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Tonto National Forest
Arizona

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Process Memorandum to File

Water Resource Analysis: Assumptions; Methodology Used; Relevant Regulations, Laws, and Guidance; and Key Documents

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Revision History

Date	Personnel	Revisions Made
8/6/18	Emily Newell	Process memorandum created
10/30/18	Chris Garrett	Edits to surface water quantity section
11/5/18	Chris Garrett	Edits to groundwater quantity section
1/14/19	Emily Newell	Edits for consistency with other process memoranda
5/15/19	Chris Garrett	Addition of water quality analyses
8/5/19	Chris Garrett	Final update for consistency prior to draft environmental impact statement release
12/14/20	Chris Garrett	Final update for consistency prior to final environmental impact statement release, including addition of mounding analysis, floodplain updates, and wetland updates

Purpose of Process Memorandum

In order to provide a concise and accessible summary of resource impacts, certain detailed information has not been included directly in the environmental impact statement (EIS). The purpose of this process memorandum is to describe additional supporting resource information in detail. The water resources section of chapter 3 of the EIS includes brief summaries of the information contained in this process memorandum. This process memorandum covers four basic topics:

- Resource analysis area
- Analysis methodology
- Regulations, laws, and guidance
- References and key documents

Water resources involve three areas of analysis: groundwater quantity and groundwater-dependent ecosystems (GDEs), groundwater and surface water quality, and surface water quantity. Each section is analyzed separately within this process memorandum to distinguish between the assumptions, methodology used, and relevant regulations, laws, and guidance in each resource.

Detailed Information Supporting Environmental Impact Statement Analysis – Groundwater Quantity and Groundwater-Dependent Ecosystems

Resource Analysis Area

Spatial Analysis Area

The spatial bounds of analysis (analysis area) for groundwater quantity was created large enough to cover all foreseeable potential groundwater quantity impacts from dewatering for mining operations, from water supply pumping from the Desert Wellfield along the Magma Arizona Railroad Company (MARRCO) corridor to changes in basin water balance that could be associated with the tailings alternatives. Note that analysis of groundwater associated with the tailings facilities is covered in the groundwater and surface water quality section (section 3.7.2) of the final EIS (FEIS), and these areas are not included in the groundwater quantity analysis area.

Temporal Analysis

Two linked groundwater models were used for the groundwater quantity analysis. The first model encompasses the operational life of mine. The second model extends up to 1,000 years post-closure. One decision resulting from the groundwater modeling workgroup (described more in section 3.7.1 of the EIS) is that predictions over such long time frames are speculative. The groundwater modeling workgroup agreed that the reasonable temporal bounds of quantitatively analyzing impacts to groundwater quantity for all alternatives would be 200 years after start of mining; however, additional qualitative descriptions are included to the full 1,000 years post-closure based on general modeled trends in groundwater levels. Therefore, the temporal bounds of the water quantity analysis extend through 1,000 years after closure of the mine.

Analysis Methodology

This section discusses detailed aspects of the analysis that are not included in the EIS but are still necessary building blocks for the disclosures in the EIS. The following aspects of the analysis methodology are discussed in full in the EIS and are not repeated here:

- Identifying and defining GDEs
- Evaluating the model and modeling approach (groundwater modeling workgroup)
- Key decisions on use of model results
    - Baseline conditions
    - Time frame
    - Level of precision
    - Strategies to address uncertainty
- Summary of models used for mine site dewatering/block caving effects
- Model used for mine water supply pumping effects

Status of Groundwater Modeling Workgroup

As noted in the FEIS, in September 2017, the Tonto National Forest convened a multidisciplinary team of professionals, referred to as the groundwater modeling workgroup. The groundwater modeling workgroup included Tonto National Forest and Washington-level U.S. Forest Service (Forest Service) hydrologists, the groundwater modeling experts on the project National Environmental Policy Act (NEPA) team, representatives from the Arizona Department of Water Resources (ADWR), Arizona Game and Fish Department, the U.S. Environmental Protection Agency (EPA), the San Carlos Apache Tribe, and Resolution Copper Mining, LLC (Resolution Copper), and its contractors. This group included not only hydrologists working on the groundwater model itself, but also the biologists and hydrologists who have conducted monitoring in the field and are knowledgeable about the springs, streams, and riparian systems in the project vicinity. The assessment of the model by the groundwater modeling workgroup, as well as the assessment of the conceptual hydrologic model upon which the numerical model is based, can be found in the technical memorandum summarizing the workgroup process and conclusions (BGC Engineering USA Inc. [BGC] 2018a).

As described in the FEIS, after publication of the draft EIS (DEIS) in August 2019, the groundwater modeling workgroup was reconvened as a more expansive water resources workgroup to assist with analysis of public comments.

Detailed Modeling Results for Groundwater-Dependent Ecosystems Summarized in the Environmental Impact Statement

The tables in the EIS summarize the impact to each GDE by using four general ranges (<10 feet, 10–30 feet, 30–50 feet, >50 feet). These ranges take into account the limitation in the precision of the modeling results determined by the groundwater modeling workgroup (i.e., drawdown results less than 10 feet are not reliable, given the modeling uncertainties and long time periods involved). The category of "<10 feet" drawdown, therefore, reflects that impacts are not anticipated.

During the groundwater modeling workgroup, one key decision made was that the no action alternative included continued dewatering of the deep groundwater system. As a result of this decision, the workgroup defined "impact" under the proposed action as the proposed action modeled drawdown minus the no action modeled drawdown. The reports produced by Resolution Copper's modeling contractors reflect this decision.

After receiving cooperating agency comments on the administrative draft of the DEIS in early 2019, the Forest Service decided that this approach—while consistent and valid—still caused confusion and perceived inconsistencies. As an example, consider spring DC-6.6W in Devil's Canyon. The no action modeled drawdown at 200 years is 1.04 feet, which Resolution Copper appropriately reports as "<10 feet." The proposed action modeled drawdown at 200 years is 10.81 feet, which Resolution Copper appropriately reports as "11 feet." But because the impact calculation is no action drawdown (1.04 feet) minus proposed action drawdown (10.81 feet), the impact result is 9.77 feet and, therefore, reported as "<10 feet." While meeting the conditions imposed by the workgroup, this leads to confusion as the reader can clearly see that greater than 10 feet of drawdown occurred at this spring but impacts still "are not anticipated."

The Forest Service determined that a simpler approach would be to report drawdown under the no action alternative and drawdown under the proposed action but do no further calculations. The intent of the impact calculation was to make clear which impacts to GDEs were caused by the approval of the mine; however, under this simpler approach the reader still can see clearly whether a GDE impacted by approval of the mine also was already impacted under the no action alternative.

For clarity, table 1 below matches up the various results in the record. These consist of

- reported no action drawdown (at end of mine life and at 200 years) from Resolution Copper's contractors;
- reported proposed action drawdown (at end of mine life and at 200 years) from Resolution Copper's contractors;
- reported proposed action "impact" (at end of mine life and at 200 years) from Resolution Copper's contractors;
- modeled drawdown for the no action alternative (at end of mine life and at 200 years), calculated directly by the NEPA team from raw modeling results;
- modeled drawdown for the proposed action (at end of mine life and at 200 years), calculated directly by the NEPA team from raw modeling results;
- EIS reported drawdown for the no action alternative (at end of mine life and at 200 years), using the ranges determined by the groundwater modeling workgroup (<10, 10–30, 30–50, >50 feet);
- EIS reported drawdown for the proposed action (at end of mine life and at 200 years), using these same ranges; and
- number of sensitivity runs (out of 87) with drawdown greater than 10 feet for the proposed action (at 200 years), as calculated directly by the NEPA team from raw modeling results.

Table 1. Detailed modeling output for impacts summarized in environmental impact statement

Specific GDE	Resolution Copper Contractor-Reported Drawdown (feet), No Action, End of Mine Life*	Resolution Copper Contractor-Reported Drawdown (feet), Proposed Action, End of Mine Life*	Resolution Copper Contractor-Reported Drawdown (feet), No Action, 200 years*	Resolution Copper Contractor-Reported Drawdown (feet), Proposed Action, 200 years*	Resolution Copper Contractor-Reported Impact Caused by Block Cave, End of Mine Life[†]	Resolution Copper Contractor-Reported Impact Caused by Block Cave, 200 years[†]	Raw Model Output - Drawdown under No Action, End of Mine Life[‡]	Raw Model Output - Drawdown under Proposed Action, End of Mine Life[§]	Raw Model Output - Drawdown under No Action, 200 years[‡]	Raw Model Output - Drawdown under Proposed Action, 200 years[§]	Drawdown as Reported in EIS Section 3.7.1, No Action, End of Mine Life	Drawdown as Reported in EIS Section 3.7.1, Proposed Action, End of Mine Life	Drawdown as Reported in EIS Section 3.7.1, No Action, 200 years	Drawdown as Reported in EIS Section 3.7.1, Proposed Action, 200 years	Number of Sensitivity Runs with Proposed Action Drawdown greater than 10 feet, 200 years[§]
Queen Creek and tributaries															
Queen Creek - Flowing reach from kilometer (km) 17.39 to km 15.55	<10	<10	<10	<10	<10	<10	3.2	3.5	0.8	6.3	<10	<10	<10	<10	4 (of 87)
Queen Creek - Whitlow Ranch Dam Outlet[¶]	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not available	Not available	Not available	Not available	<10	<10	<10	<10	Not available
Arnett Creek (from Blue Spring to confluence with Queen Creek) AC12.49 AC4.54	<10 <10	<10 <10	<10 <10	<10 <10	<10 <10	<10 <10	0.5 0.1	0.5 0.1	1.1 0.1	2.3 0.2	<10	<10	<10	<10	0 (of 87) 0 (of 87)
Telegraph Canyon (near confluence with Arnett Creek)	<10	<10	<10	<10	<10	<10	1.2	1.3	1.1	2.7	<10	<10	<10	<10	0 (of 87)
Devil's Canyon and springs along channel															
Middle Devil's Canyon (from km 9.3 to km 6.1, including springs DC8.2W, DC6.6W, and DC6.1E) DC6.1E DC6.6W DC8.2W DC8.8W DC8.1C	<10 <10 <10 <10 <10	<10 <10 <10 <10 <10	<10 <10 <10 <10 <10	<10 11 <10 <10 <10	<10 <10 <10 <10 <10	<10 <10 <10 <10 <10	0.7 2.1 0.3 0.2 0.2	1.6 4.7 4.1 2.9 3.0	0.1 1.0 −0.2 −0.1 −0.1	2.8 10.8 4.3 3.1 3.2	<10	<10	<10	10–30 (Spring DC-6.6W)	0 (of 87) 76 (of 87) 1 (of 87) 1 (of 87) 1 (of 87)
Lower Devil's Canyon (from km 6.1 to confluence with Mineral Creek, including spring DC4.1E) 5.5C 4.1E	<10 <10	<10 <10	<10 <10	<10 <10	<10 <10	<10 <10	0.2 0.1	2.1 0.4	−0.3 −0.1	2.8 0.5	<10	<10	<10	<10	0 (of 87) 0 (of 87)

Specific GDE	Resolution Copper Contractor-Reported Drawdown (feet), No Action, End of Mine Life*	Resolution Copper Contractor-Reported Drawdown (feet), Proposed Action, End of Mine Life*	Resolution Copper Contractor-Reported Drawdown (feet), No Action, 200 years*	Resolution Copper Contractor-Reported Drawdown (feet), Proposed Action, 200 years*	Resolution Copper Contractor-Reported Impact Caused by Block Cave, End of Mine Life†	Resolution Copper Contractor-Reported Impact Caused by Block Cave, 200 years†	Raw Model Output - Drawdown under No Action, End of Mine Life‡	Raw Model Output - Drawdown under Proposed Action, End of Mine Life§	Raw Model Output - Drawdown under No Action, 200 years‡	Raw Model Output - Drawdown under Proposed Action, 200 years§	Drawdown as Reported in EIS Section 3.7.1, No Action, End of Mine Life	Drawdown as Reported in EIS Section 3.7.1, Proposed Action, End of Mine Life	Drawdown as Reported in EIS Section 3.7.1, No Action, 200 years	Drawdown as Reported in EIS Section 3.7.1, Proposed Action, 200 years	Number of Sensitivity Runs with Proposed Action Drawdown greater than 10 feet, 200 years§
Mineral Creek and springs along channel															
Mineral Creek (from Government Spring [km 8.7] to confluence with Devil's Canyon, including springs MC8.4C and MC3.4W [Wet Leg Spring]) MC6.9 Lower Mineral	<10 <10	<10 <10	<10 <10	<10 <10	<10 <10	<10 <10	0.2 0.1	0.9 0.3	–0.1 0.0	1.4 0.5	<10	<10	<10	<10	0 (of 87) 0 (of 87)
Queen Creek basin springs															
Bitter Spring	<10	<10	<10	11	<10	<10	12.5	15.0	2.0	28.5	10–30	10–30	<10	10–30	87 (of 87)
Bored Spring	38	41	105	181	<10	76	38.0	41.5	105.0	108.9	30–50	30–50	>50	>50	87 (of 87)
Hidden Spring	15	17	49	91	<10	42	15.4	17.0	49.2	90.7	10–30	10–30	30–50	>50	87 (of 87)
Iberri Spring	<10	<10	<10	<10	<10	<10	0.1	0.1	0.1	0.2	<10	<10	<10	<10	1 (of 87)
Kane Spring	<10	<10	<10	57	<10	49	3.4	4.3	7.7	56.6	<10	<10	<10	>50	84 (of 87)
McGinnel Mine Spring	<10	<10	18	23	<10	<10	5.5	5.7	18.0	22.7	<10	<10	10–30	10–30	86 (of 87)
McGinnel Spring	<10	<10	24	28	<10	<10	7.1	7.2	24.0	28.3	<10	<10	10–30	10–30	85 (of 87)
No Name Spring	<10	<10	<10	<10	<10	<10	0.1	0.1	0.1	0.2	<10	<10	<10	<10	0 (of 87)
Rock Horizontal Spring	<10	<10	<10	<10	<10	<10	0.6	0.7	1.3	2.0	<10	<10	<10	<10	0 (of 87)
Walker Spring	14	14	27	41	<10	14	14.0	14.2	27.1	40.9	10–30	10–30	10–30	30–50	87 (of 87)
Water supply wells															
DHRES_16_753	<10	10	<10	22	<10	18	9.5	10.1	3.6	21.7	<10	10–30	<10	10–30	86 (of 87)
Gallery Well	<10	<10	<10	<10	<10	<10	0.0	0.0	0.0	0.1	<10	<10	<10	<10	0 (of 87)
HRES-06	<10	<10	<10	<10	<10	10	1.2	7.1	–0.7	9.7	<10	<10	<10	<10	17 (of 87)

Note: All results shown for the time period of 200 years after start of mining. Full hydrographs are included as an appendix to the EIS.

* WSP "Memo: Resolution Copper Groundwater Flow Model – Predictive Results," October 31, 2018. table 2. (Meza-Cuadra et al. 2018b).

