>; Morissette, Mary (RC) <Mary.Morissette@riotinto.com>
Cc: Peacey, Victoria (RC) <Victoria.Peacey@riotinto.com>
Subject: RE: Geochem follow-up question

Cameo,

In response to the request for tonnage information to correlate with the table of lithology percentage, the following table provides the cave production tonnage data.

Major Lith	Cave Production (Short Tons)			
	YRS 1-10	YRS 11-20	YRS 21-30	YRS 31-40
Diab	87623493	118906200	181494735	25369471
Breccia	102683761	34446379	77962119	55132993
Qzite	31938727	48740750	59893483	11223859
QEP	12647579	100460409	27821692	62397916
Kvs	9865062	90689051	70729656	17186503
Mesc	9334941	15019013	25577113	2563771
Pzls	6888075	24595892	7876176	2115711
Kqs	12031146	35149823	20009392	906484
Basalt	1430734	4281949	5181511	64412
Tw	1	0	0	8920

Thanks,
Andrew

From: Donna Morey [mailto:dmorey@swca.com]
Sent: Friday, September 15, 2017 9:35 AM
To: Flood, Cameo <Cameo.Flood@tetratech.com>; Morissette, Mary (RCC) <Mary.Morissette@riotinto.com>
Cc: Mary Rasmussen (mcrasmussen@fs.fed.us) <mcrasmussen@fs.fed.us>; Chris Garrett <cgarrett@swca.com>; Peacey,

Victoria (RC) <Victoria.Peacey@riotinto.com>
Subject: RE: Geochem follow-up question

Since Vicky is preoccupied with a new little nugget, please see the below email sent this morning for Resolution response.

Donna Morey

"Things turn out best for people who make the best of the way things turn out." – John Wooden

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From: Chris Garrett
Sent: Friday, September 15, 2017 7:53 AM
To: Peacey, Victoria (RC) <Victoria.Peacey@riotinto.com>
Cc: Mary Rasmussen (mcrasmussen@fs.fed.us) <mcrasmussen@fs.fed.us>; Donna Morey <dmorey@swca.com>
Subject: RE: Geochem follow-up question

Hi Vicky –

I had what I hope is a quick follow-up to your follow-up.

As Mark Williamson works through the geochem, he's looking to know the tonnage or volume of each major lithologic unit, over time. You must have foreseen this, because the table you sent below is incredibly useful. But it doesn't tell us the actual tonnage or volume.

I've been scanning through the GPO and I haven't run across an overall production schedule over the life of the mine, which would be the piece that would allow us to do whatever calculations we wanted.

Do you know if that's something that's been submitted? I really feel like we may have seen it already.

- C

From: Peacey, Victoria (RC) [mailto:Victoria.Peacey@riotinto.com]
Sent: Wednesday, August 09, 2017 1:24 PM
To: Chris Garrett <cgarrett@swca.com>
Cc: Mary Rasmussen (mcrasmussen@fs.fed.us) <mcrasmussen@fs.fed.us>; Donna Morey <dmorey@swca.com>
Subject: FW: Geochem follow-up question

For your review and consideration and as a follow-on to the Geochem request below, we thought information on major lithology and pyrite shown over the life of mine in 10 year intervals may be helpful.

Mass Weighted Average of Production

Major Lith	**Percentage of Production**				**LoM**
	YRS 1-10	YRS 11-20	YRS 21-30	YRS 31-40	
Diab	32%	25%	38%	14%	30%
Qzite	12%	10%	13%	6%	11%
QEP	5%	21%	6%	35%	15%
Breccia	37%	7%	16%	31%	19%
Mesc	3%	3%	5%	1%	4%
Pzls	3%	5%	2%	1%	3%
Kvs	4%	19%	15%	10%	13%

Kqs	4%	7%	4%	1%	5%
Basalt	1%	1%	1%	0%	1%
Tw	0%	0%	0%	0%	0%
Pyrite	7.6%	8.6%	8.6%	7.7%	8.3%

Thanks,
Vicky

From: Peacey, Victoria (RC)
Sent: Tuesday, July 11, 2017 12:46 PM
To: 'Chris Garrett'; Gluski, Heather (RC)
Cc: Mary Rasmussen; Donna Morey; DeAnne Rietz; Charles Coyle
Subject: RE: Geochem follow-up question

Hello Mary and Chris,

For your review and consideration please see the attached cover letter and spreadsheets per your request.

