Resolution Copper Project and Land Exchange
Environmental Impact Statement

USDA Forest Service
Tonto National Forest
Arizona

November 13, 2020

# Process Memorandum to File

## Assessment of Factual Basis for Comments on Dewatering Amounts, Water Usage, and Power Usage

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.

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# Purpose of Process Memorandum

The Draft Environmental Impact Statement (DEIS) for the Resolution Copper Project was released in August 2019. Multiple public comments were received on the DEIS concerning three related topics: the amount of dewatering required to maintain Resolution Copper mine infrastructure, the power requirements for the mine, and the overall water requirements for the mine. In each case, comments purport that the water or power amounts incorporated into the mine design and the DEIS analysis were greatly underestimated.

While these comments have been made by multiple commenters, they are handled in the most detail in two technical reports attached to comment letter #8032 (Arizona Mining Reform Coalition et. al.):

- Potential Impact of Geothermal Water on the Financial Success of the Resolution Copper Mine, Arizona. Steven H. Emerman, PhD, September 14, 2018.
- Projected Consumption of Electricity and Water by the Proposed Resolution Copper Mine, Arizona. Steven H. Emerman, PhD, March 11, 2019.

The purpose of this process memorandum is to explore the factual basis for these comments and determine if they warrant changes to the assumptions used in the DEIS analysis.

# Assessment of Factual Basis for Comments on Dewatering Amounts and Geothermal Conditions

## Purported Basis for Comments

Construction of Shaft 10 at the East Plant Site began in 2007; the shaft is 28-feet in diameter and currently 6,943 feet deep[1]. Dr. Emerman points to three articles that describe the experience of constructing Shaft 10, and the challenge of encountering hot groundwater:

- Bregel, E. 2016. Resolution Copper mine—venturing 7,000 feet below Earth's surface: Arizona Daily Star, June 4, 2016.
- Philips, M. 2016. Inside the billion-dollar dig to America's biggest copper deposit: Bloomberg Businessweek, March 4, 2016.
- Engineering and Mining Journal. 2014. Sinking America's deepest shaft. April 2014.

With respect to the dewatering amount, Emerman (2018) identifies three points of fact pulled from these articles:

- According to a summary of a presentation by Tom Goodell, general manager – shaft development for Resolution Copper, "Productivity flattened out at 6500 feet. The reason: hot water. 'In late December [2012], we hit a lot of water,' Goodell said. 'We are pumping 460 gpm [gallons per minute]…the consultants told us that we would have little or no water below

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[1] The bottom of Shaft 10 is at an elevation of 2,771 feet below mean sea level, with the collar of Shaft 10 at an elevation of 4,172 feet above mean sea level.

4000 feet…They kind of missed that call. We hit it all in one spot and it was quite dramatic.'" (Emerman 2018, p. 2, quoting EM&J 2014)

- Later reports indicated that the entry rate of geothermal water into the No. 10 shaft had increased by over a factor of three to 1400 gpm. According to a report in Bloomberg Businessweek, "A 6-foot-tall submersible pump in 20 feet of water beneath the shaft fills a dumpster-size tank. From the tank, two large pumps each shoot 700 gallons per minute up to the surface" (Emerman 2018, p. 2, quoting Philips 2016)
- The existence of two pumps (although not the discharge rate of each pump) was confirmed by the Arizona Daily Star, "Two huge water pumps send water out of the cave." (Emerman 2018, p. 2, quoting Bregel 2016)

With respect to water temperature, Emerman (2018) assumes in the analysis of power needs that the temperature of the geothermal water would be 180°F. This is based on another quote from the articles:

- The report by Bloomberg Businessweek also stated, "Without the elaborate refrigeration system that pumps chilled air down No. 10, the bottom of the mine would be 180°F, far too hot for a human to withstand." (Emerman 2018, p. 3, quoting Phillips 2016).

## Assessment of Validity of Emerman Dewatering Calculations

The information compiled by Dr. Emerman is quoted correctly from sources and is factual as applied to the specific location and experience of constructing Shaft 10. However, Dr. Emerman has then extrapolated these facts to the project as a whole. When taken in the context of the entire project and all other available information, the extrapolation conducted by Dr. Emerman is not valid.

There are four general reasons these comments are not valid for the project as a whole:

### Consideration #1: Pumping Amount from Shaft 10 is Misconstrued

The amount of pumping in 2012-2013 is correctly quoted from the EM&J article as being 460 gallons per minute. However, there is no basis for the claim that the entry rate had "increased by over a factor of three to 1400 gpm". A close read of the quoted paragraph indicates there is a sump that gradually fills with groundwater, and then is periodically evacuated by the two 700-gpm pumps. Since they run periodically to evacuate the sump, it is not appropriate to assume that these pumps are continually running at a combined 1,400 gpm. To be clear, it is certainly reasonable to believe that the pumping rate has increased since 2012, given that the shaft is deeper and penetrates a greater thickness of the deep groundwater system; however, assuming the pumping rate is 1,400 gpm based on the description provided in the published articles is not supported.