† WSP "Memo: Resolution Copper Groundwater Flow Model – Predictive Results," October 31, 2018. table 3. (Meza-Cuadra et al. 2018b).

‡ Estimated from raw model data provided by WSP (Meza-Cuadra et al. 2018c). Calculated by subtraction of no action modeled water elevation for time step Day 73,050 (200 years) minus no action modeled water level elevation for time step Day 365 (1 year).

§ Estimated from raw model data provided by WSP (Meza-Cuadra et al. 2018c). Calculated by subtraction of proposed action modeled water elevation for time step Day 73,050 (200 years) minus proposed action modeled water level elevation for time step Day 365 (1 year).

¶ Whitlow Ranch Dam Outlet is not modeled specifically, as this cell is defined by a constant head in the model. Output described is based on estimated head levels at this location.

Assumption of Hydrologic Connection

Identifying whether a GDE derives flow from deeper aquifers or shallow aquifers was a key part of the effort of the groundwater modeling workgroup. A number of lines of evidence helped determine the most likely groundwater source for a number of GDEs: hydrological and geological framework, inorganic water quality, isotopes, riparian vegetation, and the flow rate or presence of water; however, many more GDEs had little or no evidence to consider, or the multiple lines of evidence led to contradictory conclusions. In order to conduct a conservative analysis (i.e., assuming that GDEs could be impacted by drawdown rather than ruling them out), in these cases it was assumed that a GDE has the potential to be impacted. This choice reflects general Forest Service policy:

> "The national ground water policy sets out the framework in which groundwater resources are to be managed on NFS lands. The policy is designed to be located in two parts of the Forest Service Manual, FSM 2880, Geologic Resources, Hazards, and Services, and FSM 2543, Ground Water Resource Management. As of the publication date of this technical guide [May 2007], FSM 2543 is in draft form and may change due to agency and public comment prior to finalization. Regional Foresters and Forest Supervisors are directed by the national ground water policy to perform the duties detailed below . . .
>
> Always assume that hydrological connections exist between ground water and surface water in each watershed, unless it can be reasonably shown none exist in a local situation." (Forest Service 2007: 5–6)

Assessment of Need to Collect Additional Information

In several circumstances in the analysis of groundwater quantity and GDEs (section 3.7.1 of the EIS), uncertainties exist. These include uncertainties with the source of some GDEs (as noted above), as well as uncertainties that exist within the groundwater model, particularly where connections are present between groundwater and surface waters.

These uncertainties do not undermine the analysis and would not be remedied by additional data collection. Council on Environmental Quality regulations address the need for additional data collection under 40 Code of Federal Regulations (CFR) 1502.22. The ability to collect additional information needs to be addressed when "the incomplete information relevant to reasonably foreseeable significant adverse impacts is *essential to a reasoned choice among alternatives*" (emphasis added).

In this case, all impacts caused by groundwater drawdown are common among all alternatives. The only differences between alternatives are those GDEs that are directly disturbed within the tailings storage facility footprint. The groundwater modeling does not represent a point of difference between alternatives; therefore, the primary concern is that the disclosure of impacts is reasonable and conservative (i.e., not underestimating impacts). The modeling choices and assumptions made provide for a conservative disclosure of impacts.

Rationale for Use of East Salt River Valley Model for Desert Wellfield

The above modeling discussion is specific to the drawdown caused by the mine dewatering and block caving. Elsewhere, the makeup water supply for the mine would be pumped from a series of groundwater wells located along the MARRCO corridor in the East Salt River valley subbasin; these wells are known as the Desert Wellfield.

The Desert Wellfield is located beyond the modeling domain for the Resolution Copper groundwater model, which ends at Whitlow Ranch Dam. To model the impact of pumping from the Desert Wellfield, Resolution Copper obtained and updated ADWR's Salt River Valley groundwater flow model. This model has been developed and used by ADWR since the early 1990s and has been updated multiple times. It is widely used for planning purposes, including specific planning scenarios within the East Salt River valley subbasin (Hipke 2007). Because this tool has already been widely validated, the Forest Service did not consider it necessary for the groundwater modeling workgroup to review this modeling work for the DEIS.

Further, the types of impacts occurring in the East Salt River valley subbasin are less complicated than those occurring at the mine site:

- The Desert Wellfield taps a large, deep alluvial aquifer with well-documented hydraulic properties.
- The basic effects of pumping from large alluvial basins is easily calculated, even without resorting to groundwater flow models.
- More importantly, groundwater levels in this area are deep enough (400–500 feet) that there are no questions of any connections to GDEs or possibility of impacts to GDEs resulting from pumping at the Desert Wellfield.

Based on public comments on the DEIS, however, further review of the Desert Wellfield model was undertaken to ensure that it represented a reasonable tool for estimating impacts to groundwater levels (Walser 2020a).

Subsidence Related to Groundwater Withdrawal – Desert Wellfield

Most deep alluvial basins in central Arizona have the potential for subsidence and earth fissures to occur related to groundwater withdrawal. Subsidence occurs when sediments consolidate as groundwater is removed, which ultimately causes a lowering of the ground surface. Fissures tend to appear near basin margins or where underlying geology causes subsidence of the alluvial sediments to occur at different rates, known as differential subsidence. Subsidence is irreversible. The material consolidation remains even if groundwater levels later recover or rise (Arizona Department of Water Resources n.d.).

No earth fissures have been specifically mapped in the vicinity of the Desert Wellfield; however, this area also falls outside of any detailed study areas. Subsidence fissures have been mapped at two nearby study areas in the same subbasin: the Hawk Rock study area near Apache Junction (approximately 10 miles to the northwest) and the Chandler Heights study area near the San Tan

Mountains (approximately 10 miles to the southwest). Since 2005, ADWR also has conducted aerial surveying to detect changes in land surface elevation, using Interferometric Synthetic Aperture Radar (InSAR) data. No subsidence has been detected around the Desert Wellfield, but ADWR survey data show subsidence areas exist to the northwest (approximately 5 miles away) and to the southwest (approximately 10 miles away).

Groundwater levels in this area have been rising since the late 1980s/early 1990s. For instance, measured groundwater levels have risen 60 to 85 feet in the last few decades near the Desert Wellfield, and as much as 170 feet farther south near New Magma Irrigation Drainage District (Bates et al. 2018). In the broader basin, the impacts caused by withdrawals from the Desert Wellfield will not exceed these historical conditions. In the immediate vicinity of the Desert Wellfield, the drawdown caused by mine water supply pumping would be greater than that historically observed.

Long-term drawdown of 10 to 30 feet from Desert Wellfield pumping is modeled to occur in the nearby known subsidence areas. Any groundwater pumping within a groundwater basin with known subsidence has the potential to contribute to that subsidence, including the pumping from the Desert Wellfield.

For the DEIS, it was determined that further detailed analysis is not feasible beyond noting the potential for any pumping to contribute to drawdown and subsidence. Subsidence effects are a basin-wide phenomenon, and analytical tools do not exist to isolate the impact from one individual pumping source on subsidence.

Based on public comments on the DEIS, however, further review was undertaken to quantify potential subsidence impacts attributable to the Desert Wellfield pumping (Walser 2020b).

Subsidence Related to Groundwater Withdrawal – East Plant Site

Aside from the alluvial basin where the Desert Wellfield is located, there is also potential for land subsidence due to dewatering of the deep aquifer as part of mining operations. But unlike the Desert Wellfield, dewatering pumping is currently taking place and the Oak Flat area has been directly monitored for active land subsidence for some years.

Resolution Copper has analyzed land subsidence using the same InSAR technique used by ADWR, specifically using archive imagery from the RADARSAT-2 satellite acquired between 2011 and 2016 and from the ENVISAT ASAR satellite between 2004 and 2010 (3v Geomatics Inc. 2016).

No subsidence greater than 0.06 inch per year was observed between 2004 and 2010. The analysis concluded that subsidence appears to begin between 2010 and 2011 for most points in the analysis area, reaching a rate of 0.3 inch per year in 2016. Total land surface downward displacement observed in the analysis area since 2011 is approximately 1.5 inches.

These levels of displacement—while observable—are consistent with pumping from aquifers comprising fractured rock, which do not exhibit compression like alluvial sediments. Ultimately, the effect of ground subsidence solely from dewatering pumping is moot. Once operations begin, any observable displacement caused by groundwater pumping would be subsumed by the much greater subsidence caused by block caving.

Inability to Analyze Individual Wells

To evaluate the effects of groundwater drawdown on an individual well, a number of details need to be known about the well construction and operation. These include depth to water, depth of well, location of perforated intervals, and the type and depth of pump equipment within the well. In general, individual water supply wells vary so much that it is not feasible to analyze them one by one. For instance, a hypothetical 10-foot drop in the water table could leave a shallow well completely dry and require it to be redrilled to a greater depth. The same drawdown could require a different well owner to set their pump 10 feet lower but otherwise not be affected, or it could have no noticeable effect at all on a well drilled slightly deeper with a deeper pump. The impact depends heavily on the exact construction of the well and equipment installed.

Most wells in the modeling area are considered to be exempt wells; these wells are small enough that they do not require a specific groundwater right in order to pump for domestic and stock purposes. Reporting requirements for exempt wells are virtually nonexistent, except when the well is originally drilled. Even then, often key details like pump type and depth are not reported. This makes any compilation of individual well information from existing data sources incomplete. Nor is it feasible to collect such information in the field. If not known by the well owner, observing pump depth or pump settings would require disrupting water service for wells by physically pulling the pump from the well.

Ultimately, the groundwater model is still useful for determining whether local wells and water supplies would be disrupted by dewatering. In lieu of analyzing individual wells, typical wells in key communities were analyzed using the groundwater flow model, including wells near Top-of-the-World (using well HRES-06 as a proxy), wells within the town of Superior (using well DHRES-16 as a proxy), and wells near Boyce Thompson Arboretum (using the Gallery well as a proxy).

Available Groundwater in East Salt River Valley

The holistic effects of regional groundwater use were evaluated in the cumulative effects subsection of section 3.7.1 of the DEIS. This approach was expanded in the FEIS in chapter 4—the new stand-alone cumulative effects chapter—to include many aspects of regional water supplies raised by commenters during scoping and during public comments on the DEIS. These include climate change, drought, Colorado River water shortages and the Drought Contingency Plan, development and population growth in the East Salt River valley, and predictions of shortages in the Pinal Active Management Area.

Full Detail for Tailings Water Balances

The original water balance for the general plan of operations (GPO) is evaluated in Rietz (2016). The full water balances for all tailings alternatives is evaluated in Ritter (2018).

Percent Contribution of Spring DC6.6W to Devil's Canyon

Spring DC6.6W is anticipated to be impacted by the proposed action, and it is important to assess the magnitude of the contribution of this spring to flow in Devil's Canyon. Table 2 summarizes the spring flow information available from spring DC6.6W with the nearest downstream monitoring location (DC5.5C). Eleven monitoring events provide reasonable overlap to allow contribution to be estimated; the contribution of spring DC6.6W to Devil's Canyon ranges approximately from 0 to 5 percent. This information is used in the impacts analysis in section 3.7.1 of the EIS.

Table 2. Monitoring data for springs DC6.6W and DC5.5C

Date of Available Flow Data for DC6.6W	Flow Measurement or Estimate for DC6.6W (gallons per minute)	Date of Available Flow Data for DC5.5C	Flow Measurement or Estimate for DC5.5C (gallons per minute)	Estimated Percent Contribution of DC6.6W to Devil's Canyon
5/29/2003	0	No data	No data	No data
9/3/2003	0	No data	No data	No data
11/4/2003	1	11/10/2003	22	4.55%
2/18/2004	1	2/25/2004	500	0.20%
5/5/2004	0	5/20/2004	11	0.00%
8/19/2004	0	8/23/2004	9	0.00%
11/12/2004	1	11/18/2004	60	1.67%
2/16/2005	32	2/28/2005	10,500	0.30%
5/17/2005	0	5/24/2005	18	0.00%
9/7/2005	0	8/23/2005	40	0.00%
No data	No data	2/25/2009	1,400	No data
No data	No data	3/19/2010	1,600	No data
No data	No data	7/16/2010	10	No data
No data	No data	10/19/2010	7	No data
No data	No data	8/26/2011	5	No data
No data	No data	3/6/2012	160	No data
5/4/2012	2	No data	No data	No data
2/27/2014	1	2/25/2014	75	1.33%
No data	No data	5/20/2014	6	No data
9/25/2014	0.1	8/28/2014	15	0.67%
11/7/2014	1	11/25/2014	35	2.86%

Regulations, Laws, and Guidance – Groundwater Quantity

Mining operations are subject to a wide range of Federal, State, and local requirements. Table 3 provides a summary of water resources laws, regulations, policies, and plans at the Federal, State, and local level.

Table 3. Laws, regulations, policies, and guidance applicable to groundwater resources