Please let me know if you need anything further.

Best,
Vicky

From: Chris Garrett [mailto:cgarrett@swca.com]
Sent: Tuesday, June 20, 2017 4:18 PM
To: Gluski, Heather (RC); Peacey, Victoria (RC)
Cc: Mary Rasmussen; Donna Morey; DeAnne Rietz; Charles Coyle
Subject: Geochem follow-up question

Hi Vicky & Heather –

Hoping you can help with something. This is a follow-up clarification to the informal request for geochemical information we sent on May 4 that Resolution replied to on May 12. I apologize for the length, but I wanted to make it as specific as possible.

We're currently working through all the geochem data that you provided—and as I mentioned at our last biweekly meeting, the data now look very complete and all we need to do is organize it for the team so they can begin their data validation efforts. However, there are two pieces of information that I do not believe we have that are necessary for the data validation. Those two items are: for each geochemical sample for which we have data, we need to know 1) rock type, and 2) location.

I hate to ask for something we already have, so there are three places I looked for this type of information:

- The May 12 data submittal. These Excel tables contain all of the various geochemical data for every sample, but I did not see any information in these Excel tables that could be used to link each sample to rock type and location.

- PDFs of geochemical reports. We did find some places where samples are linked to rock type. For instance, see the screenshot below from Table 2 in Appendix G of the GPO. This table matches up the unique physical sample (Hole ID, Depth interval) with the geologic interpretation (Lithology, Alteration). While containing the correct info, Table 2 was one of the only tables we found and I do not believe we have similar consistent tables for all geochem results (ABA, Humidity cells, XRF, etc.). Other reports we have (Geochimica 2007) look like they may have once had Excel files originally attached that aren't part of the PDF we received for the project record.

- AcQuire database. I suspected this information might be in the AcQuire data submitted in 2016. Indeed, there is a table titled "GeoDetails" that does this matchup (see below). But this table doesn't seem complete. For instance, Table 2 from Appendix G of the GPO refers to Holes RES-001C, RES002A, etc. These holes don't show up in the AcQuire database.

Anyway—bottom line, I don't think we have the necessary info in our hands yet. Here's what I think we need:

MATCHUP TO ROCK TYPE

1) For each sample for which we have any type of geochemical data (ABA, SPLP, HCT, MWMP, mineralogy, etc), we need to document the borehole/interval, the lithology or rock unit that sample represents, and any description of alteration assigned. If possible, please provide a list that will allow us to match either sample ID to a specific lithology/alteration, or alternatively will allow us to match a Hole ID/depth interval to a specific lithology/alteration. (If the latter, I'm assuming we probably can figure out the link between sample ID and hole ID/depth)

MATCHUP TO GEOGRAPHIC LOCATION

Two specific requests:

1) The AcQuire database contains geographic locations in a table titled "HoleCoord" that contains geographic coordinates for each hole. As with the "GeoDetails" table, though, it seems some holes like RES-001C are missing. Is there an updated coordinate table?

2) For any given sample, if we know surface X/Y coordinates and depth, that will give us a rough way to know where the sample fits spatially. This may be all we need for the data validation effort. However, we recognize that because a lot of directional drilling has been done for this project, the X/Y coordinates at the surface and the depth probably won't give us the actual X/Y/Z coordinates of the sample itself. I can't know right now if this is a critical piece of information for data validation, but I'll throw the question out there: is there a way to match up any given geochem sample with real X/Y/Z coordinates?

Thanks – Happy to get on the phone or chat at Friday's meeting to clarify, especially if you think it's something we have in our hands already.

- C

DHRES-01	RES	0	1580.052	1	HydroFormation	Tal
DHRES-01	RES	0	1580.052	1	HydroLithology	Tuff
DHRES-01	RES	1580.052	1620.079	1	HydroFormation	Talv
DHRES-01	RES	1580.052	1620.079	1	HydroLithology	VTuf
DHRES-01	RES	1620.079	1680.118	1	HydroFormation	Talbt

DHRES-01	RES	1620.079	1680.118	1	HydroLithology	Tuff
DHRES-01	RES	1680.118	3049.869	1	HydroFormation	Tw2
DHRES-01	RES	1680.118	3049.869	1	HydroLithology	Cgl
DHRES-01	RES	3049.869	4500	1	HydroFormation	Tw3

Table 2. Summary of samples selected for Tier 2 testing.