### Consideration #2: Improperly Extrapolating from a Single Location/Fracture

The geology of the area where Shaft 10 is being constructed, and from where the ore will be removed via block-caving, is characterized by consolidated hard rock. There are two primary aquifers identified beneath Oak Flat, both comprised of consolidated rock units: the Apache Leap Tuff aquifer, and the deeper groundwater system, characterized largely by Cretaceous volcanoclastic sediments. The deeper groundwater system is where the dewatering has been taking place since 2009, and where the unanticipated flow in Shaft 10 occurred[2].

Groundwater in both the Apache Leap Tuff and deep groundwater system exists and flows primarily within fractures (WSP 2019). In this type of geology, groundwater exists in and flows through individual, discrete fractures or fracture networks. As a whole, the aquifer displays enough connectivity between fracture networks to be treated as a single continuous unit, but physically this flow is concentrated in individual fractures, with virtually no groundwater in the solid blocks of consolidated rock between fractures.

The high flow rate encountered during construction of Shaft 10 may have surprised the shaft engineers, but it is consistent with fractured flow hydrology, where flow is concentrated in single fractures that may or may not be encountered by a single well. The quoted article sums this up quite well: "We hit it *all in one spot* and it was quite dramatic." (EM&J 2014, emphasis added)

While the amount of water originating from an individual fracture is not appropriate to extrapolate, the amount of water removed from the bottom of Shaft 10—460 gpm as reported in 2014—is indeed a valid representation of the groundwater contribution from all of the fractures encountered in the 28-foot-diameter shaft. That said, the flow rates experienced by that single fracture are not without value. This is a piece of useful information that was appropriately incorporated into the analysis (see Consideration #4). However, it is only a single data point. It is not appropriate to extrapolate this single data point to the entirety of the mine site without consideration for all the other data points, especially in fracture flow conditions.

Consideration #3: Additional Pertinent Data for Entire Mine Site

The geology and hydrology of the mine site has been thoroughly investigated[3]. Additional pertinent information to the current issue includes:

- Aquifer testing of wells constructed in the deep groundwater system
- Overall documented dewatering experience between 2009 and 2018

Aquifer tests are conducted by pumping from a well, typically at a constant and known rate, and then observing the reaction in the aquifer in the form of changing groundwater levels or piezometric heads. The experience in Shaft 10 is—in essence—equivalent to a single long-term aquifer test, albeit with a very large-diameter well. Over the mine site as a whole, aquifer tests have been conducted on eight other wells in the deep groundwater system (WSP 2019, Appendix A). The longest of these (DHRES-15) took place for 70 days. This is an extremely long period for an aquifer test, which rarely extend more than 72 hours in common practice. The overall productivity of the aquifer has been measured from these controlled aquifer tests; it is this analysis that supports the predictions of required dewatering that were used in the DEIS analysis.

DHRES-15 offers a further example of why extrapolation from a single data point is inappropriate. The average pumping rate from the 70-day test at DHRES-15 was 130.1 gpm (Montgomery & Associates

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[2] The EM&J 2014 article includes a figure that indicates the increased flow took place at a depth of about 6,450 feet below the shaft collar, which would be well within the deeper groundwater system.

[3] Both geology and hydrology were vetted during preparation of the DEIS by the Geology and Subsidence Workgroup and the Groundwater Modeling Workgroup.

2016), from a 6-inch diameter borehole with a screened length of about 760 feet. By one metric, this equates to 0.11 gpm per square foot of inflow. By comparison, Shaft 10 (roughly 28 feet diameter, 500 feet length between 6,450 and 6,943) yields 0.01 gpm per square foot of inflow. By this metric, not only was the flow in Shaft 10 not unexpectedly high for the mine site as a whole, but actually was an order of magnitude less than anticipated. This analysis of gpm/square foot is not offered here as a particularly useful or valid assessment; rather, it is offered as an example of why single data points must be looked at in context.

Because extrapolating from single data points is not always appropriate, activities that reflect the combined response of the entire aquifer are especially useful. In this case, Resolution Copper has been pumping from a suite of wells on the north and south side of Highway 60 near Shafts 3 and 10 since 2009, which has resulted in a reduction in groundwater levels in the deep groundwater system (see DEIS, p. 309). The pumping is being conducted under a dewatering permit issued by the Arizona Department of Water Resources (permit 59-524492.0003). This pumping represents the physical amount of water necessary to be removed in order to maintain water levels within the Resolution Graben (where the ore body is located) to a level of about sea level. The following pumping amounts have been reported to ADWR[4].