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Arizona Administrative Code R12-15, Article 8, Well Permits/Well Construction Standards	All wells drilled within Arizona, as well as borings greater than 100 feet deep, must comply with well construction standards, as administered by the ADWR. Authorization is obtained by filing of a notice of intent with the ADWR. Well construction standards also apply to proper capping and abandonment of wells and borings when no longer needed.	Resolution Copper noted in the GPO that as many as 30 wells could be drilled for the Desert Wellfield; however, based on modeling, approximately 12 wells would be required to meet the supply.
Arizona Groundwater Management Act of 1980	Established a sustainable groundwater goal of achieving "safe yield" by 2025 in the most populous areas of the state. As established under this Act, all pumping of groundwater within an active management area requires some form of groundwater right or groundwater withdrawal permit.	The water supply for the Resolution Copper mine would be withdrawn from wells located within the Phoenix Active Management Area and would require some form of groundwater right. The exact type of right is not yet determined but pumping is likely to be allowed either under a mineral extraction permit or by permitting the Desert Wellfield as recovery wells to recover stored recharge credits.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Arizona Water Settlements Act of 2004	Title I of the legislation provides adjustments to the allocations of Central Arizona Project (CAP) water and settles litigation between the United States and the Central Arizona Water Conservation District (CAWCD) regarding repayment of the CAP. Title II authorized the Gila River Indian Community Water Rights Settlement and Title III amended and reauthorized the Southern Arizona Water Rights Settlement Act of 1982. The Act represents a significant accomplishment and settles numerous water rights issues in Arizona. The settlements provide funding that will enable the Gila River Indian Community and Tohono O'odham Nation to rehabilitate and expand water infrastructure to meet the needs of their reservations. The settlement also provides funds to pay the fixed operation and maintenance charges associated with delivery of CAP water to Arizona Indian tribes. The Act allows Tribes to make use of water rights that previously existed only on paper.	Pursuant to the Arizona Water Settlements Act, the CAWCD and Bureau of Reclamation periodically redistribute designated non-Indian agricultural priority CAP water. In 2013, Resolution Copper applied for a portion of the non-Indian agricultural water allocations for use on the project. This possibility was considered as a possible reasonably foreseeable future action during the NEPA process.
Tonto National Forest and Land Resource Management Plan	Establishes the long-term management of the Tonto National Forest. The plan accommodates for multiple use, maximizes long-term net public benefits in an environmentally sound manner through sustained yield of goods and services from the forest.	Standard guidelines in the Tonto National Forest Plan (October 1985, as amended) call for compliance with the State of Arizona's Ground Water Management Act.
Forest Service Manual 2520	Provides guidance for watershed protection and management.	Relevant areas of responsibility include planning, implementing, and monitoring watershed improvements (including abandoned mine lands); managing riparian areas for long-term conservation, productivity, biological diversity, and ecosystem integrity; and managing wetlands and floodplains.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Forest Service Manual 2530	Provides guidance for water resource management.	Areas relevant to Resolution Copper mine include integrating water resource management with land management plans, coordinating with other agencies, conducting water resource investigations and collecting hydrologic data, and managing and monitoring water quality. Water quality management and monitoring have the specific objective of protecting and improving water quality to allow beneficial uses on National Forest System land.
Forest Service Manual 2880	Provides direction for the inventory and analysis of GDE ecosystems.	Resolution Copper and the Forest Service must abide by set guidelines for hydrogeological investigation techniques.
Arizona Revised Statutes Sections 45-831.01 and 45-852.01	Artificial recharge of water to an aquifer requires issuance of a water storage permit by the ADWR. Contracting of available CAP water is a separate process executed through the CAWCD.	Between 2006 and 2011, Resolution Copper arranged for delivery of approximately 190,000 acre-feet of CAP water to New Magma Irrigation and Drainage District (NMIDD). NMIDD has been permitted as a "groundwater savings facility" through ADWR. At a groundwater savings facility, legal groundwater pumping (allowed with irrigation groundwater rights) is foregone by farmers and renewable surface water is used on crops instead. This mechanism allows groundwater to stay in the aquifer (which has the same effect as the physical recharge of water) within the same basin from which the Desert Wellfield will eventually withdraw groundwater. Resolution Copper undertook similar measures for Roosevelt Water Conservation District (located in the East Salt River valley, west of the Desert Wellfield) for an additional 14,000 acre-feet of water. Resolution Copper has also physically recharged approximately 20,000 acre-feet of water at the Tonopah Desert Recharge Project; this facility is located west of the Phoenix metropolitan area and not in the same aquifer, but within the Phoenix Active Management Area.

Key Documents and References Cited for Groundwater Quantity and Groundwater Modeling

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Detailed Information Supporting Environmental Impact Statement Analysis – Groundwater and Surface Water Quality

Resource Analysis Area

Spatial Analysis Area

The spatial bounds of analysis (analysis area) for groundwater quality includes the block-cave zone, each alternative tailings footprint, and the respective portion of aquifer downgradient from each tailings facility. For the Near West (Alternatives 2 and 3) and Silver King (Alternative 4) tailings locations, this includes the fractured rock aquifer beneath the facilities, the alluvial materials in ephemeral washes that are tributary to Queen Creek, and the alluvial aquifer along Queen Creek itself. For the Peg Leg (Alternative 5) tailings location, the analysis area includes the alluvial materials beneath the facility and extending to the Gila River. For the Skunk Camp (Alternative 6) tailings location, the analysis area includes the fractured rock aquifer beneath the facility and the alluvial materials along Dripping Spring Wash, extending to the Gila River. These analysis areas capture potential changes in groundwater quality immediately below the tailings facility, as well as the likely migration pathway downgradient. The spatial bounds of analysis for surface water quality are similar but consist of the surface watersheds and drainages downstream from tailings facilities, including tributaries to Queen Creek, Queen Creek itself, Donnelly Wash, Dripping Spring Wash, and the Gila River.

Temporal Analysis

A series of linked models was used to estimate the impacts to water quality due to seepage from the tailings facility. Each model analyzes a different time frame:

- Groundwater flow model. As described above, this model extends to 1,000 years post-closure. The inputs used from the groundwater flow model to inform the block-cave geochemistry model extended through the operational life of the mine only (41 years).
- Block-cave geochemistry model. This model extends through the operational life of the mine (41 years).
- Tailings solute geochemistry models. These models (one per alternative) extend through the operational life of the mine (41 years).
- Embankment sulfide oxidation model. This model extends through the 41 years of operation and an additional 204 years post-closure, for 245 years total. This time frame matches that used for the bypass seepage mixing/loading models.
- Bypass seepage mixing/loading models. These models (one per alternative) extend through the operational life of the mine (41 years), and an additional 204 years post-closure, for 245 years total. This time frame was selected by Montgomery and Associates, informed by discussions of the groundwater modeling workgroup that limited the use of quantitative modeling results to 200 years. As with groundwater modeling results, qualitative ongoing trends in water quality concentrations are disclosed as well in the results (see, specifically, the

appendix with water quality plots referenced in section 3.7.2). Note that an additional refined numerical water quality model was prepared for the FEIS for Alternative 6; this model extends beyond 245 years, but output was used to correspond with the time steps of the other mixing/loading models.

Analysis Methodology

This section discusses aspects of the analysis that are not included in the EIS but are still necessary building blocks for the disclosures in the EIS. The following aspects of the analysis methodology are discussed in full in the EIS and are not repeated here:

- Overall geochemistry modeling process.
- The block-cave geochemistry model, including modeling details and assumptions, uncertain and unknown information.
- The tailings solute models, including modeling details and assumptions, uncertain and unknown information.
- The embankment sulfide oxidation model, including modeling details and assumptions, uncertain and unknown information.
- The tailings seepage models, including modeling details, estimates of total and lost seepage, and assumptions, uncertain and unknown information.
- The bypass seepage mixing/loading models, including modeling details and assumptions, uncertain and unknown information.
- The overall effect of uncertainties on the model outcomes, including
    - uncertainty of hydrogeological framework,
    - uncertainty of background water quality,
    - uncertainty of block-cave oxidation,
    - uncertainty of effectiveness of engineered seepage controls, and
    - conclusions as to reasonableness of models.
- Forest Service disclosure and Arizona Department of Environmental Quality (ADEQ) permitting requirements, including discussions on
    - assimilative capacity and
    - impaired waters.
- Constituents of concern.

Details of Geochemistry Workgroup

Similar to geology and subsidence and groundwater modeling, a multidisciplinary workgroup was formed to evaluate the techniques, assumptions, and processes used by Resolution Copper to assess water quality. The workgroup includes specialists from the NEPA team in geochemistry, hydrology, and tailings and mine processes. The workgroup held their initial meeting in November 2016.

Assimilative Capacity Calculations

The EIS contains summaries of estimated reductions in assimilative capacity. The detailed calculations are included in this process memorandum as attachments 1 and 2.

Reduced Assimilative Capacity from Reductions in Runoff

The change of surface flow conditions potentially could also change the assimilative capacity by reducing the amount of stormwater that would dilute the pollutant load. In reality, because all parts of the watershed contribute to the pollutant load in these systems, the reduction in stormwater runoff from the subsidence crater and tailings facility would almost certainly be accompanied by some reduction in pollutant load as well. On the balance, water quality concentrations and assimilative capacity might not be affected at all by reduced flow conditions.

For the purposes of the EIS, however, the change in assimilative capacity was estimated by assuming only the stormwater runoff changed, while the pollutant load remained the same. These calculations are included in this process memorandum as attachments 3 and 4.

Existing Groundwater Quality – Frequency of Samples with Concentrations Above Standards

The EIS contains characterizations of the quality of existing groundwater in the shallow system, Apache Leap Tuff aquifer, and deep groundwater system. The terms used in the text to describe the frequency with which samples occur that are above various standards are qualitative: "rarely," "occasionally," and "often." Table 4 contains the quantitative basis for these qualitative descriptions.

- "Rarely" means concentrations were above standards in less than 15 percent of the available samples.
- "Occasionally" means concentrations were above standards in 15 to 30 percent of the available samples.
- "Often" means concentrations were above standards in more than 30 percent of the available samples.

Table 4. Samples with concentrations above Arizona Numeric Aquifer Water Quality Standards or U.S. Environmental Protection Agency primary or secondary maximum contaminant levels

	Al	As	Be	Cd	Cr	Cu	F	Fe	Mn	Ni	NO_3	Pb	Sb	SO_4	TDS	Th
Arizona numeric AWQS (mg/L)	–*	0.05	0.004	0.005	0.1	–	4	–	–	0.1	10	0.05	0.006	–	–	0.002
EPA primary MCL (mg/L)	–	0.01	0.004	0.005	0.1	–	4	–	–	–	10	0	0.006	–	–	0.002
EPA secondary MCL (mg/L)	0.05	–	–	–	–	1	2	0.3	0.05	–	–	0.015	–	250	500	–
Shallow System																
Total samples†	29	28	29	29	15	29	31	29	26	29	29	29	29	30	26	29
Number samples above AWQS	–	0	0	0	0	–	0	–	–	0	2	0	0	–	–	0
Number samples above EPA MCLs	5	0	0	0	0	0	0	4	12	–	2	1	0	4	6	0
Apache Leap Tuff Aquifer																
Total samples†	151	152	104	151	47	151	116	151	144	151	180	152	92	117	112	92
Number samples above AWQS	–	0	6	0	0	0	0	–	–	0	0	0	2	–	–	10
Number samples above EPA MCLs	44	0	6	0	0	0	0	27	37	–	0	0	2	028	2	10
Deep System																
Total samples†	37	39	36	37	15	39	19	37	39	39	33	39	37	19	20	37
Number samples above AWQS	–	1	0	1	1	–	3	–	–	1	0	1	1	–	–	1
Number samples above EPA MCLs	15	2	0	1	1	1	6	15	15	–	0	1	1	6	8	1

Notes: Al =

AWQS = Aquifer Water Quality Standards; MCL = maximum contaminant level (for lead, the action level of 0.015 is used); mg/L = milligrams per liter.

"Rarely" means concentrations were above standards in less than 15 percent of the available samples.

"Occasionally" means concentrations were above standards in 15 to 30 percent of the available samples.

"Often" means concentrations were above standards in more than 30 percent of the available samples.

* Dash indicates there is no applicable standard for this constituent. This table includes only constituents for which some samples had concentrations above standards.

† Includes both total and dissolved samples, except for chromium (only total shown).

Evolution of the Fully Lined Alternative

During alternatives development, based on scoping comments, the Forest Service pursued a "fully lined" concept for the tailings storage facility. "Lined" was taken to mean either a synthetic geomembrane (high-density polyethylene [HDPE] or linear low-density polyethylene) or a geosynthetic clay liner. As alternatives evolved, the concept of a fully lined facility evolved as well, for three primary reasons:

- Requiring a full liner on a slurry tailings facility has safety ramifications. Controlling the amount of water present in the tailings, particularly within the embankment, is one of the most important factors for determining the stability and ultimate safety of a facility (discussed in detail in section 3.10.1 of the EIS). If a full liner were used, seepage would still leave the facility, because a seepage collection system would be used in conjunction with any liners, but there are serious safety ramifications if the seepage collection system failed or operated poorly.
- There are concerns over the practicability of a geomembrane or geosynthetic clay liner being used on such an unprecedented scale, on the terrain being considered. Practical installation concerns include the ability to prevent defects from occurring, given the height of the facility and static pressure that would be on the liner, and the conditions (hot and dry) under which it would be installed (Pilz 2018). Operational concerns include the longevity of the liner, particularly under potential acid drainage conditions (Meyer 2018), and the ability to maintain low hydraulic heads above the liner (Pilz 2018), since seepage increases almost linearly with increased head. KCB (2019a) noted specific practicability concerns with Alternative 4, including the steep and rugged terrain and the unprecedented size, height, and slope.
- There are other methods of creating low-permeability layers in the facility that would be equally or more effective than a liner. Rather than a single tool to control seepage, a variety of tools are available that can be applied where they will be the most effective. For instance, Pilz (2018) indicates that low conductivity tailings (typically slime or overflow tailings) can have a permeability of less than 1×10^{-6} or 1×10^{-7} centimeters/second. This is less than the permeability required under Arizona prescriptive best available demonstration control technology (BADCT), as described below.

Estimate of Seepage from a Fully Lined Facility

"Fully lined" is a generic term. In reality, a number of different techniques are used in the field to approach full containment. Compacted clay could be used if sufficient natural material were available, which is not the case for the Resolution Copper Project. In lieu of that, a geosynthetic clay liner could be used, which is typically a bentonite clay layer sandwiched between two geotextile layers, or a geomembrane (such as 1.5-millimeter-thick HDPE). A more advanced system might use a composite liner, which is composed of a geomembrane over a clay liner, which can either be a compacted clay liner (if sufficient natural material exists nearby) or a geosynthetic clay liner.

Rowe (2012) notes that in the absence of holes, the leakage of water through a typical geomembrane is negligible, but that it is extremely difficult to ensure no holes exist in practical situations. Confounding factors leading to holes include

- manufacturing defects,
- handling of the geomembrane rolls,
- on-site placement and seaming (i.e., connecting adjacent rolls),
- placement of drainage gravel over the liner system,
- traffic over the liner, and
- stress cracking as the geomembrane ages.

Field research by Nosko and Touze-Foltz (2000) documented failures of geomembranes at 300 sites in 16 countries (over 3 million square meters of geomembrane) and characterized over 4,000 points of damage, coming to approximately 5 holes per acre. Design guidance suggests that 1 to 2 holes per acre is reasonable for design considerations (Rowe 2012).

The amount of seepage through a liner is driven by Darcy's Law and depends on the hydraulic head above the liner. Estimates of total flow through various liners (in feet per year) is shown in table 5, for a variety of liner types.

Table 5. Total flow through liner under various conditions (feet/year)

	Head = 1 foot	Head = 16.5 feet
Geomembrane* (2 holes per acre)	0.24	0.96
Geosynthetic clay layer†	0.16	2.65
Compacted clay layer†	0.16	0.96
Composite liner‡ of geomembrane/geosynthetic clay layer (2 holes per acre)	2.4×10^{-6}	4.1×10^{-5}
Composite liner‡ of geomembrane/compacted clay layer (2 holes per acre)	2.4×10^{-4}	3.1×10^{-3}

* Geomembrane data based on Rowe, table 2 (2012). Assumes radius of hole as 1 millimeter (mm).

† Geosynthetic clay layer (GCL) and compacted clay layer (CCL) based on Rowe, table 3 (2012). Assumes no attenuation layer and unsaturated zone below liner; thickness of 0.01 meter (m) for GCL, 0.6 m for CCL; conductivity of 5×10^{-11} meter per second (m/s) for GCL, 1×10^{-9} m/s for CCL.

‡ Composite liner based on Rowe, tables 7 and 8 (2012). Assumes conductivity of liner of 7×10^{-12} m/s, theta of 1×10^{-10} m^2/s, hole radius of 5.64 mm (for geomembrane/GCL) and 1 mm (geomembrane/CCL).