Hole ID	Depth Interval (m)	Test ID	Mass (g)	Water:Rock Proportion	Grain Size	Lithology	Alteration	1% Copper Shell	Weeks Tested
RES-001C	1639.00-1642.00	1S	10000	1:3	fine (-10mesh)	Kvs	PRO	above	24
	1745.00-1748.00	2	10000	1:3	fine (-10mesh)	Kvs	POT	above	51
	1771.75-1791.40	3	20000	1:5	coarse (-1/2")	Dm	SKRET	above	24
	1855.00-1858.00	4S	5000	1:2.78	very fine (-10mesh)	Dm	SKN	above	16
	1855.00-1858.00 (dup)	5	5000	1:2.78	very fine (-10mesh)	Dm	SKN	above	16
	1873.00-1876.00	6	8000	1:3	fine (-10mesh)	Dm	HFLRET	below	51
	2041.00-2044.00	7	1500	1:1.5	fine (-10mesh)	Diab	POT	below	24
	2041.00-2044.00 (dup)	8	8000	1:3	fine (-10mesh)	Diab	POT	below	24
RES-002A	888.00-891.00	9S	8000	1:3	very fine (-10mesh)	Kvs	PHY	above	16
	1154.00-1156.00	10S	5000	1:2.78	very fine (-10mesh)	Kvs	PHY	above	16
	1414.60-1417.00	11	5000	1:2.78	fine (-10mesh)	QEP	PHY	above	24
	1454.00-1457.00	12	5000	1:2.78	fine (-10mesh)	Kvs	PHY	below	74
	1454.00-1457.00 (dup)	13	5000	1:2.78	fine (-10mesh)	Kvs	PHY	below	24
	1927.00-1930.00	14	10000	1:3	fine (-10mesh)	Diab	POT	below	51
RES-005I	1317.28-1320.28	15	12000	1:3	coarse (-1/2")	Tw	UNALT	above	16
	1428.18-1431.18	16S	4000	1:2	very fine (-10mesh)	Kvs	AA	above	16
	1428.18-1431.18 (dup)	17S	4000	1:2	very fine (-10mesh)	Kvs	AA	above	16
	1499.00-1502.00	18S	4000	1:2	very fine (-10mesh)	Kvs	PHY	above	16
	1586.46-1589.46	19S	4000	1:2	very fine (-10mesh)	QEP	PHY	above	16
	1632.56-1635.56	20S	5000	1:2.78	very fine (-10mesh)	Kvs	PHY	above	24
	1652.00-1654.93	21	2000	1:1.5	fine (-10mesh)	QEP	PHY	above	51
	1654.93-1659.80	22S	4000	1:2	very fine (-10mesh)	QEP	PHY	below	24
	1759.23-1761.23	23	1500	1:1.5	very fine (-10mesh)	QEP	PHY	below	51
	1892.81-1895.00	24	1500	1:1.5	very fine (-10mesh)	Qzite	PHY	below	24
	1917.29-1920.90	25S	2000	1:1.5	fine (-10mesh)	Diab	POT	below	24
RES-005J	1660.40-1686.47	26	20000	1:5	coarse (-1/2")	QEP	PHY	below	74

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Chris Garrett

Sent:
To:
Cc:
Subject:

Hi Chris,

Please see responses to your questions in blue text below.

Thanks,
Vicky

From: Chris Garrett [mailto:cgarrett@swca.com]
Sent: Thursday, January 11, 2018 1:19 PM
To: Peacey, Victoria (RC)
Cc: Mary Rasmussen; Donna Morey; Charles Coyle
Subject: Need clarification on material amounts

Hi Vicky –

This is a follow up to the issue you raised yesterday with Mary and I. I sat down to draft an explanation of this issue to our NEPA crew, and I realized there are different numbers floating around, and making sure we use the right numbers is probably a key part of the overall clarification.