**Table 1. Dewatering conducted under right 59-524492.0003**

| Year | Pumping reported to ADWR (acre-feet) | Pumping reported to ADWR (gpm) |
|---|---|---|
| 2010 | 2,004 | 1,242 |
| 2011 | 2,341 | 1,451 |
| 2012 | 1,287 | 798 |
| 2013 | 1,532 | 950 |
| 2014 | 1,489 | 923 |
| 2015 | 1,460 | 992 |
| 2016 | 1,489 | 923 |
| 2017 | 1,287 | 798 |
| 2018 | 1,432 | 888 |

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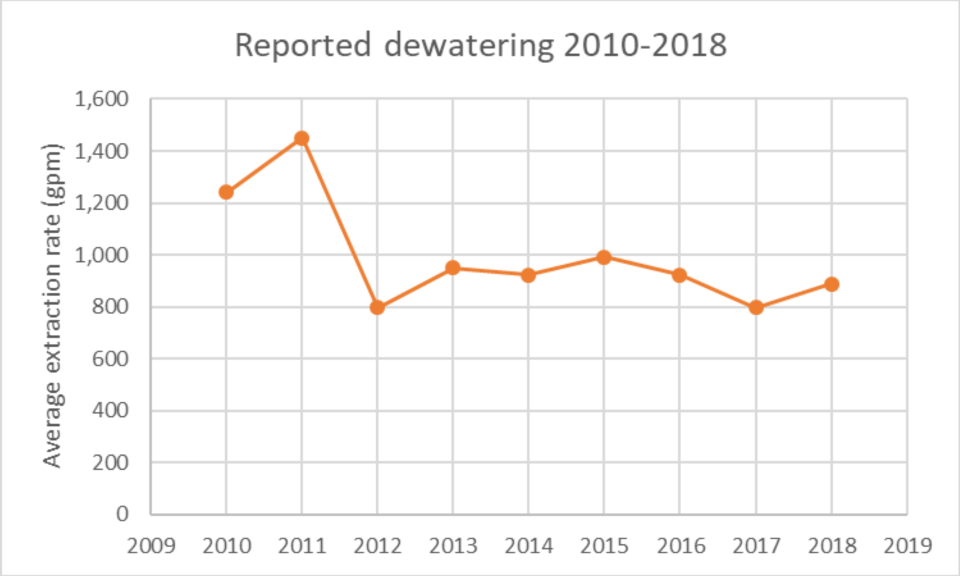
[4] Documentation up through 2015 was referenced in the DEIS (Rietz 2016b). Documentation from 2016 through 2018 was retrieved for the purposes of this white paper.

**Figure 1. Reported dewatering rate between 2010 and 2018**



As shown in table 1 and figure 1, dewatering rates have been consistent after the first two years of pumping, averaging between 800 and 1,000 gpm. This more accurately reflects anticipated dewatering amounts for the entire mine area than the flow from a single fracture network encountered by Shaft 10.

Consideration #4. Inappropriate Prediction of Dewatering Requirements

Dr. Emerman proceeds to predict or extrapolate what dewatering rate might be required for the entire mine site, using a derivation from the Thiem equation. This results in a prediction that dewatering the entire mine site would require 3,800 gpm, which is termed “a best-case scenario” (Emerman 2018 p. 13).

The calculation made by Emerman is not appropriate for four reasons.

1. This estimate is based on a pumping rate of 1,400 gpm. As noted in Consideration #1, a pumping rate of 1,400 gpm is not supported by the data.
2. The simplifying assumptions that form the basis for the Thiem equation are not supported in this situation:
   - The simplifying assumptions of the Thiem equation do not reflect the complex hydrogeology at the mine site. The geology and hydrology were thoroughly vetted by the Forest Service and the complexities have been documented in the project record and the DEIS. At the very least, the existence of the faults bounding the Resolution Graben radically affects the effective movement of groundwater. This is not conjecture; it is clearly demonstrated by groundwater data measured at the site since dewatering began in 2009. Table 3.7.1-1 of the DEIS (p. 309) shows that drawdown caused by dewatering pumping has caused over 2,000 feet of decline in groundwater head within the Graben, but at most a couple of hundred feet outside of the Graben. This is pertinent because these demonstrated barriers to groundwater movement

reduce the amount of groundwater that must be removed to drop heads below the mine infrastructure. The Thiem equation assumes an infinite aquifer and a radius of drawdown that expands until balanced by recharge inputs; the presence of the Resolution Graben is a physical constraint that negates this assumption of the Thiem equation.

    - A simplistic equation like the Thiem equation also can't account for the fundamental changes in the hydrogeologic framework that would occur because of the block caving, and the fracturing of overlying aquifers. These changes over time violate the steady-state condition required by the Thiem equation.

3. The complexities of the hydrogeologic framework and the changes in the fundamental hydrologic properties of the aquifer over time require a different type of tool to adequately predict dewatering rates. The Forest Service determined that the appropriate tool that could handle these complexities was a three-dimensional numerical finite-difference groundwater flow model (MODFLOW-SURFACT): "In the end, the Tonto National Forest asserts that…A three-dimensional numerical finite-difference groundwater model is the only tool that can be reasonably used to predict the results of the block-caving and dewatering, given the complex geology, changes in geology and hydrology introduced by the block-caving, long time frames, and large geographic area." (BGC 2018)[5] The groundwater modeling conducted using this more appropriate tool indicates that groundwater inflow into the block-cave zone would range from about 1,300 gpm (years 6-12 of mining) to 800 gpm (years 37-46 of mining). It should be noted that the inflows into Shaft 10 were actually used and replicated in the development of the groundwater flow model (WSP 2019).
4. The results obtained from the groundwater model (800 to 1,300 gpm) are reasonably similar to those experienced during physical dewatering since 2009 (800 to 1,000 gpm). Both these data sources are inconsistent with the theoretical prediction by Dr. Emerman of 3,800 gpm.