A composite liner would achieve the best performance, from virtually no seepage to approximately 12 acre-feet per year over a 4,000-acre facility, depending on total head above the liner. The more likely geomembrane or geosynthetic clay liner could yield from 600 to 10,000 acre-feet per year seepage over a 4,000-acre facility. It is reported that none of these techniques is precedented below a tailings storage facility at this scale (Pilz 2018).

The geomembrane liner is used for comparison in the EIS. Arizona prescriptive BADCT allows for multiple techniques and one of those is: "Heap Leach Pad or tailing facility composite liner." This calls for a geomembrane at least 30 mils thick (60 mils for HDPE), underlain by at least 12 inches of native or natural ⅜-inch minus materials compacted in two 6-inch lifts to achieve a saturated hydraulic conductivity no greater than 10^{-6} centimeters/second (ADEQ 2004). Seepage for a geomembrane over a 3,300-acre facility would be at least 792 acre-feet per year, with minimal head (1 foot) over the liner.

Evaluation of Filtered Tailings at Other Tailings Locations

One concern raised by cooperating agencies during alternatives development and review of the administrative draft of the DEIS in early 2019 is the ability for the document to support the evaluation of filtered tailings at locations other than Silver King.

During the NEPA process, it is not necessary to analyze every permutation of every possible tailings location, disposal technique, and facility design. During alternatives development the NEPA team focused on identifying a reasonable range of alternatives that would still result in an adequate analysis of the key characteristics of a tailings facility. The application of filtered tailings technologies to alternative locations was considered but the NEPA team determined that the analysis of filtered tailings at the Silver King location would be sufficient to assess the environmental impact of filtered tailings at all locations, if desired.

After completion of the analysis, this decision is borne out by the results. Three primary types of impacts are pertinent to whether filtered tailings could be used at other locations: air quality, tailings safety, and water quality.

Air Quality

During alternatives analysis, before modeling was completed, it was not clear whether filtered tailings would result in more or less particulate emissions from fugitive dust than a traditional slurry tailings facility. Emissions modeling of the alternatives, with all applicant-committed environmental protection measures in place, shows that particulate emissions from Alternative 4 are fundamentally no different from other tailings alternatives. For example:

- Slurry alternative emissions for particulate matter (PM) 10 range from 231 to 359 tons per year; Alternative 4 emissions for PM10 are 228 tons per year.
- Slurry alternative emissions for PM2.5 range from 31.6 to 40.2 tons per year; Alternative 4 emissions for PM2.5 are 39.8 tons per year.

Air quality modeling of the impacts of emissions found that national ambient air quality standards are met at the fence line (i.e., ambient air quality boundary) for all tailings facilities, regardless of location. Based on the lack of any substantial difference in emissions, filtered tailings could be successfully applied at any location.

Tailings Safety

Impacts to downstream environments are primarily driven by the distance a hypothetical tailings failure would travel. Filtered tailings have much of the water removed prior to placement and lack any active water storage within the tailings facility. Unlike the slurry tailings facilities, the filtered tailings are not anticipated to runout in the event of a tailings facility failure, but rather collapse or slump much like a landslide. The impact from this type of failure is localized within a few miles of the facility, based on the modeling conducted for Alternative 4.

The DEIS catalogs the downstream environment for each tailings facility location, including distances to population centers, key infrastructure, water supplies, and sensitive riparian areas. Applying a slump failure of filtered tailings to any of these locations is readily done, given the known distances to downstream resources and population centers.

Water Quality

During alternatives analysis, before modeling was completed, it was not clear whether filtered tailings would represent a benefit to water quality. It was believed that the lack of water in the facility would help limit seepage, but the exposure of potentially acid generating (PAG) tailings to oxygen—unlike the subaqueous deposition used in the slurry tailings facilities—was expected to result in higher metal concentrations in the seepage that would occur.

After completion of analysis, the risk to water quality from tailings seepage has arisen as a strong differentiating factor between alternative locations. The DEIS analysis determined that some locations like the Near West location (Alternatives 2 and 3) do have potential water quality concerns due to the proximity to downstream waters and geological conditions. A reasonable question is whether filtered tailings could be applied at these locations and result in a viable alternative.

The NEPA team designed an analysis strategy for water quality that allows for this comparison to be made without explicit modeling of filtered tailings at every location. This is done by assessing the total amount of pollutant loading expected from each facility and comparing it to modeled "allowable" levels of pollutant loading (i.e., the known amount and quality of seepage that would not result in concentrations above aquifer or surface water quality standards).

The maximum allowable seepage calculated for each location is as follows:

- Alternative 2: 3 acre-feet per year, limited by anticipated selenium concentrations in Queen Creek
- Alternative 3: 3 acre-feet per year, limited by anticipated selenium concentrations in Queen Creek
- Alternative 4: 6 acre-feet per year, limited by anticipated selenium concentrations in Queen Creek
- Alternative 5: 261 acre-feet per year, limited by anticipated selenium concentrations in the downgradient aquifer
- Alternative 6: 329 acre-feet per year, limited by anticipated selenium concentrations in the Gila River (Gregory and Bayley 2018a)

Each of these seepage rates has an associated pollutant loading (in kilograms [kg]) that is known not to cause concentrations of these constituents above either aquifer or surface water quality standards.

These loading rates are shown in table 6. Pollutant loading is looked at two ways in this table: total pollutant load over the entire modeling period (kg), or the highest loading in any given year (kg).

Table 6. Pollutant loading rates based on maximum allowable seepage

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Total pollutant load calculated over 245-year modeling period (kg)					
Nitrate	3,730.6	3,248.3	2,934.4	204,077.8	230,175.5
Antimony	97.0	6.30	32.3	424.0	411.1
Cadmium	8.4	6.90	21.6	449.5	502.1
Copper	141.4	135.4	362.4	136,181.4	17,410.5
Selenium	175.8	152.9	460.9	8,836.1	10,541.3
Sulfate	1,793,160.2	1,679,061.9	4,113,749.1	109,223,209.7	108,925,439.5
Total dissolved solids	**3,171,525.3**	**2,617,284.0**	**6,067,930.8**	**164,767,399.0**	**175,055,657.6**
Maximum pollutant load generated in any given year over 245-year modeling period (kg)					
Nitrate	32.58	30.0	25.15	1,544.39	1,764.25
Antimony	0.05	0.04	0.17	2.35	2.23
Cadmium	0.06	0.06	0.12	3.22	2.43
Copper	1.20	0.74	1.49	1,481.32	79.09
Selenium	1.28	1.29	2.51	65.96	53.13
Sulfate	9,053.30	8,905.37	20,495.7	514,152.10	485,066.6
Total dissolved solids	**18,543.0**	**14,615.46**	**30,384.8**	**747,097.06**	**761,668.14**

The actual pollutant load expected from Alternative 4 during operations and closure is summarized in table 7.

Table 7. Modeled pollutant loads from Alternative 4

Component of pollutant load	**Alternative 4**
Estimated amount of lost seepage during operations (acre-feet)	9 to 17
Estimated amount of lost seepage post-closure (acre-feet)	15.2 to 31.92
Total pollutant load calculated over 245-year modeling period (kg)*	

Component of pollutant load	Alternative 4
Nitrate	13,904.8
Antimony	171.3
Cadmium	114.5
Copper	1,781.7
Selenium	2,449.6
Sulfate	21,808,724.0
Total dissolved solids	**32,152,882.9**
Maximum pollutant load generated in any given year over 245-year modeling period (kg)*	
Nitrate	71.3
Antimony	0.89
Cadmium	0.63
Copper	7.92
Selenium	13.35
Sulfate	109,037.0
Total dissolved solids	**161,647.0**

* Loading calculation uses maximum seepage rate to avoid underestimating pollutant loads.

The following conclusions can be drawn from tables 6 and 7, using selenium and total pollutant loads over the entire modeling period as examples. The results are similar for all other constituents, and similar if the highest annual pollutant load is used instead. Key points include the following:

- The total 245-year pollutant load from Alternative 4 (2,449.6 kg) exceeds the maximum "allowable" pollutant load calculated for Alternative 4 (460.9 kg). This is reflected in the EIS water quality analysis results, which indicates that Alternative 4 tailings seepage results in concentrations above surface water quality standards in Queen Creek.
- If ultimately it was desired to use filtered tailings at the Alternative 2 location for the selected alternative, the following would be true:
    - The total 245-year pollutant load from Alternative 4 (2,449.6 kg) exceeds the maximum "allowable" pollutant load calculated for Alternative 2 (175.8 kg).
    - This indicates that it would be problematic to use filtered tailings at the Alternative 2 location.
    - The pollutant load estimated for Alternative 4 is dependent on engineered seepage controls, which are site-specific. It is feasible that engineered seepage controls could vary with location. It is a simple calculation to estimate how much seepage would have to be controlled to stay below the "allowable" pollutant loads. For filtered tailings implemented at the Alternative 2 location, seepage from the filtered tailings would have to be reduced

by approximately 93 percent from the current design levels (which are already at 90 percent seepage capture efficiency) in order to stay below "allowable" pollutant loads.

- If ultimately it was desired to use filtered tailings at the Alternative 5 location for the Selected Action, the following would be true:
  - The total 245-year pollutant load from Alternative 4 (2,449.6 kg) is less than the maximum "allowable" annual pollutant load calculated for Alternative 5 (8,836.1 kg).
  - This indicates that it would be feasible to use filtered tailings at the Alternative 5 location. The pollutant load generated by filtered tailings would not result in concentrations above aquifer or surface water quality standards. The underlying reason is that the capacity of the downstream environment to handle the tailings seepage is fundamentally greater at this location.
- If ultimately it was desired to use filtered tailings at the Alternative 6 location for the Selected Action, the following would be true:
  - The total 245-year pollutant load from Alternative 4 (2,449.6 kg) is less than the maximum "allowable" annual pollutant load calculated for Alternative 6 (10,541.3 kg).
  - This indicates that it would be feasible to use filtered tailings at the Alternative 6 location. The pollutant load generated by filtered tailings would not result in concentrations above aquifer or surface water quality standards. The underlying reason is that the capacity of the downstream environment to handle the tailings seepage is fundamentally greater at this location.

To summarize, during alternatives development the NEPA team made an explicit decision to only apply filtered tailings at a single location (Silver King) based on the belief that the EIS analysis, once conducted, would be flexible enough to assess the use of filtered tailings at other locations if desired. As demonstrated above, the analysis indeed is able to allow such an evaluation.

The conclusions drawn from the evaluation presented above is that based on considerations of air quality, tailings safety, and water quality, filtered tailings could be considered at the Peg Leg or Skunk Camp locations, but are not likely feasible at the Near West location.

Consideration of Consolidation of Tailings in Seepage Analysis

Concerns were raised by cooperating agencies about whether consolidation of tailings was considered in the seepage analysis. The following explanations were provided by the Resolution Copper engineers, detailing how consolidation was incorporated into the seepage estimates.

The following is from KCB (Patterson 2019), who prepared the alternative designs for Alternatives 2, 3, 4, and 6:

- **For slurry facilities (Alternatives 2, 3, and 6)**
  - During operations: consolidation water during operations is relatively minor compared to the seepage produced by slurry deposition and the reclaim pond (for example, maybe 5 gallons per minute [gpm] of 100 gpm, *note: numbers exemplary are to explain the*

concept and not based on actual estimates). Therefore, initial settled tailings properties were maintained (i.e., higher saturated hydraulic conductivity) for conservative estimates of seepage; consolidated tailings properties were not used.

  - After operations (deposition stops and reclaim pond is removed): consolidation water can become a significant portion of the seepage water (as part of the above example: maybe 5 gpm of 8 gpm). Therefore, a normalized draindown curve was applied to the end of operations seepage rate estimate to account for gradual drawdown of porewater and tailings consolidation water for the purpose of estimating the time of active water management required (i.e., how long until seepage can be passively managed by evaporation). The curve was based on 2D seepage analyses, historical case studies and changes in the tailings' porosity over time (based on the tailings consolidation properties).

- **For filtered facilities (Alternative 4)**
  - Does not include slurry deposition or a reclaim pond on the tailings. Therefore, any downward drainage is significant during operations and post-closure.
  - We have conceptualized that the majority of seepage would be a result of storm events on thin layers of filtered tailings (see KCB's Alternative 4 seepage appendix [1D numerical analysis]).

From Golder (Pilz 2019), who prepared the alternative designs for Alternative 5:

Golder did account for consolidation water release by including the difference in the placement water content minus the residual water as the tailings consolidation versus time. This difference was based on the change in void ratio between the placed slurry and dry density versus depth characteristics of the tailings. The 1D model CONDES was used to complete the consolidation analysis for both the PAG and non-potentially acid generating (NPAG) embankments.

- Consolidation analyses are described in attachment 3 to appendix G (water balance) of our report. The time rate of consolidation is shown on figures 2 (PAG) and figure 3 (NPAG). The plots are in terms of dry density, but since the tailings are assumed to remain saturated could be converted to water release. Water expelled during the consolidation process was then included in the water balance. It was found that PAG tailings continue to consolidate after closure (see figure 4). Due to the tailings characteristics and larger surface area of the NPAG facility consolidation is largely complete at closure (figure 5). This observation is in line with a tailings storage facility that is operating as a thin lift facility. We did not complete further detailed analyses that would model small compression/water release effects of the tailings once the majority of the primary consolidation water is released.
- Golder provides these responses to specific questions raised in comments:
  - *"Was a consolidation-seepage model performed for tailings facilities? Yes, see Appendix G, Attachment 3*
  - *"How does the tailings seepage model address the additional seepage volume estimate resulting from consolidation of tailings sediments over time, from operational life through the modeled closure period for each facility?" Addressed within the Goldsim water balance.*

- *"How long does this effect last?" See Figures 4 and 5 for PAG and NPAG facilities (Appendix G, Attachment 3)*
- *"How long will seepage and tailings fluid drain-down occur at each facility?" PAG: Ranges from a few up to 100 yrs. NPAG: negligible post closure (this is a large, thin lift facility).*
- *"Tailings drawdown curves for each facility?" See figures 4 & 5 (plotted in terms of dry density), could be plotted in terms of water expelled.*
- *"How does consolidation influence the affect the overall seepage and potential seepage impacts evaluation?" At this stage the consolidation effects are smaller than the seepage effects. Golder considers that these analyses are appropriate for this stage of design / evaluation.*
- *"For reference, I believe the 2018 Rosemont Mine tailings seepage model considered 2D consolidation in the total seepage. I believe accounting for consolidation effects was non-trivial in the assessment of seepage impacts. Analysis of tailings fluids seepage volume and potential impacts without consideration of tailings sediment consolidation tends to underestimate the impacts. A simple example would be like squeezing (consolidation) a water soaked sponge--it releases more water the more it is squeezed." We can't comment on Rosemont analysis.*

Comparison of Alternatives 5 and 6 Surface Water Samples to Additional Gila River Water Quality Samples

The seepage modeling assumes that all seepage eventually enters surface water downstream. In the case of Alternatives 5, seepage is assumed to enter the Gila River at the mouth of Donnelly Wash, and for Alternative 6, seepage is assumed to enter the Gila River at the mouth of Dripping Spring Wash. There are no existing water quality data for these specific points on the Gila River and, therefore, samples were collected in November 2018 to support the seepage analysis. The uncertainty of using single grab samples was clearly identified in the EIS.