- I think the main reason for why the inconsistency you pointed out never showed up on our radar, is that the most common number we throw around for how much rock gets removed from the ground is 1.9 billion tons, not 1.4 billion tons. [To be clear on units, this is U.S. short tons, or 2,000 pounds]. Key cites:
  - GPO, p. 88 "The total mineral resource is estimated to be 1,915 Mton". Also on p. 95
  - I don't find that we ever conveyed the term "1.9 billion" to the public, except indirectly. For the public meetings, Mark Nelson wanted to convey the amount of copper to be produced. This has not been stated by Resolution (that we could find at the time) so we calculated it ourselves. I documented this in the record [PR #000632], building off of the same 1.915 Mton resource, which resulted in "25 million tons" of copper. This "25 million ton" number made it into the scoping meeting materials.

Resolution Copper's latest published inferred resource (Rio Tinto 2015 Annual report) is 1,766 million tonnes at 1.51% Copper. The GPO was submitted in 2013 and based on the information we had at that time. A copy of the relevant pages and a link to the RT 2015 annual report is contained in the March 24, 2017 response to request for data #1B. This does not change the amount of rock that will be mined.

- However, I see that later materials submitted by RCM do actually cite a 1.4 Billion ton amount for rock mined. Notably, there were two tables you provided with the breakdown of the amount of rock mined, and from which rock type, over the life of the mine [They were emails, but I captured them in the record in process memos, PR #001731 and 002003. The key email was from Andrew Luke, 10/2/17]

Yes, approximately 1.4B tons of rock will be mined. More specifically over the life of the operation: total cumulative cave production is 1.4B tons, total cumulative development rock is 33M tons, total cumulative ore milled is 1.433B tons (cave production + development rock).

- As for tailings, the most common number floating around seems to be 1.5 Btons. Key cites:
  - GPO, p. 125. "approximately 1.5 billion tons (1.4 billion tonnes) or 1.3 billion yd3 (1.0 billion m3) of tailings will be produced."
  - The scoping materials use 1.5 billion tons as well.
  - I spot-checked some of the geochemistry reports dealing with tailings and they seem to cite 1.5 billion tons as well.
  - The only outlier I could find came in the latest reports for the investigations at the TSF, and there I see that at least one of the reports (KCB) says 1.6 billion tons.
  - Looks like in the Alternatives Evaluation Report, as well as throughout the internal alternative development, we consistently used 1.5 billion tons. Actually, most of the time we were using 1.3 billion cubic yards in lieu of tons, since we were concerned with pit capacity.

In the GPO we provide an estimated tailings of approximately 1.5B tons. The number, calculated more specifically is 1.37B tons.

Okay, so in my mind there are several questions to answer before we get too far in deciding how to nail this down and be consistent:

1. Is there any conflict between the 1.915 billion ton resource described in the GPO and the 1.4 billion tons of rock estimated to be removed that was provided later in the 10/2/17 table from Andrew? More specifically, because "resource" is a very specific term, is this a case of comparing apples-to-oranges? No, there is no conflict. It is not unusual to have a difference between the stated resource number and mined rock number. Just because there is a stated volume of resource, does not mean it can all be mined. Resolution Copper has imposed geotechnical boundaries to limit the impacts from subsidence. This is detailed on page 93 and 94 of the GPO. As such, what is considered minable within the geotechnical constraints is 1.4B tons. Resolution Copper will monitor and measure subsidence impacts over the life of the mine and adjust the mine plan as necessary.

2. If the reduction of rock mined from 1.9 to 1.4 billion tons is real and not just terminology, then can we document what drove that change? Is there a fundamental explanation for the reduction (i.e., different panels are being mined), or is this simply fine-tuning by engineers as additional rock info comes in? There is no change and the amount of rock mined remains consistent at 1.4B tons as per the GPO.

3. Depending on the answer to #1 and #2, is 1.5 billion tons of tailings the right number? On the face of it, 1.5 billion tons either looks kind of low (1.9 billion tons resource becomes 1.5 billion tons tailings) or kind of high (1.4 billion tons rock mined becomes 1.5 billion tons tailings). That said, though, I don't want to assume that the relationship between rock mined and tailings is anything simple. At the very least, there's a pretty large amount of entrained water that would change the mass of the tailings. The calculated tailings is 1.37 B tons.

I'm not convinced yet there is any inconsistency. I can see at least one scenario where all of these numbers are correct, once you are very precise about what that number represents. (Except perhaps the 1.6 btons referenced by KCB, and we discussed that inconsistency yesterday). Regardless, once we all understand, I'll document it for the project record to make sure we can always point back to the explanation.

BTW - For all of this discussion, I think for simplicity we exclude anything considered speculative, as discussed yesterday.

- C

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