## Assessment of Validity of EmermanTemperature Assumptions

A general weakness of the Emerman reports is that they were prepared prior to the release of the DEIS. Based on the literature cited in and content of the reports, Emerman appears to rely primarily on information in the General Plan of Operations prepared by Resolution Copper in 2014, and incorporates very little of the actual analysis undertaken by the Forest Service between 2016 and 2019, or the large body of supporting documents. This is the case for the temperature assumptions.

Emerman's analysis of unanticipated cooling costs focuses on two factors:

- That more water will be flowing in than anticipated
- That the temperature of this water was not taken into account

The first factor is assessed above and the calculation of a flow rate of 3,800 gpm is not reasonable.

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[5] This reference (BGC 2018) is a memo that summarizes the conclusions of the Groundwater Modeling Workgroup used to vet the hydrologic predictions at the mine site supporting the DEIS analysis.

With respect to the second factor, the temperature of the ultimate mine is not new information. Part of the work reviewed by the Forest Service NEPA team was the temperature effects on geochemical reactions in the block-cave zone. The basis for that work found in the project record is Moreby (2018), "Resolution Project Drawpoint Rock Pile Temperatures", which states:

> *For the purposes of this work, a conservative average 74°C [165°F] is used. This compares with a rock temperature of 80°C [176°F] measured at the bottom of #10 shaft.* (Moreby 2018, p. 7)

In other words, Dr. Emerman has taken an anecdotal mention from a magazine article and characterized it as unexpected or unanticipated. Based on the information actually reviewed by the Forest Service to support the disclosures in the DEIS, these temperatures have been assumed all along and incorporated into both design and analysis.

## Assessment of Factual Basis for Comments on Power Usage

### Purported Basis for Comments

The first sentence of the March 2019 report states: "Rio Tinto has provided no estimate of the electricity consumption of the proposed Resolution Copper Mine…" The report then proceeds to estimate the electricity consumption from various literature sources that assess worldwide mining power use.

As noted in the previous section, a general weakness of the Emerman reports is that they were prepared prior to the release of the DEIS. Based on the literature cited in and content of the reports, Emerman appears to rely primarily on information in the General Plan of Operations prepared by Resolution Copper in 2014, and incorporates very little of the actual analysis undertaken by the Forest Service between 2016 and 2019, or the large body of supporting documents. In the overarching DEIS comment letter (#8032), Emerman provides a cover memo that indicates the DEIS was reviewed later, in order to assess the applicability of the previous comments. In the cover memo Emerman states:

> *The DEIS now estimates total electricity consumption at 250-280 MW, whereas previous documents (except for my report) provided no estimates. The DEIS references Garrett, 2019, "Process Memorandum to File—Power Requirements of Mine, Mine Facilities, and Alternative Tailings Storage Facilities," which gives maximum electricity consumption of 6.45 MW for dewatering and 6 MW for refrigeration. None of these estimates are accompanied by any explanation. Therefore, I believe that the estimates given in my report (best-case scenario of 260 MW and worst-case scenario of 1900 MW), are still valid.* (Emerman, October 2019, p. 1)

The best-case estimate Emerman refers to comes from a number of literature studies and approaches for estimating power use, calculating 236 MW as the power use of the mine. To this Emerman adds additional power requirements ranging from 24 MW to 1,664 MW to account for geothermal water entry.

### Assessment of Validity of Emerman Power Use Calculations

There are four considerations to address with the Emerman assumptions of power use.

1. Criticism that power estimates were not disclosed
2. Estimates of basic power use (what Dr. Emerman calls “best-case”)
3. Estimates of additional power to account for geothermal water
4. Comparison of Emerman estimates to power use disclosed in DEIS

Consideration #1: Disclosure of Power Requirements

The criticism that power estimates were not disclosed is simply not true. Power requirements are described in the DEIS (p. 50).

Consideration #2: Estimate of Basic Power Usage by Mine

Dr. Emerman makes use of literature and various studies to provide a variety of estimates for power usage for Resolution Copper:

- 248 MW (based on Bleiwas 2011 estimates by ton of copper)
- 569 MW (based on Bleiwas 2011 estimates by ton of ore)
- 360 MW (based on Fagerstrom 2015 estimates by ton of copper)
- 178 MW (based on Fagerstrom 2015 estimates by ton of ore)
- 321 MW (based on Northey et al 2013 estimates based on ton and grade of copper)
- 236 MW (based on Koppelaar and Koppelaar 2016, which Emerman describes as “The most reliable estimate”)

Power usage for the mine is disclosed as 250 to 280 MW (DEIS, p. 50). This corresponds well with Emerman’s “most reliable estimate”, as well as a several of the other estimates. The charge that disclosed power usage is out of step with expectations for a large mine is not valid.

Consideration #3: Assumption of Geothermal Water

The issue of the amount and temperature of geothermal water has been fully described earlier in this process memo, with the conclusions that the amount estimated by Emerman (3,800 gpm) is not a valid estimate, and that the anticipated temperature of the water was indeed already incorporated into the mine design.

This supposed influx of geothermal water is the basis for the inflated power usage of 1,900 MW, which does not appear to have any reasonable basis.