Although no historical water quality data set exists for the points in question, other sampling has been conducted on the Gila River over the past 50 years. In order to estimate the amount of uncertainty inherent in using single water quality samples, the historical data set was compared to the grab sample used in the seepage modeling. Water quality data were obtained from www.waterqualitydata.us, which compiles data from multiple sources. In this case, water quality data were available in the U.S. Geological Survey (USGS) National Water Information System database and the EPA STORET database (Bayley 2019).

In addition to constituents of concern, calcium and magnesium are included in this assessment in order to estimate hardness and assess whether the hardness value used to define numeric surface water quality standards was reasonable.

There is little doubt that the seepage analysis would benefit from a longer and pertinent period of record, rather than being based on a single grab sample. The historical data set described in table 8 (for the Gila River near Alternative 5) and table 9 (for the Gila River near Alternative 6) helps inform the uncertainty, but has substantial problems with consistency:

- Some constituents have long periods of record (even back to the 1950s), but many constituents have not been sampled for over a decade, and some not since the 1980s.
- All constituents would be expected to change over time. Sulfate and nitrate, for instance, will change with changes in land use and associated runoff, while metals could be influenced by point source discharges that may not be consistent over time. An example of this is the known Ray Mine drainage entering the Gila River from Mineral Creek; this particular discharge has been the subject of mitigation efforts. This results in much of the historical data not being pertinent to the current conditions on the Gila River.
- There is substantial inconsistency with the historical data with the use of non-detection or reporting limits. This includes changes in laboratory technology over time that has lowered detection limits substantially.

Reasonableness of Peg Leg Values Used in Seepage Modeling

On the balance, the values used for the last step of the Alternative 5 seepage modeling (the prediction of concentrations in the Gila River) were reasonable, considering the historical data set:

- Hardness may be substantially higher than that used in the seepage modeling. This particular sampling location actually has an enormous number of calcium and magnesium samples that have been collected over the years that can be used to estimate hardness (over 1,000 samples over 56 years). The median estimated hardness (368 milligrams per liter [mg/L]) is much higher than the November 2018 grab sample (290 mg/L). Higher hardness means higher water quality standards for certain metals. Therefore, the seepage analysis is conservative in that it compares potential impacts against lower water quality standards. The seepage modeling does not predict any concentrations in the Gila River above these lower water quality standards; therefore, changes in hardness would not affect the outcome of the modeling.
- For all constituents of concern, the values from the November 2018 grab sample are within the historical range of results and appear to be reasonable.
- The values for antimony, cadmium, copper, and selenium used in the seepage modeling cannot be directly compared to the median results from the historical period of record, because the calculation of the historical median is dominated in every case by non-detection values. The same issue was encountered with antimony, cadmium, and selenium with the grab sample from November 2018—these concentrations were also below the laboratory detection limit. For the seepage modeling, the concentration was then set to the detection limit in order to avoid underestimating the pollutant loading already in the Gila River.

Reasonableness of Skunk Camp Values Used in Seepage Modeling

On the balance, the values used for the last step of the Alternative 6 seepage modeling (the prediction of concentrations in the Gila River) were reasonable, considering the historical data set:

- For all constituents of concern, the values from the November 2018 grab sample are within the historical range of results and appear to be reasonable.

- The values for antimony, cadmium, copper, and selenium used in the seepage modeling cannot be directly compared to the median results from the historical period of record, because the calculation of the historical median is dominated in every case by non-detection values. The same issue was encountered with antimony, cadmium, and selenium with the grab sample from November 2018—these concentrations were also below the laboratory detection limit. For the seepage modeling, the concentration was then set to the detection limit in order to avoid underestimating the pollutant loading already in the Gila River.

Assessment of Need to Collect Additional Information

The water quality samples used represent the best available samples in that (a) they are current, (b) all constituents are comparable (from the same sample collected at the same time and analyzed to the same laboratory quality standards), and (c) are at the geographic location of interest.

Given the limitations of both the historical period of record and the uncertainty inherent in using the single grab sample from November 2018, obtaining additional, current, consistent water quality data from the Gila River would be beneficial.

Council on Environmental Quality regulations address the need for additional data collection under 40 CFR 1502.22. The ability to collect additional information needs to be addressed when "the incomplete information relevant to reasonably foreseeable significant adverse impacts *is essential to a reasoned choice* among alternatives" (emphasis added).

In this case, although it is beneficial to reduce uncertainty, additional water quality is by no means essential to understanding the differences between the alternatives. The current modeling provides reasonably clear answers to the risks posed to water quality by each alternative, and the conclusions would not be likely to change by variations in Gila River water quality. This is demonstrated below.

For Alternative 5, no constituents are anticipated in the Gila River that are above numeric surface water quality standards; however, the anticipated copper and selenium concentrations both use up a portion of the assimilative capacity at this location:

- For dissolved copper, the current concentration being used for the Gila River at Donnelly Wash is 0.00408 mg/L, and the numeric water quality standard for the most restrictive use is 0.02928 mg/L, yielding an assimilative capacity of 0.0252 mg/L. The increase in copper from the seepage is 0.00582 mg/L, which uses up 23 percent of the assimilative capacity. As a hypothetical, the historical median dissolved copper concentration, ignoring any samples with non-detection values, is higher at 0.00545 mg/L. If this were the baseline water quality in the Gila River, the assimilative capacity would be slightly less (0.02383 mg/L), and the addition of the seepage pollutant load would use up 24 to 25 percent of the assimilative capacity. This is not a substantial change in outcomes that would render the alternative comparison invalid.
- For total selenium, the current concentration being used for the Gila River at Donnelly Wash is 0.0004 mg/L, and the numeric water quality standard for the most restrictive use is 0.002 mg/L, yielding an assimilative capacity of 0.0016 mg/L. The increase in selenium from the seepage is 0.0006 mg/L, which uses up 37 to 38 percent of the assimilative capacity. As a

hypothetical, the historical median total selenium concentration, ignoring any samples with non-detection values, is higher at 0.001 mg/L. If this were the baseline water quality in the Gila River, the assimilative capacity would be less (0.001 mg/L), and the addition of the seepage pollutant load would use up 60 percent of the assimilative capacity. While higher, this change passes no fundamental threshold and the outcome disclosed in the EIS remains the same, albeit with a different number.

For Alternative 6, no constituents are anticipated in the Gila River that are above numeric surface water quality standards; however, the anticipated selenium concentrations use up a portion of the assimilative capacity at this location:

- For total selenium, the current concentration being used for the Gila River at Dripping Spring Wash is 0.0004 mg/L, and the numeric water quality standard for the most restrictive use is 0.002 mg/L, yielding an assimilative capacity of 0.0016 mg/L. The increase in selenium from the seepage is 0.0005 mg/L, which uses up 31 percent of the assimilative capacity. As a hypothetical, the historical median total selenium concentration, ignoring any samples with non-detection values, is higher at 0.001 mg/L. If this were the baseline water quality in the Gila River, the assimilative capacity would be less (0.001 mg/L), and the addition of the seepage pollutant load would use up 60 percent of the assimilative capacity. While higher, this change passes no fundamental threshold and the outcome disclosed in the EIS remains the same, albeit with a different number.
- For the FEIS, a refined numeric groundwater flow model was prepared to incorporate site-specific information collected and reported after publication of the DEIS. This model supplements the DEIS mixing/loading model, and generally shows extremely low releases of constituents related to tailings seepage to the Gila River; however, after review by the NEPA team specialists, specific limitations were noted with this model, as explored by Walser (2020). It is being presented in the FEIS as a supplemental model, not a replacement model.

Table 8. Comparison of historical data from Gila River near Kelvin Bridge/Mineral Creek

Constituent	**Date Range of Historical Data**	**Number of Samples**	**Median Result with All Data* (mg/L)**	**Median Result without Non-Detects (mg/L)**	**Range of Results (mg/L) with Number of Non-Detects Shown in Brackets [XX]**	**Value Used from Grab Sample for Seepage Modeling (mg/L)**
Calcium, dissolved	12/1950–6/2006	1,051	108	108	24.2–989	None
Magnesium, dissolved	12/1950–6/2006	1,033	24	24	5.9–300	None
Calculated hardness from calcium and magnesium				368		290

Constituent	Date Range of Historical Data	Number of Samples	Median Result with All Data* (mg/L)	Median Result without Non-Detects (mg/L)	Range of Results (mg/L) with Number of Non-Detects Shown in Brackets [XX]	Value Used from Grab Sample for Seepage Modeling (mg/L)
Antimony, dissolved	9/2001–1/2016	20	ND	0.000281	ND [14]–0.00065	<0.00023 (assumed to be 0.00023 for modeling)
Cadmium, dissolved	11/1974–1/2016	52	ND	0.000036	ND [47]–0.010	<0.000063 (assumed to be 0.00006 for modeling)
Copper, dissolved	11/1974–5/2016	48	ND	0.00545	ND [28]–0.03	0.00408
Nitrate as NO_3, total	12/1950–9/1966	199	1.7	1.7	0.1–23	0.091
Selenium, total	11/1974–1/2016	74	ND	0.001	ND [45]–0.003	<0.0004 (assumed to be 0.0004 for modeling)
Sulfate, dissolved	12/1950–6/2006	503	195	195	10–2,400	159

* There are multiple methods for handling non-detection values when calculating statistics. For the calculation in this column, to determine the median, all non-detection values were set to zero. This ensures that the results are not artificially high due to high reporting limits. Where the resulting median was calculated as zero, "ND" is shown.

Table 9. Comparison of historical data from Gila River from Dripping Spring Wash to Winkelman

Constituent	Date Range of Historical Data	Number of Samples	Median Result with All Data* (mg/L)	Median Result without Non-Detects (mg/L)	Range of Results (mg/L) with Number of Non-Detects Shown in Brackets [XX]	Value Used from Grab Sample for Seepage Modeling (mg/L)
Calcium, dissolved	1/1976–9/1984	86	58	58	18–150	None
Magnesium, dissolved	1/1976–9/1984	86	17.5	17.5	9.4–68	None
Calculated hardness from calcium and magnesium				217		242
Antimony, dissolved	11/2002–5/2003	4	ND	ND	ND [4]	<0.00023 (assumed to be 0.00023 for modeling)
Cadmium, dissolved	1/1976–5/2003	10	ND	ND	ND [10]	<0.000063 (assumed to be 0.00006 for modeling)

Constituent	Date Range of Historical Data	Number of Samples	Median Result with All Data* (mg/L)	Median Result without Non-Detects (mg/L)	Range of Results (mg/L) with Number of Non-Detects Shown in Brackets [XX]	Value Used from Grab Sample for Seepage Modeling (mg/L)
Copper, dissolved	6/1976–5/2003	17	ND	0.010	ND [9]–0.020	0.00207
Nitrate as NO_3, total	4/1976–12/1976	4	0.155	0.155	0.05–0.4	0.305
Selenium, total	1/1976–5/2003	63	ND	0.001	ND [33]–0.004	<0.0004 (assumed to be 0.0004 for modeling)
Sulfate, dissolved	1/1976–9/1984	86	120	120	56–530	99.5

* There are multiple methods for handling non-detection values when calculating statistics. For the calculation in this column, to determine the median, all non-detection values were set to zero. This ensures that the results are not artificially high due to high reporting limits. Where the resulting median was calculated as zero, "ND" is shown.

Calculations of Pollutant Loading for Constituents of Concern from Each Alternative

Part of the EIS analysis assesses pollutant loading to impaired waters. Based on the estimated concentrations of pollutants in seepage lost from the tailings storage facility, and the estimated seepage flow rates, the additional pollutant load to the watershed for the constituents of concern can be calculated. The estimate shown in table 10 is provided in kg per day, in order to match the units ADEQ uses when calculating total maximum daily loads.

Table 10. Estimate of contaminant loading used in the Environmental Impact Statement

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Estimated amount of lost seepage during operations (acre-feet)	20.7	2.7	9–17	261	65–178
Estimated amount of lost seepage post-closure (acre-feet)	20.7	2.7	15.2–31.92	261	202–258
Concentration during operations and post-closure (mg/L)*					
Nitrate	8.39; 3.34	8.10; 3.32	3.4; 1.49	4.8; 2.15	4.35; 2.06
Antimony	0.135; 0.0092	0.0118; 0.0091	0.0057; 0.02105	0.0071; 0.0073	0.0055; 0.005
Cadmium	0.016; 0.008	0.015; 0.0071	0.0006; 0.01301	0.010; 0.005	0.006; 0.005
Copper	0.325; 0.103	0.199; 0.108	0.2012; 0.2012	4.604; 1.950	0.195; 0.154
Selenium	0.3464; 0.164	0.349; 0.163	0.0055; 0.2807	0.205; 0.099	0.131; 0.101

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Pollutant daily loading (kg/day) during operations†					
Nitrate	0.5870	0.0739	0.1954	4.2345	2.6171
Antimony	0.0094	0.0001	0.0003	0.0063	0.0033
Cadmium	0.0011	0.0001	0.0000	0.0088	0.0036
Copper	0.0227	0.0018	0.0116	4.0616	0.1173
Selenium	0.0242	0.0032	0.0003	0.1808	0.0788
Pollutant daily loading (kg/day) post-closure†					
Nitrate	0.2337	0.0303	0.1608	1.8967	1.7964
Antimony	0.0006	0.0001	0.0023	0.0064	0.0044
Cadmium	0.0006	0.0001	0.0014	0.0044	0.0044
Copper	0.0072	0.0010	0.0217	1.7203	0.1343
Selenium	0.0115	0.0015	0.0303	0.0873	0.0881

Note: Only those constituents of concern with numeric aquifer or surface water quality standards are included.

* Most variation in concentrations occurs during the operational mine life, so the concentration for operations refers to maximum concentration modeled for years 0 to 41. For post-closure refer to the concentration modeled for year 245 in order to estimate long-term loading.

† For Alternatives 4 and 6, loading calculation uses maximum seepage rate to avoid underestimating pollutant loads.

Analysis for Technologically Enhanced Naturally Occurring Radioactive Materials

Radioactive materials such as uranium, thorium, and radium occur naturally in the earth's crust and soil. In some cases, these materials can be concentrated by mining processes, leading to a concern that technologically enhanced naturally occurring radioactive materials (TENORM) could result in water quality concerns in seepage from the tailings storage facility.

Thresholds of Concern

Exposure to radioactive materials is handled under a wide variety of regulatory frameworks (The Interstate Technology and Regulatory Council Radionuclides Team 2002). Many of these focus on radiation exposure, given in millirems per year, which are difficult to apply to site characterization data; however, some regulatory guidance exists on acceptable levels of radioactive materials in soils and water, as shown in table 11. Note that these regulatory thresholds are being provided for the purpose of assessing the potential for TENORM or exposure to radioactive materials, but they are not all directly applicable in a legal or regulatory sense.