Consideration #4: Comparison of Emerman Estimates to DEIS Estimates

As noted above, power usage for the mine is disclosed as 250 to 280 MW (DEIS, p. 50). This corresponds well and is even a bit greater than Emerman’s “most reliable estimate” of 236 MW.

With respect to just the dewatering component, Emerman (2018) concludes that: “In summary, under the best-case scenario, the power required for both dewatering and refrigeration of the completed underground mine will be 24 MW.”

Garrett (2019) summarizes the power requirements for the mine, which were obtained from Resolution Copper. The power requirements at the end of the mine life for refrigeration (WPS, EPS underground, EPS surface[6]) and dewatering come to 24.3 MW.

In other words, in both the general case (236 MW Emerman vs. 250-280 MW DEIS disclosure) and the specific case (24 MW Emerman vs. 24.3 MW DEIS disclosure), the simplistic approach taken by Emerman to estimate power use, without knowledge of detailed engineering or design, is still remarkably similar to the power requirements disclosed in the DEIS. Far from contradicting this portion of the DEIS analysis, these comments independently validate this portion of the DEIS analysis.

## Assessment of Factual Basis for Comments on Overall Mine Water Usage

### Purported Basis for Comments

Emerman (2019) draws information from multiple literature sources in order to form a comparison to the water usage predicted by Resolution Copper. These include:

- Mudd 2008.
- Gunson 2013
- Northey et al 2013
- Singh 2010

Emerman cites the following data from these sources for water consumption for producing copper ore:

- Mudd (2008): 1.27 m3/t ore, or 172 m3/t copper. The numbers used by Dr. Emerman appear to be the averages taken directly from table 3 in Mudd 2008.
- Gunson (2013): 0.59 m3/t ore, or 89 m3/t copper. Gunson reports mine ore grades, ore production, and water use for a four-year period from 2006 to 2009. The numbers used by Dr. Emerman appear to be derived from the average for 2006 to 2009 of the water use per ton of ore from table 4.7 of Gunson 2013, and then translated into tons of copper using the average for 2006 to 2009 from table 4.6 from Gunson 2013 (0.66 grade ore).
- Northey et al (2013): 74 m3/t copper as a global average. It is much more difficult to identify the source of these numbers, as this study does not disaggregate by type of mining, or provide global ore grades. It may also be that the commenter relied upon the underlying database of statistics, which was not provided to the Forest Service with the comment. The validity of this assumption cannot be determined on the strength of the comment submittal.
- Singh (2010): 28.3 gallons/pound copper [translates to 236 m3/t copper, assuming metric tons or tonnes were used in the above sources]. This study is specific to Arizona and looks at the reported or estimated water use for seven open-pit copper mines. The number used by Dr.

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[6] Emerman notes only underground cooling. In reality the cooling requirements are distributed wherever the ore moves; hence, refrigeration at all locations was included in this estimate.

> Emerman given appears to be the mean of the average of all seven mines as shown on page 6 of the Singh 2010 report.

From these sources, Dr. Emerman makes the following ultimate conclusion:

> *…the water-consumption prediction from Rio Tinto is 10.2% of the average for copper mines in Arizona (Singh, 2010), 32.5% of the global average (Northey et al., 2013), and 38.9% of the predicted water consumption for the just-approved Rosemont Mine in Arizona (Sing, 2010).* (Emerman 2019, p. 8)

This conclusion by Dr. Emerman appears to be the basis for the statement occurring in many comments that Rio Tinto is claiming to use only 10% of the water used by other mines.

### Assessment of Validity of Emerman Water Use Calculations

Emerman Water Use Calculations based on Literature

To make this assessment, Dr. Emerman has converted all estimates of annual water use to units of acre-feet. These calculations appear to assume 150,000 metric tons of ore per day, with a grade of 1.47%:

- Mudd: 56,000 acre-feet (based on ore)
- Mudd: 112,000 acre-feet (based on copper)
- Gunson: 26,000 acre-feet (based on ore)
- Gunson: 58,000 acre-feet (based on copper)
- Northey et al: 48,000 acre-feet
- Singh: 154,000 acre-feet

On the whole, to the extent they can be deciphered from the original material and with the assumptions inherent in the sources, these calculations appear to be appropriately calculated.

Predicted Mine Water Use

The consumptive water use by the mine is described in Appendix H of the DEIS. The water balance is complex, with multiple recycling loops, so the focus must be on the three sources of fresh water supply entering the process[7]: makeup water from the Desert Wellfield, dewatering from the East Plant Site, and stormwater captured at the tailings storage facility.

*Alternative 2 (Proposed Action)*

> Year 6-12: 8,932 acre-feet from Desert Wellfield; 2,118 acre-feet from dewatering at EPS; 1,110 acre-feet from stormwater capture at TSF

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[7] For simplicity, this analysis does not take into account changes in storage that occur in the tailings storage facility; see Appendix H for details of this relatively minor contribution.