Table 11. Summary of regulatory thresholds for soils and water

Media	Source of Regulatory Threshold	Constituent	Regulatory Threshold
Surface soils	EPA standards for uranium mill tailings (40 CFR 192; 10 CFR 40, Appendix A)	Radium-226	5 pCi/g
Subsurface soils	EPA standards for uranium mill tailings (40 CFR 192; 10 CFR 40, Appendix A)	Radium-226	15 pCi/g
Water	EPA Primary Drinking Water Standards, Maximum Contaminant Level (40 CFR 141.15–16); State of Arizona Numeric Aquifer Water Quality Standards (R18-11-406E); State of Arizona Numeric Surface Water Quality Standards (Drinking Water) (R18-11, Appendix A)	Gross Alpha	15 pCi/L
Water	EPA Primary Drinking Water Standards, Maximum Contaminant Level; State of Arizona Numeric Aquifer Water Quality Standards; State of Arizona Numeric Surface Water Quality Standards (Drinking Water)	Radium-226 plus Radium-228	5 pCi/L
Water	EPA Primary Drinking Water Standards, Maximum Contaminant Level	Uranium	30 µg/L
Water	State of Arizona Numeric Surface Water Quality Standards (Full and Partial Body Contact)	Uranium	2,800 µg/L

Note: pCi/g = picoCuries per gram; pCi/L = picoCuries per liter; µg/L = micrograms per liter.

In addition to regulatory thresholds, of interest is whether ore or groundwater in the Resolution Copper project area has significantly greater concentrations of uranium or thorium than average concentrations found in the naturally occurring environment. Available data on natural occurrence are summarized in table 12.

Table 12. Summary of typical background concentrations of uranium and thorium

Media	Source of Information	Constituent	Typical Concentrations
Soil	The Earth Technology Corporation 1991 (citing USGS data)	Uranium	Range: 1.1–3.4 ppm Average: 2.1 ppm
Rock, average for continental crust	International Atomic Energy Agency 2003; National Council on Radiation Protection and Measurement 1988	Uranium	Average: 2.8 ppm (0.97 pCi/g)
Rock, average for continental crust	Same	Thorium	Average: 10.7 ppm (1.19 pCi/g)
Rock, average for continental granite	Same	Uranium	Average: 3 ppm (1.08 pCi/g)
Rock, average for continental granite	Same	Thorium	Average: 17 ppm (1.89 pCi/g)

Media	Source of Information	Constituent	Typical Concentrations
Soil, average	Same	Uranium	Average: 1–8 ppm (1.78 pCi/g)
Soil, average	Same	Thorium	Average: 9 ppm (1.0 pCi/g)
Rock, upper continental crust	Rudnick and Gao 2003 (citing previous studies)	Uranium	Range of averages: 1.5–2.45 ppm
Rock, upper continental crust	Rudnick and Gao 2003 (recommendation of authors)	Uranium	Average: 2.7 ppm
Rock, upper continental crust	Rudnick and Gao 2003 (citing previous studies)	Thorium	Range of averages: 8.6–10.8 ppm
Rock, upper continental crust	Rudnick and Gao 2003 (recommendation of authors)	Thorium	Average: 10.5 ppm
*General average for rock/soil**		*Uranium*	*2.1–3 ppm*
General average for rock/soil†		*Thorium*	*10.5–17 ppm*

Notes: pCi/g = picoCuries per gram; ppm = parts per million.

* Excludes range of soil from International Atomic Energy Agency (2003) and National Council on Radiation Protection and Measurement (1988) in favor of Arizona-specific data; excludes range of averages from Rudnick and Gao (2003) in favor of authors' recommended value.

† Excludes range of averages from Rudnick and Gao (2003) in favor of authors' recommended value.

Occurrence of Natural Radioactive Materials in Resolution Copper Project Area

Thorium and uranium are generally hosted in trace amounts (usually defined as less than 1,000 parts per million [ppm]) in minerals like thorite ($ThSiO_2$) and uraninite (UO_2). Thorium and uranium can also occur in minerals like monazite ($SmPO_4$), apatite ($Ca_5(PO_4)3F$), and zircon ($ZrSiO_4$) The most common uranium silicate mineral is coffinite $U(SiO_4)$1-x(OH)4x, but it is rare compared to uraninite. Of these minerals, only apatite and zircon have been detected in the Resolution Copper ore with trace to minor abundances (Duke 2019b).

Thorium and uranium were both measured in 5,987 samples of Resolution Copper ore from 137 exploration boreholes that lie within the mine panels (Duke 2019b).

- Thorium was detected in 96 percent of the samples. Thorium content ranged from <0.2 ppm to 68.7 ppm, with an average of 3.4 ppm, and a 90th percentile of 6.3 ppm. The average falls well below the range shown in table 12 for typical background concentrations (10.5 to 17 ppm); based on the 90th percentile concentration, very few ore samples are above typical background concentrations.
- Uranium was detected in 77 percent of the samples. Uranium content ranged from <0.5 ppm to 61.1 ppm, with an average of 2.6 ppm, and a 90th percentile of 5.2 ppm. The average falls within the range shown in table 12 for typical background concentrations (2.1 to 3 ppm); based on the 90th percentile concentration, a number of the ore samples are above typical background concentrations.

Gross alpha, radium-226, and radium-228 were also measured in 224 samples of ore and development rock (Duke 2019b).

- Gross alpha had a range of non-detection to 133.9 picoCuries per gram (pCi/g), a median value of 2 pCi/g, and a 90th percentile of 8.2 pCi/g.
- Radium-226 had a range from 0.06 to 102.4 pCi/g, a median value of 0.69 pCi/g, and a 90th percentile of 2.17 pCi/g. Radium-228 had a range from non-detection to 81.4 pCi/g, a median value of 2.5 pCi/g, and a 90th percentile of 7.77 pCi/g. The combined means fall below the lowest threshold of concern of 5 pCi/g (set for surface soils), and the combined 90th percentile values fall below the threshold of concern of 15 pCi/g (set for subsurface soils).

In addition to the rock samples, in 2014 12 master ore composites were produced and subjected to metallurgical processing to produce simulated NPAG tailings, and concentrations of uranium and thorium were analyzed in the composites (Duke 2019b):

- Thorium content ranged from 0.37 to 3.9 ppm in the 12 NPAG composite samples, below the typical background concentration.
- Uranium content ranged from 0.75 to 3.4 ppm in the 12 NPAG composite samples, with an average of 1.7 ppm, below the typical background concentration.

Six additional simulated NPAG tailings were produced through processing in pilot plant testing in 2014, and also analyzed for concentrations of uranium and thorium (Duke 2019b):

- Thorium content ranged from 2.8 to 3.2 ppm in the six NPAG tailings samples, all below the typical background concentration.
- Uranium content ranged from 1.8 to 2.0 ppm in the six NPAG tailings samples, all below the typical background concentration.

Groundwater samples collected by Resolution Copper in different groundwater systems also can be used to assess naturally occurring radioactive materials:

- Of 198 groundwater samples analyzed for radium-226 plus radium-228, 171 samples (86 percent) were below the threshold of concern (5 picoCuries per liter [pCi/L]). The maximum concentration observed was 16 pCi/L. Excluding Shaft 9 discharges (which, as noted earlier in section 3.7.2, are not representative of in-situ groundwater), 98 percent of samples were below the threshold of concern, with only four samples exhibiting concentrations greater than 5 pCi/L (wells DHRES-02, and RES-09).
- Of 159 groundwater samples analyzed for uranium-234, uranium-235, and uranium-238, only two samples exceeded the threshold of concern of 30 pCi/L, those for uranium-234 (well DHRES-09).
- Of 112 groundwater samples analyzed for gross alpha activity (adjusted), 97 samples (87 percent) were below the threshold of concern (15 pCi/L). The maximum concentration observed was 105 pCi/L. Excluding Shaft 9 discharges, 94 percent of samples were below the

threshold of concern, with only seven samples exhibiting concentrations greater than 15 pCi/L (two private wells, and DHRES-02).

Conclusions on Presence of Naturally Occurring Radioactive Materials

In summary, substantial information exists on the occurrence of naturally occurring radioactive materials in the project area, including ore rock, simulated tailings, and groundwater samples.

With respect to typical background concentrations, the most appropriate comparison is to compare average or median values with the known average background concentrations. This comparison indicates that uranium and thorium are below or within the range of average background concentrations. Some portion of the samples (the 90th percentile, as an example) are above background averages; statistically this is not unexpected. With respect to threshold of concern, when Shaft 9 discharges are excluded, the large majority of groundwater samples (94 to 98 percent) are below thresholds of concern for radium, gross-alpha, and uranium.

On the balance, review of existing information at the site does not suggest the strong presence of naturally occurring radioactive materials above typical concentrations, although a small percentage (2 to 6 percent) of samples have exhibited concentrations above thresholds of concern.

Potential for Technological Enhancement of Naturally Occurring Radioactive Materials

The primary concern is not necessarily the occurrence of these materials in the ore deposit, but the potential for them to be concentrated during processing and then go on to impact groundwater or surface water through tailings seepage. This would be the primary mode of exposure of any naturally occurring radioactive materials from the tailings storage facility.

The concern for TENORM is based on documented problems that have occurred in the past. The EPA presented a number of case studies, including two potentially pertinent to the Resolution Copper Project because of vicinity: Pinto Valley groundwater contamination and Magma Copper Company's smelter and concentrator operations at San Manuel (EPA 1999). In general, the EPA report concludes: "The data show that dump leaching operations and solvent extraction-electrowinning procedures, as well as the practice of recycling raffinate at copper mines, may extract and concentrate soluble radioactive materials" (EPA 1999).

A review of the EPA document by Resolution Copper's geochemistry consultant reached a similar conclusion: "These TENORM occurrences are not associated with uranium mining or ore-grade uranium-bearing rocks; they are associated with copper mineralization that contains traces of uranium. Aggressive leaching with acidic solutions and/or recycling of solutions causes the uranium and other radioactive elements to become concentrated" (Duke 2019b).

The Resolution Copper Project does not include any heap leaching, solvent extraction-electrowinning, or recycling of raffinate. The processes that historically have been documented with problems will not occur at the Resolution Copper Project.

Regardless, analysis is also available to describe how naturally occurring radioactive materials would concentrate during the flotation process itself. Resolution Copper conducted locked cycle testing, which reproduces the processing at bench scale. The test starts with an initial ore and water feed, then the ore is passed through seven cycles of concentration, similar to what would occur at the West Plant Site. At each of seven cycles, the process water is recycled, resulting in the same increase in solute concentrations that would occur in full-scale flotation cells.

The results of the materials from the locked cycle testing as well as the final process water demonstrate whether or not radioactive materials are enhanced in the processing plant, as shown in table 13. Based on the site-specific testing, for solid material—copper concentrate, NPAG tailings, PAG tailings—no concentrations from the locked cycle testing are above any thresholds of concern (radium 226). In addition, for the final process water coming out of the locked cycle testing, no concentrations are above any thresholds of concern (uranium, radium, gross alpha).

Table 13. Results of locked cycle testing with respect to concentration of radioactive materials

Locked Cycle Test	Sample	Uranium	Uranium Threshold of Concern	Thorium	Thorium Threshold of Concern	Radium 226	Radium 228	Radium Threshold of Concern	Gross Alpha	Gross Alpha Threshold of Concern
1	Ore feed	1.2 ppm	–	11.5 ppm	–	–	–	–	–	–
1	Copper concentrate	1.1 ppm	–	2.5 ppm	–	0.189 pCi/g	<2.7 pCi/g	–	18.9	–
1	NPAG tailings	1.8 ppm	–	8.6 ppm	–	0.459 pCi/g	<2.7 pCi/g	5–15 pCi/g for Ra-226	16.2	–
1	PAG tailings	1.8–2.9 ppm	–	4.7-10 ppm	–	0.513-1.08 pCi/g	<2.7 pCi/g	5–15 pCi/g for Ra-226	21.6	–
1	Final process water	0.2 µg/L	30 µg/L	0.2 µg/L	–	<2.7 pCi/L	<0.135 pCi/L	5 pCi/L for Ra-226+Ra-228	<5.94 pCi/L	15 pCi/L
2	Ore feed	1.2 ppm	–	11.5 ppm	–	–	–	–	–	–
2	Copper concentrate	1.2 ppm	–	1.9 ppm	–	0.432 pCi/g	<2.7 pCi/g	–	16.2 pCi/g	–
2	NPAG tailings	1.7 ppm	–	6.8 ppm	–	1.566 pCi/g	<2.7 pCi/g	5–15 pCi/g for Ra-226	29.7 pCi/g	–
2	PAG tailings	2.9-4.0 ppm	–	4.4–9.0 ppm	–	0.54–1.512 pCi/g	<2.7 pCi/g	5–15 pCi/g for Ra-226	24.3–27 pCi/g	–
2	Final process water	0.2 µg/L	30 µg/L	0.2 µg/L	–	<2.7 pCi/L	<2.7 pCi/L	5 pCi/L for Ra-226+Ra-228	<7.56 pCi/L	15 pCi/L

Notes: µg/L = micrograms per liter.

Overall Conclusions on Technologically Enhanced Naturally Occurring Radioactive Materials

On the balance, review of existing information at the site does not suggest the strong presence of naturally occurring radioactive materials above typical background concentrations, although a small percentage (2 to 6 percent) of samples have exhibited concentrations above thresholds of concern.

Regardless, site-specific locked cycle testing has simulated the effect of processing to potentially concentrate radioactive materials, and no concentrations are above any thresholds of concern for uranium, radium, and gross alpha activity.

Details of Mixing Model Construction

Each of the alternative tailings locations uses different modeling methods to determine the rate of seepage to the environment. Once seepage enters the environment, however, the approach for estimating downstream impacts is similar between alternatives. A series of model mixing cells are built, segmenting the aquifer downgradient between the tailings facility and the first perennial water.

Because mixing and dilution are the fundamental processes in the mixing model, the details of the aquifer mixing cells are important. The purpose of this section is to briefly describe the mixing model for each alternative.

Alternatives 2 and 3

- Reference: Gregory and Bayley 2018e
- Number of aquifer mixing cells:
  - Five total
  - Roblas Canyon
  - Potts Canyon
  - Three cells along Queen Creek (QC3, QC2, QC1)
- First perennial water: Queen Creek at Whitlow Ranch Dam, approximately 2–3 miles downstream
- Hydraulic conductivity of mixing cells:
  - 500 feet/day in Potts Canyon alluvium
  - 1,000 feet/day in Queen Creek alluvium, based on an aquifer test of a well within the Queen Creek alluvium
- Other hydraulic conductivity values of interest (from the steady-state model used to estimate seepage):
  - Bedrock = 1.32×10^{-2} feet/day
  - NPAG tailings = 2.83×10^{-2} feet/day

- Dimensions of mixing cells:
    - Potts Canyon: Length = 20,200 feet; average width = 370 feet; saturated thickness = 8.6 feet for Alternative 2, 7.2 feet for Alternative 3[1]
    - Roblas Canyon: Length = 20.700 feet; average width = 370 feet; saturated thickness = 3.4 feet for Alternative2, 2.8 feet for Alternative 3
    - QC3: Length = 15,700 feet; average width = 1,140 feet; saturated thickness = 7.0 feet for Alternative 2, 6.3 feet for Alternative 3
    - QC2: Length = 6,400 feet; average width = 880 feet; saturated thickness = 20.4 feet for Alternative 2, 18.7 feet for Alternative 3
    - QC1: Length = 6,300 feet; average width = 1,320 feet; saturated thickness = 14.3 feet for Alternative 2, 13.2 feet for Alternative 3

Alternative 4

- Reference: Gregory and Bayley 2018b
- Number of aquifer mixing cells:
    - Nine total
    - Silver King Wash
    - Happy Camp Wash East
    - Happy Camp Wash West
    - Five cells along Queen Creek (QC5, QC4, QC3, QC2, QC1)
- First perennial water: Queen Creek at Whitlow Ranch Dam, approximately 6–8 miles downstream
- Hydraulic conductivity of mixing cells:
    - 500 feet/day in Silver King and Happy Camp alluvium
    - 1,000 feet/day in Queen Creek alluvium, based on an aquifer test of a well within the Queen Creek alluvium
- Dimensions of mixing cells:
    - Silver King Wash: Length = 20,100 feet; average width = 510 feet; saturated thickness = 1.1 feet
    - Happy Camp Wash East: Length = 23,700 feet; average width = 600 feet; saturated thickness = 0.2 foot
    - Happy Camp Wash West: Length = 12,300 feet; average width = 490 feet; saturated thickness = 0.1 foot
    - QC5: Length = 3,500 feet; average width = 310 feet; saturated thickness = 2.2 feet

[1] The saturated thickness varies between these alternatives because it is not measured physically but is estimated using Darcy's Law based on the flow rate anticipated to flow through the cells, which includes not only the tailings seepage, but underflow from upgradient and recharge. With respect to Alternatives 2 and 3, the amount of tailings seepage changes the overall flow and, therefore, changes the calculation of saturated thickness.

- QC4: Length = 9,900 feet; average width = 550 feet; saturated thickness = 3.4 feet
- QC3: Length = 15,700 feet; average width = 1,140 feet; saturated thickness = 5.6 feet
- QC2: Length = 6,400 feet; average width = 880 feet; saturated thickness = 17.1 feet
- QC1: Length = 6,300 feet; average width = 1,320 feet; saturated thickness = 12.1 feet

Alternative 5

- Reference: Gregory and Bayley 2018c
- Number of aquifer mixing cells:
  - Five total along Donnelly Wash (DW1, DW2, DW3, DW4, DW5)
- First perennial water: Gila River, approximately 8 miles downstream
- Hydraulic conductivity of mixing cells:
  - 2.11 feet/day
- Other hydraulic conductivity values of interest (from modeling used to estimate seepage):
  - Granodiorite = 2.8×10^{-2} feet/day
  - NPAG tailings = 1.4×10^{-1} feet/day
- Dimensions of mixing cells:
  - DW1: Length = 12,500 feet; average width = 21,500 feet; saturated thickness = 177 feet
  - DW2: Length = 5,700 feet; average width = 18,900 feet; saturated thickness = 142 feet
  - DW3: Length = 5,500 feet; average width = 15,500 feet; saturated thickness = 174 feet
  - DW4: Length = 4,600 feet; average width = 14,000 feet; saturated thickness = 165 feet
  - DW5: Length = 9,500 feet; average width = 11,900 feet; saturated thickness = 308 feet

Alternative 6 (referenced in the FEIS as the Alternative 6 "DEIS water quality model")

- Reference: Gregory and Bayley 2018d
- Number of aquifer mixing cells:
  - Five total along Dripping Spring Wash (DS1, DS2, DS3, DS4, DS5)
- First perennial water: Gila River, approximately 13 miles downstream
- Hydraulic conductivity of mixing cells:
  - 500 feet/day, based on Near West estimates
- Other hydraulic conductivity values of interest (from the modeling used to estimate seepage):
  - Gila Conglomerate (fresh) = 2.8×10^{-2} feet/day
  - Gila Conglomerate (weathered) = 2.8×10^{-1} feet/day
  - NPAG tailings = 2.8×10^{-2} feet/day

- Dimensions of mixing cells:
  - DS1: Length = 15,400 feet; average width = 1,040 feet; saturated thickness = 11.0 feet
  - DS2: Length = 11,200 feet; average width = 2,070 feet; saturated thickness = 7.2 feet
  - DS3: Length = 10,000 feet; average width = 2,010 feet; saturated thickness = 10.5 feet
  - DS4: Length = 12,200 feet; average width = 2,130 feet; saturated thickness = 15.4 feet
  - DS5: Length = 17,200 feet; average width = 1,600 feet; saturated thickness = 28.2 feet
- As noted, this model has been supplemented for the FEIS with a numeric groundwater flow model (referred to in the FEIS as the Alternative 6 "FEIS water quality model"). A direct comparison of key parameters between the DEIS water quality model and the FEIS water quality model is contained in section 3.7.2 of the FEIS.

Mounding Analysis

Public comments on the DEIS question whether groundwater mounding might occur below and downgradient of the tailings storage facilities. The specific concern is that such mounding would potentially reach the surface and change ephemeral drainages (Queen Creek, Donnelly Wash, Dripping Spring Wash) into intermittent or perennial drainages, as well as providing an exposure pathway not accounted for in the modeling.

The issue of mounding was raised by the Bureau of Land Management in comments on the Administrative DEIS in early 2019. The following estimates were made at that time:

- The estimated subsurface flow in Queen Creek downstream of Alternatives 2, 3, and 4 is at least 575 acre-feet (see Gregory and Bayley 2018e, table 2a showing underflow between model cells QC3 and QC2). For Alternatives 2 (20.7 acre-feet of seepage), 3 (2.7 acre-feet of seepage), and 4 (9–17 acre-feet of seepage), the increase in the alluvial flow is approximately 0.5 to 3.5 percent, which did not seem sufficient to change the fundamental ephemeral nature of flow in the channel.
- For Alternative 5, the design of the pumpback system is designed specifically to the capacity of the aquifer to accept flow. By definition the pumpback system should ensure that water levels do not rise to the land surface and become surface flow.
- For Alternative 6, the estimated subsurface flow in Dripping Spring Wash is approximately 456 acre-feet (see Gregory and Bayley 2018d, table 2 showing underflow from model cell DS1 to DS2 with tailings storage facility seepage subtracted). Alternative 6 seepage of 70 to 180 acre-feet per year represents approximately 15 to 40 percent, which is substantial; however, the depth to water in the aquifer is approximately 70 feet, with an average width of approximately 2,000 feet, and a gradient of 0.021 to 0.024 foot. KCB estimated K for alluvium of 27 feet/day. Solving Darcy's Law for the thickness of aquifer (d) needed to transmit 180 acre-feet of water:

$$Q = K * (dh/dl) * (W * d)$$

Where:

Q = Flow ($feet^3/day$) = 180 acre-feet/year = 21,480 $feet^3/day$

K = Hydraulic conductivity (feet/day) = 27 feet/day

dh/dl = Hydraulic gradient = 0.024

W = width of alluvium (feet) = 2,000 feet

d = thickness of alluvium needed to transmit flow (feet)

$$d = Q / (K * (dh/dl) * W) = 21{,}480 / (27 * 0.024 * 2{,}000) = 16.5 \text{ feet}$$

This theoretical thickness of the aquifer (16.5 feet) is the additional aquifer capacity needed to move 180 acre-feet downgradient and is substantially less than the 70 foot depth to water, suggesting that while groundwater mounding would occur, it would not be sufficient to create new exposure points.

Regulations, Laws, and Guidance – Groundwater and Surface Water Quality

Mine operations are subject to a wide range of Federal, State, and local requirements. Table 14 provides a summary of groundwater and surface water quality laws, regulations, policies, and plans at the Federal, State, and local level.

Table 14. Groundwater and surface water quality laws, regulations, policies, and plans at the Federal, State, and local level

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Safe Drinking Water Act (Public Law 93-523)	As mandated by the Safe Drinking Water Act, passed in 1974, the EPA regulates contaminants of concern to domestic water supply. Contaminants of concern relevant to domestic water supply are defined as those that pose a public health threat or that alter the aesthetic acceptability of the water. The EPA regulates these types of contaminants through the development of national primary and secondary maximum contaminant levels for finished water.	In Arizona, the ADEQ administers the Safe Drinking Water Act (Arizona Administrative Code [AAC] R18-4).
Clean Water Act (CWA) (33 United States Code 1251-1376)	The CWA and the Water Quality Act of 1987 form the major Federal legislation governing water quality. The objective of the CWA is “to restore and maintain the chemical, physical, and biological integrity of the nation’s waters.”	All waters within the analysis area are subject to management by the CWA.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
CWA Section 401 (Water Quality Certification)	Requires an applicant for any Federal permit who proposes an activity that may result in a discharge to waters of the U.S. (WUS) to obtain a certification from the appropriate State that the discharge will not result in a violation of State surface water quality standards. Arizona Revised Statutes (ARS) 49-202(B)–(H) outline the State's water quality certification procedures for any Federal permit or license that involves a discharge to WUS. The ADEQ may certify, deny, or waive water quality certification. No Federal permit or action may be approved if the State denies certification.	Activities by Resolution Copper may result in a discharge to WUS. Resolution Copper must demonstrate that the discharge will not result in a violation of State surface water quality standards. ADEQ issued the Section 401 water quality certification for the Resolution Copper project on December 22, 2020.
CWA Section 402 / Arizona Pollutant Discharge Elimination System (ARS 49-255.01)	Section 402 of the CWA establishes the National Pollutant Discharge Elimination System, a permitting system for the discharge of any pollutant (except for dredged or fill material) into WUS. Since 2002, the ADEQ has had primacy over Section 402 through implementation of the Arizona Pollutant Discharge Elimination System (AZPDES). The AZPDES program regulates point sources of discharge. The most common source regulated is stormwater runoff from construction activities and industrial sites. Coverage may be obtained either through issuance of an Individual Permit or a General Permit by the ADEQ (AAC R18-9-C901).	There are several AZPDES general permits that may apply to Resolution Copper: de minimis discharges, stormwater runoff from construction activities (the construction general permit), and stormwater runoff from industrial sites (the multisector general permit). Minor temporary discharges, such as pipeline hydrostatic testing or well testing, may be covered as de minimis discharge. Linear construction activities, including road building, utility line construction, and other ground disturbance performed off the mining facility site and greater than 1 acre in size may require separate coverage under the construction general permit if not covered under the mining multisector general permit.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
		The current multisector general permit for stormwater discharges associated with industrial activity/mineral industry was approved by ADEQ on December 20, 2010. This mining multisector general permit specifically applies to stormwater runoff from industrial activities related to metal mining, including tailings, waste rock, haul roads, milling, and ancillary facilities. A key condition for using the general permit is that stormwater runoff may not mix with mine drainage or process water. Stormwater discharges can be covered under the mining multisector general permit if the applicant meets the permit's eligibility criteria and complies with the permit's substantive requirements. Additionally, the mining general permit requires monitoring for several parameters specific to copper mining operations.
CWA Section 303	The ADEQ has developed surface water quality standards, including narrative limitations, to define water quality goals for Arizona's streams and lakes and provide the basis for controlling discharge of pollutants to surface waters. Beneficial uses for water bodies are identified in State water quality standards (18 AAC Chapter 11, Article 1) and must be achieved and maintained as required under the CWA. Beneficial uses can include support of aquatic life, fish consumption, public water supply, and irrigation. The 303(d) list, as required by Section 303(d) of the CWA, is a list of water bodies that have a designated beneficial use that is impaired by one or more pollutants. Water bodies included on this list are referred to as "impaired waters." The State must take appropriate action to improve impaired water bodies by establishing total maximum daily loads and reducing or eliminating pollutant discharges.	Certain reaches within the analysis area that would receive pollutants from the mine activities are on the 303(d) impaired waters list. The primary reach of concern is Queen Creek between Superior and Whitlow Ranch Dam, impaired for copper.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Aquifer Protection Permits (ARS 49-241)	Any discharge of a pollutant from a facility either directly to an aquifer or to the land surface or the vadose zone in such a manner that there is a reasonable probability that the pollutant would reach an aquifer requires issuance of an Aquifer Protection Permit (APP) by the ADEQ. Unless the discharge is either specifically exempted by statute (ARS 49-250), or if the discharge is authorized under one of the general aquifer protection permits issued by the ADEQ (AAC R18-9, Article 3), then the discharge requires issuance of an individual APP by ADEQ.	Temporary discharges associated with the construction phase (hydrostatic line testing and equipment wash) or on-site wastewater treatment facility would likely be covered under a general APP. An individual permit is required for potential discharges at the mine associated with various process facilities. In addition, mine tailings facilities are considered to be discharging facilities requiring permits (ARS 49-241.B6).
AAC Title 18, Chapter 11	State regulations dictate numerical water quality standards for groundwater through Aquifer Water Quality Standards.	Numeric Arizona Aquifer Water Quality Standards apply to all groundwater within the state.
Tonto National Forest and Land Resource Management Plan	In addition to the standards and guidelines listed above in the groundwater quantity section, the Tonto National Forest Plan (October 1985, as amended) also provides guidance on minimizing impacts on water resources from all ground-disturbing activities and mitigating adverse effects of planned activities through the use of best management practices.	A stated goal of the forest plan is to provide direction and support to resource management activities to meet minimum water quality standards and emphasize improvement of water quality.
FS-990a, "National Best Management Practices for Water Quality Management on National Forest System Lands"	Guidance for best management practices for managing water quality on National Forest System lands. Forest Service direction established agency policy and objectives and assigns responsibilities to Forest Service personnel for that policy. Forest Service guidance is nonprescriptive in nature. It does not provide absolute requirements for managing water quality or water resources but provides general objectives to be considered when managing those resources.	The analysis area occurs on Forest Service land and is subject to guidance practices outlined in FS-990a.

Key Documents and References Cited for Groundwater and Surface Water Quality

The following list is meant to highlight key process or analysis documents available in the project record. It should not be considered a full list of all available documentation considered within this process memorandum or the EIS analysis.