> Year 13-36: 19,926 acre-feet from Desert Wellfield; 1,772 acre-feet from dewatering at EPS; 1,865 acre-feet from stormwater capture at TSF
>
> Year 37-46: 4,576 acre-feet from Desert Wellfield; 1,298 acre-feet from dewatering at EPS; 1,625 acre-feet from stormwater capture at TSF
>
> Total water use over life of mine: 586,508 acre-feet from Desert Wellfield; 70,334 acre-feet from dewatering at EPS; 68,780 acre-feet from stormwater captures at TSF. Equates to 17,698 acre-feet/year on average, with a maximum of 23,563 acre-feet per year.

*Alternative 6 (Preferred Alternative)*

> Year 6-12: 5,578 acre-feet from Desert Wellfield; 2,118 acre-feet from dewatering at EPS; 2,589 acre-feet of stormwater capture at TSF
>
> Year 13-36: 17,948 acre-feet from Desert Wellfield; 1,772 acre-feet from dewatering at EPS; 5,111 acre-feet of stormwater capture at TSF
>
> Year 37-46: 7,506 acre-feet from Desert Wellfield; 1,298 acre-feet from dewatering at EPS; 6,451 acre-feet of stormwater capture at TSF
>
> Total water use over life of mine: 544,858 acre-feet from Desert Wellfield; 70,334 acre-feet from dewatering at EPS; 103,077 acre-feet of stormwater capture at TSF. Equates to 17,519 acre-feet/year on average, with a maximum of 24,831 acre-feet per year.

Dr. Emerman states that Resolution Copper “has predicted 15,700 acre-feet per year with a maximum of 20,000 acre-feet per year” (Emerman 2019, p. 8, citing the GPO)

As noted in each of the other two primary issues explored in this process memo (dewatering amounts and power usage), a general weakness of the Emerman reports is that they were prepared prior to the release of the DEIS. Based on the literature cited in and content of the reports, Dr. Emerman appears to rely primarily on information in the General Plan of Operations prepared by Resolution Copper in 2014, and incorporates very little of the actual analysis undertaken by the Forest Service between 2016 and 2019, or the large body of supporting documents. This is the case for the water usage; Dr. Emerman has used old numbers that were refined during the DEIS analysis process. That said, it is acknowledged that the differences between the GPO and the DEIS are not so great as to render moot the underlying point Dr. Emerman attempts to make.

Rather, the point of Dr. Emerman’s report is rendered moot because it ignores the fundamental differences between the Resolution Copper project, global copper mines, and mines in Arizona that are described in the literature. There are indeed differences between water use as disclosed in the DEIS and the sources used by Dr. Emerman; however, these differences in water use are readily explained by the actual details of the project, which were clearly disclosed in the DEIS—which was not reviewed by Dr. Emerman for the report[8]. The specific reasons for the purported discrepancy in reported water use by Resolution Copper are given below.

Primary Source of Water Loss from Resolution Copper

Appendix H of the DEIS clearly identifies where water is consumptively lost from the mine cycle, which is ultimately what requires makeup water. Percentages shown in parentheses reflect the percent of the total water loss for that component, rounded.

*Alternative 2 (Proposed Action)*

Years 6-12:

- Evaporation from shaft, vent, and refrigeration at EPS: 2,374 acre-feet (21%)
- Moly plant losses at WPS: 490 acre-feet (4%)
- TSF evaporation losses: 3,779 acre-feet (33%)
- TSF entrainment: 4,723 acre-feet (41%)
- TSF lost seepage: 77 acre-feet (1%)
- Copper concentrate moisture: 74 acre-feet (1%)
- Total annual losses: 11,517 acre-feet

Years 13-36:

- Evaporation from shaft, vent, and refrigeration at EPS: 3,247 acre-feet (14%)
- Moly plant losses at WPS: 497 acre-feet (2%)
- TSF evaporation losses: 9,705 acre-feet (41%)
- TSF entrainment: 9,692 acre-feet (41%)
- TSF lost seepage: 153 acre-feet (1%)
- Copper concentrate moisture: 168 acre-feet (1%)
- Total annual losses: 23,462 acre-feet

Years 37-46:

- Evaporation from shaft, vent, and refrigeration at EPS: 1,911 acre-feet (24%)
- Moly plant losses at WPS: 488 acre-feet (6%)
- TSF evaporation losses: 4,853 acre-feet (60%)
- TSF entrainment: 617 acre-feet (8%)

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[8] While the Emerman reports pre-date the DEIS, a cover memo from Emerman was included with the comments, purporting to bring them in line with a review of the DEIS. However, Emerman makes no changes to his water use consumption estimates in the cover memo.

- TSF lost seepage: 153 acre-feet (2%)
- Copper concentrate moisture: 56 acre-feet (1%)
- Total annual losses: 8,078 acre-feet

*Alternative 6 (Preferred Alternative)*

Years 6-12:

- Evaporation from shaft, vent, and refrigeration at EPS: 2,374 acre-feet (24%)
- Moly plant losses at WPS: 490 acre-feet (5%)
- TSF evaporation losses: 3,221 acre-feet (33%)
- TSF entrainment: 3,600 acre-feet (36%)
- TSF lost seepage: 114 acre-feet (1%)
- Copper concentrate moisture: 74 acre-feet (1%)
- Total annual losses: 9,873 acre-feet

Years 13-36:

- Evaporation from shaft, vent, and refrigeration at EPS: 3,247 acre-feet (13%)
- Moly plant losses at WPS: 497 acre-feet (2%)
- TSF evaporation losses: 11,110 acre-feet (45%)
- TSF entrainment: 9,275 acre-feet (37%)
- TSF lost seepage: 453 acre-feet (2%)
- Copper concentrate moisture: 168 acre-feet (1%)
- Total annual losses: 24,750 acre-feet

Years 37-46:

- Evaporation from shaft, vent, and refrigeration at EPS: 1,911 acre-feet (12%)
- Moly plant losses at WPS: 488 acre-feet (3%)
- TSF evaporation losses: 9,524 acre-feet (61%)
- TSF entrainment: 2,991 acre-feet (19%)
- TSF lost seepage: 627 acre-feet (4%)
- Copper concentrate moisture: 56 acre-feet (1%)
- Total annual losses: 15,597 acre-feet

To summarize the above, while the amounts and percentages vary over time and among alternatives, a commonality is that the tailings storage facility represents the primary source of water loss, both through entrainment and evaporation. These losses vary between 68 and 82 percent of the total water loss.

Singh (2010) explores this same water balance for an idealized 50,000 metric-ton/day mining operation and results in similar findings, with entrainment and evaporation being the larges overall water loss (94%):

- Plant site losses: 140 acre-feet (2%)
- TSF evaporation losses: 5,693 acre-feet (63%)
- TSF entrainment: 2,805 acre-feet (31%)
- TSF seepage: 429 acre-feet (5%)
- Copper concentrate moisture: 25 acre-feet (0%)
- Total annual losses: 9,092 acre-feet

*Tailings Solids Content at Resolution Copper*

The solids content at Resolution Copper is clearly described in the DEIS, for example see figure 2.2.2-10 (DEIS p. 50), table 2.2.4-1 (DEIS p. 73), and table 2.2.8-1 (DEIS p. 99). The slurry at Resolution Copper is not a traditional slurry, which generally has a 20-50% solids range, but a thickened slurry, which generally has a 50-70% solids range.

For the two examples explored in this process memo (Alternative 2 and Alternative 6)[9]:

- Alternative 2, PAG tailings (16% of total tailings stream): 50% solids
- Alternative 2, NPAG tailings, thickened cyclone overflow (36% of total tailings stream): 50-60% solids
- Alternative 2, NPAG tailings, cyclone sand (31% of total tailings stream): 60% solids
- Alternative 2, NPAG tailings, deposited direct from mill (17% of total tailings stream): 65% solids
- Alternative 6, PAG tailings (16% of total tailings stream): 50% solids
- Alternative 6, NPAG tailings, thickened cyclone overflow (36% of total tailings stream): 60% solids
- Alternative 6, NPAG tailings, cyclone sand (31% of total tailings stream): 60% solids
- Alternative 6, NPAG tailings, deposited direct from mill (17% of total tailings stream): 60% solids

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[9] These details are found in the alternative design documents for each alternative, authored by Klohn Crippen Berger.

*Tailings Solids Content Assumed in Literature*

The data sources referenced by Dr. Emerman are largely silent on the solids content of the underlying mines being researched. Singh (2010) explicitly assumes a 50% solids content for his idealized mining facility (see Singh table 1). Northey et al (2013) does not report tailings type for the underlying data, nor does Gunson or Mudd. As these are generally aggregation studies of operating mines worldwide, it is reasonable to assume they reflect traditional tailings facilities, which have tailings between 20% and 50% solids content.

*Explanation for Discrepancies between Resolution Copper Water Use and Emerman Estimates*

Commenters, particularly Dr. Emerman, charge that Resolution Copper is under-predicting anticipated water use by the mine. The foundation of this charge are the four literature studies presented above. These studies have been used to predict the following water use for Resolution Copper:

- Mudd: 56,000 acre-feet (based on ore)
- Mudd: 112,000 acre-feet (based on copper)
- Gunson: 26,000 acre-feet (based on ore)
- Gunson: 58,000 acre-feet (based on copper)
- Northey et al: 48,000 acre-feet
- Singh: 154,000 acre-feet

These are compared to the 17,500 to 24,800 acre-feet per year predicted for use by Resolution Copper, depending on year and alternative.

At the most basic level, these literature studies reflect mines that are entirely different than that proposed for Resolution Copper. The tailings for Resolution Copper are being thickened, which is different from traditional tailings slurries used in the past. A full 84% of the Resolution Copper tailings stream is thickened to a solids contents greater than seen in traditional slurries upon which the literature estimates likely are based.

This thickening has many ramifications:

- It reduces the amount of water needed to move the slurry
- It can change the dynamics of the tailings storage facility, including entrained water and the size of the reclaimed water pond and amount to evaporation, and propensity for seepage

Given these ramifications and the clear differences between the tailings proposed for Resolution Copper and traditional mines, deviation from the literature studies should have been anticipated.

Put another way, Resolution Copper is indeed using less water than other mines, because Resolution Copper is investing in the use of thickening technology in order to reduce overall water use. The discrepancies with literature don't reflect an oversight or error in the DEIS, but rather demonstrate the efficacy of the Resolution Copper tailings design for saving water.

*Demonstration of Relative Magnitude of Differences*

An additional question can be asked: are these differences in tailings solids content between Resolution Copper (~60%) and traditional slurries (<50%) sufficient to reflect such large discrepancies in water use?

Tailings storage facilities are complex and each one is managed in specific ways. The water use estimates made by Resolution Copper for each alternative best describe the overall water use. The following simplified analysis does not replace this detailed work.

In their design reports for the alternatives, Klohn Crippen Berger (KCB) provides the calculation for how much slurry water is needed. By looking at several different scenarios it is clear that tailings solids percentage makes a significant difference. The calculation used by KCB is as follows:

*Slurry water needed (tons) = Tailings mass (tons) x (100 – slurry % solids)/(slurry % solids)*

**Table 2. Scenario 1: Resolution Copper tailings (Alternative 2)**

| Tailings component | Tonnage (Mtons) | Percent solids | Slurry water (Mtons) | Slurry water (acre-feet)** |
|---|---|---|---|---|
| PAG | 220 | 50 | 220 | 161,876 |
| NPAG overflow | 544 | 60* | 363 | 267,095 |
| NPAG underflow | 370 | 60 | 247 | 181,743 |
| NPAG direct | 236 | 65 | 127 | 93,447 |
| TOTAL | 1370 | | 957 | 704,161 |

* A range from 50 – 60 is given in the design documents

** Calculated as 1 Mton of water = 735.8 acre-feet

**Table 3. Scenario 2: Resolution Copper tailings (Alternative 6)**

| Tailings component | Tonnage (Mtons) | Percent solids | Slurry water (Mtons) | Slurry water (acre-feet) |
|---|---|---|---|---|
| PAG | 220 | 50 | 220 | 161,876 |
| NPAG overflow | 544 | 60 | 363 | 267,095 |
| NPAG underflow | 370 | 60 | 247 | 181,743 |
| NPAG direct | 236 | 60 | 157 | 115,521 |
| TOTAL | 1370 | | 987 | 726,235 |

**Table 4. Scenario 3: Theoretical Resolution Copper tailings if managed at high end of traditional slurry tailings solids content**

| Tailings component | Tonnage (Mtons) | Percent solids | Slurry water (Mtons) | Slurry water (acre-feet) |
|---|---|---|---|---|
| PAG | 220 | 50 | 220 | 161,876 |
| NPAG overflow | 544 | 50 | 544 | 400,275 |
| NPAG underflow | 370 | 50 | 370 | 272,246 |
| NPAG direct | 236 | 50 | 236 | 173,649 |
| TOTAL | 1370 | | 1370 | 1,008,046 |

**Table 5. Scenario 4: Theoretical Resolution Copper tailings if managed with average traditional slurry tailings solids content**

| Tailings component | Tonnage (Mtons) | Percent solids | Slurry water (Mtons) | Slurry water (acre-feet) |
|---|---|---|---|---|
| PAG | 220 | 40 | 330 | 242,814 |
| NPAG overflow | 544 | 40 | 816 | 600,413 |
| NPAG underflow | 370 | 40 | 555 | 408,369 |
| NPAG direct | 236 | 40 | 354 | 260,473 |
| TOTAL | 1370 | | 2055 | 1,512,069 |

The point of this exercise is not to calculate actual water consumption, since this calculation ignores such things as evaporation losses, entrainment, and recycling loops. The point is simply to illustrate that the solids content of the tailings has a significant impact: a traditional tailings slurry can use from 140% to 210% more water than what is proposed for Resolution Copper and could readily account for the differences between literature estimates and Resolution Copper site-specific design estimates.

## Conclusion as to Validity of Dr. Emerman Comments on Dewatering Amounts and Temperature, Power Usage, and Water Usage

The technical reports by Dr. Emerman submitted as part of comment letter #8032 were reviewed and assessed for validity. In general it appears that Dr. Emerman did not review or assess the actual information used by the Forest Service NEPA team, but relied only on the 2014 General Plan of Operations and a review of the DEIS after the memos were originally written. The NEPA analysis relies on much more information than this, including analysis in the project record and many reports available to commenters as references to the DEIS.

With respect to geothermal temperatures and some estimates of power usage, Dr. Emerman's analysis validates the assumptions contained in these background documents. With respect to dewatering amounts and other estimates of power usage, Dr. Emerman has extrapolated individual anecdotes to draw overarching conclusions about the mine as a whole, and then used these extrapolations to estimate greater dewatering and power needs. Not only are these extrapolations unsupportable, but they are refuted by the totality of evidence the Forest Service NEPA team assessed for the DEIS analysis.

The single issue raised by Dr. Emerman that appears valid is that the Resolution Copper project will use less water than other mines. However, this difference does not reflect an error, discrepancy, or miscalculation. It reflects the fact that Resolution Copper is investing in water-reducing technologies—specifically thickening of slurry tailings—to reduce overall water use.

In conclusion, none of the issues raised by Dr. Emerman in the two reports assessed in this process memo require changes to the analysis approach for the FEIS.

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