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Detailed Information Supporting Environmental Impact Statement Analysis – Surface Water Quantity

Resource Analysis Area

Spatial Analysis Area

The analysis area includes any areas in which surface water quantity may be reduced because of project activities. These include the following areas:

- Queen Creek. The western part of the study area is drained by Queen Creek, which arises in the highlands around the Pinal Mountains and flows past Oak Flat and through the town of Superior. Queen Creek ultimately flows to Whitlow Ranch Dam, approximately 11 miles west of Superior. The dam is an ungated flood risk management structure that was constructed in 1960 to reduce the risk of downstream flood damage to farmland and the communities of Chandler, Gilbert, Queen Creek, and Florence Junction. The dam includes a diversion structure to satisfy local water rights. As discussed in the groundwater quantity section, Queen Creek is primarily ephemeral but exhibits perennial flow downstream of the Town of Superior wastewater treatment plant, both from effluent and groundwater discharges from a nearby mine pit. Above Superior, Queen Creek would see reductions in surface flow due to the subsidence crater intercepting surface runoff. Below Superior, Queen Creek would see reductions in surface flow caused by Alternatives 2, 3, or 4, due to surface water management requirements of the tailings storage facilities.
- Devil's Canyon. The ore body is located approximately 6,000 feet beneath Oak Flat in the upper Queen Creek basin. Devil's Canyon is located to the immediate east of Oak Flat with its headwaters located north of U.S. Route 60. Devil's Canyon cuts through the Apache Leap Tuff, forming a steep-sided canyon that flows in a southerly direction for approximately 9 miles. Devil's Canyon discharges into the reservoir of Big Box Dam. Mineral Creek, to the immediate east of Devil's Canyon, also discharges into the reservoir. Big Box Dam was constructed to divert flows from Devil's Canyon and Mineral Creek around the Ray Mine and into the Gila River. As discussed in the groundwater quantity section, much of upper Devil's Canyon is ephemeral, where runoff is driven by rainfall events; however, there are several perennial reaches that are sustained either by shallow, recharged groundwater systems or a deep bedrock aquifer that discharges to the surface via seeps and springs. Devil's Canyon would see reductions in surface flow due to the subsidence crater intercepting surface runoff.
- Gila River Watershed. Alternative 5 – Peg Leg would impact Donnelley Wash, which flows north to join the Gila River downstream of the Ray Mine. The wash flows through an alluvial valley and has more gentle slope gradients compared to the other watersheds. The mainstem channel of Donnelley Wash is entirely ephemeral, with no known perennial reaches. Alternative 6 – Skunk Camp would impact Dripping Spring Wash. Dripping Spring Wash is located in the eastern part of the study area. The wash flows to the southeast for approximately 18 miles before discharging into the Gila River downstream of the Coolidge Dam. The mainstem channel of Dripping Spring Wash is entirely ephemeral, with no known

perennial reaches. Both Alternative 5 and 6 would reduce flows in the Gila River due to stormwater management requirements of the tailings storage facilities.

Analysis Methodology

Surface Water Effects – Modeling Approaches

Two separate modeling approaches were used to assess how the subsidence crater and tailings storage facilities would affect runoff. Flood flows are often characterized by the "return period," i.e., a 2-year or 20-year flood event, which is just another way of expressing the probability of an event occurring. A 2-year event has a 50 percent chance of occurring for any given storm, and a 20-year event has a 5 percent change of occurring for any given storm. An approach developed by the USGS was used to analyze how reduced watershed area would affect peak flood flows with different return periods (Lehman 2017, 2018).

The USGS approach is designed to allow estimation of flood flow frequency and volume-duration-frequency at ungaged stream sites, where only watershed drainage area, mean annual precipitation, and mean elevation of the watershed are known. These variables are used with regression equations the USGS developed using streamflow data (through 2010) for dozens of streamflow sites with available gages. The USGS approach is found in USGS Scientific Investigations Reports 2014-5211 (peak flow frequency) and 2014-5109 (volume-duration-frequency) and was adapted to the project by JE Fuller and Associates (Lehman 2017, 2018).

In addition to changes to individual flood events, the loss of watershed area also would affect the overall volume of water flowing through a wash and available to wildlife, vegetation, and surface water users. A "monthly water balance" modeling approach was used to assess reductions in the volumes of water available to the natural system due to the subsidence crater and the tailings storage facilities (BGC 2018b).

The monthly water balance model is a fundamentally different approach. Whereas the USGS approach relies on regression equations developed from historical data, the monthly water balance estimates water inputs to the watershed and partitions them among various components. The specific model used by BGC (2018) is known as the Australian Water Balance Model (AWBM) and was selected because it performed well when calibrated to available data from Pinto Creek.

In its simplest form, the AWBM consists of a store of water in the underlying soils of a catchment. The capacity of this storage unit, C, represents the storage capacity of the catchment and is expressed in units of depth (millimeters). The model assumes that when rainfall or snowmelt occurs, no runoff occurs until the storage unit is filled, following which all rainfall/snowmelt becomes runoff. The AWBM allows for additional moisture stores to be defined for a watershed, recognizing that land cover is almost never uniform over a watershed. The model also allows for evaporation (E) losses from the moisture stores at a calibrated fraction of the defined potential evaporation (P). BGC conducted the AWBM using daily time steps, then summarized the results by month. Full details of the AWBM modeling approach and construction is in BGC 2018.

Floodplains and Lack of Available Data

With respect to floodplains, because large portions of the analysis area lie within the Tonto National Forest, the Federal Emergency Management Agency (FEMA) has not delineated the 100-year floodplains for most major waterways. This analysis is based on a reasonable estimate of the extent of 100-year floodplains, based primarily on geological mapping, in lieu of FEMA-delineated floodplains:

- Devil's Canyon. The upper part of the Devil's Canyon drainage lies within the Tonto National Forest and 100-year floodplains have not been mapped by FEMA, although they have been mapped for the lower 1.5 miles. There are no project disturbances within this area, however, for any alternatives, and floodplains would not be affected.
- Mineral Creek. The 100-year floodplains have been mapped for the lower 0.5 mile of Mineral Creek; however, there are no project disturbances within this area for any alternatives, and floodplains would not be affected.
- Queen Creek above Whitlow Ranch Dam. The 100-year floodplains in the Queen Creek watershed above Whitlow Ranch Dam largely have not been mapped, as they lie within Tonto National Forest. There are no project disturbances that would impact Queen Creek, but tributaries to Queen Creek will be assessed qualitatively.
- Donnelly Wash. The 100-year floodplains have been mapped for the Donnelly Wash watershed and impacts from the project are analyzed quantitatively.
- Dripping Spring Wash. The 100-year floodplains have been mapped for the Dripping Spring watershed and impacts from the project are analyzed quantitatively.

Detailed Floodplain Impacts

Table 15 shows the detailed floodplain impacts by alternative based on the available floodplain coverage. In the cases of pipeline corridors, any permanent changes in floodplains are likely overstated, as pipelines crossing major drainages would be buried or use pipe bridges that span the ordinary high water mark. Exact changes to downstream floodplains would not be known until final design stage based on the selected corridor. Necessary floodplain permitting, if any, would be needed at that time.

Table 15. Detailed floodplain impacts

Alternative	Area of Mapped 100-Year Floodplain Impacted (acres)	Primary Drainages Impacted
Alternative 2 (Near West)	8.5	Most of disturbed area has not been mapped for floodplains. The acreage shown reflects impacts to a wash tributary to Queen Creek, north of U.S. Route 60, that runs along the eastern edge of the West Plant Site.
Alternative 3 (Near West)	8.5	Most of disturbed area has not been mapped for floodplains. The acreage shown reflects impacts to a wash tributary to Queen Creek, north of U.S. Route 60, that runs along the eastern edge of the West Plant Site.

Alternative	Area of Mapped 100-Year Floodplain Impacted (acres)	Primary Drainages Impacted
Alternative 4 (Silver King)	8.5	Most of disturbed area has not been mapped for floodplains. The acreage shown reflects impacts to a wash tributary to Queen Creek, north of U.S. Route 60, that runs along the eastern edge of the West Plant Site.
Alternative 5 (Peg Leg)	178.7	Floodplains associated with Donnelly Wash and an unnamed tributary wash. The pipeline crosses mapped floodplains associated with the Gila River and Walnut Canyon.
Alternative 6 (Skunk Camp)	786.1	Floodplains are associated with Dripping Spring Wash and tributaries, including Stone Cabin Wash and Skunk Camp Wash. The pipeline crosses Devil's Canyon and Mineral Creek; floodplains have been mapped for portions of these drainages, but no floodplains are impacted by the pipelines. The pipeline also crosses Queen Creek east of Superior; floodplains are not mapped but are unlikely to exist in this area based on existing mapped segments. In addition, this is a bridged pipeline crossing.

Detailed Wetland Impacts

Table 16 shows the detailed wetland impacts by alternative based on the National Wetlands Inventory mapping.

Table 16. Detailed wetland impacts

Category of Mapped Wetland*	Alternative	Area of Wetland Impacted (acres)	Description
PFO1A	Alternatives 2 and 3	5.64	Associated with channel of Queen Creek at Castleberry Campground
PSS1A	Alternatives 2 and 3	22.8	Associated with ephemeral washes in tailings storage facility; MARRCO corridor; recreation mitigations
PSS1Ah	Alternatives 2 and 3	5.03	Associated with KP Reservoir in subsidence area; ephemeral washes along MARRCO corridor
PUSCx	Alternatives 2 and 3	5.35	Associated with KP Reservoir in subsidence area; portion of Benson Spring Canyon; stock impoundments along MARRCO corridor, filter plant, and transmission line
R2UBHx	Alternatives 2 and 3	0.34	Associated with ephemeral washes along MARRCO corridor
R2USC	Alternatives 2 and 3	1.68	Associated with channel of Queen Creek along MARRCO corridor and at tailings facility

Category of Mapped Wetland*	Alternative	Area of Wetland Impacted (acres)	Description
R4SBJ	Alternatives 2 and 3	121.87	Associated with ephemeral washes in subsidence area, tailings storage area, and tailings pipeline; transmission lines; recreation mitigations; MARRCO corridor; East Plant Site; filter plant, borrow area; and Silver King Road realignment
PFO1A	Alternative 4	5.64	Associated with channel of Queen Creek at Castleberry Campground
PSS1A	Alternative 4	15.39	Associated with ephemeral washes in tailings storage facility; MARRCO corridor; recreation mitigations
PSS1Ah	Alternative 4	5.03	Associated with KP Reservoir in subsidence area; ephemeral washes along MARRCO corridor
PUSCx	Alternative 4	5.26	Associated with KP Reservoir in subsidence area; stock impoundments along MARRCO corridor, filter plant, and transmission line
R2UBHx	Alternative 4	0.34	Associated with ephemeral washes along MARRCO corridor
R2USC	Alternative 4	1.23	Associated with channel of Queen Creek along MARRCO corridor
R4SBJ	Alternative 4	142.55	Associated with ephemeral washes in subsidence area, tailings storage area and tailings pipeline; transmission lines; recreation mitigations; MARRCO corridor; East Plant Site; filter plant, borrow area; and Silver King Road realignment
PFO1A	Alternative 5	6.3	Associated with channel of Queen Creek at Castleberry Campground, and at tailings pipeline crossing
PF01B	Alternative 5	6.7	Associated with Gila River crossing by tailings pipeline
PSS1A	Alternative 5	12.96	Associated with ephemeral washes along tailings pipeline; MARRCO corridor; recreation mitigations
PSS1B	Alternative 5	1.92	Associated with ephemeral washes along tailings pipeline
PSS1Ah	Alternative 5	5.03	Associated with KP Reservoir in subsidence area; ephemeral washes along MARRCO corridor
PUSCx	Alternative 5	11.21	Associated with KP Reservoir in subsidence area; stock impoundments along MARRCO corridor, filter plant, and transmission line; and at tailings facility
R2UBH	Alternative 5	0.64	Associated with ephemeral washes along tailings pipeline
R2UBHx	Alternative 5	0.34	Associated with ephemeral washes along MARRCO corridor

Category of Mapped Wetland*	Alternative	Area of Wetland Impacted (acres)	Description
R2USC	Alternative 5	1.23	Associated with channel of Queen Creek along MARRCO corridor
R4SBJ	Alternative 5	244.64	Associated with ephemeral washes in subsidence area, tailings storage area, and tailings pipeline; transmission lines; recreation mitigations; MARRCO corridor; East Plant Site; filter plant, borrow area; and Silver King Road realignment
PFO1A	Alternative 6	5.64	Associated with channel of Queen Creek at Castleberry Campground
PSS1A	Alternative 6	5.43	Associated with ephemeral washes along tailings pipeline (including Mineral Creek crossing); MARRCO corridor; recreation mitigations
PSS1Ah	Alternative 6	6.03	Associated with KP Reservoir in subsidence area; ephemeral washes along MARRCO corridor and at tailings facility
PUSCx	Alternative 6	11.27	Associated with KP Reservoir in subsidence area; stock impoundments along MARRCO corridor, filter plant, and transmission line; and at tailings facility
R2UBHx	Alternative 6	0.34	Associated with ephemeral washes along MARRCO corridor
R2USC	Alternative 6	1.23	Associated with channel of Queen Creek along MARRCO corridor
R4SBJ	Alternative 6	220.98	Associated with ephemeral washes in subsidence area, tailings storage area and tailings pipeline; transmission lines; recreation mitigations; MARRCO corridor; East Plant Site; filter plant, borrow area; and Silver King Road realignment

* Calculations exclude 11.78 acres mapped of ponds (PUBHx) and 5.82 acres mapped of channel (R4SBJ) within the currently disturbed area of West Plant Site.

PFO1A – Palustrine, forested, broad-leaved deciduous, temporarily flooded. These are freshwater wetlands.

PF01B – Palustrine, forested, broad-leaved deciduous, seasonally saturated. These are freshwater wetlands.

PSS1A – Palustrine, scrub-shrub, broad-leaved deciduous, temporarily flooded.

PSS1B – Palustrine, scrub-shrub, broad-leaved deciduous, seasonally saturated.

PSS1Ah – Palustrine, scrub-shrub, broad-leaved deciduous, temporarily flooded, impounded.

PUBHx – Palustrine, unconsolidated bottom, permanently flooded, excavated. These are freshwater ponds, usually stock tanks.

PUSCx – Palustrine, unconsolidated shore, seasonally flooded, excavated. These are freshwater ponds, usually stock tanks.

R2UBH – Riverine, perennial, unconsolidated bottom, permanently flooded. These are primarily flowing streams, but much of Queen Creek is mapped in as riverine-perennial.

R2UBHx - Riverine, perennial, unconsolidated bottom, permanently flooded, excavated. These are primarily flowing streams, but much of Queen Creek is mapped in as riverine-perennial.

R2USC – Riverine, perennial, unconsolidated shore, seasonally flooded. These are primarily flowing streams, but much of Queen Creek is mapped as riverine-perennial.

R4SBJ – Riverine, intermittent, streambed, intermittently flooded. These are primarily ephemeral washes.

Acreage Differences

As noted above, two separate modeling exercises were used to estimate effects to surface runoff. There are some differences in acreage between the two analyses, but do not substantially affect the results:

- For Queen Creek at Whitlow Ranch Dam and Queen Creek at Magma Avenue, estimates from both sources are within 1 percent.
- For Devil's Canyon at Mineral Creek, estimates from both sources are within 1 percent.
- For Dripping Spring Wash, estimates from both sources are within 1 percent.
- For Donnelly Wash, estimates differ by approximately 2.7 percent.
- For the Gila River, two separate measurement points are referenced. For the Gila River at Dripping Spring Wash, JE Fuller calculated the upstream watershed area as 15,473 square miles, while BGC relied on flow measurements at a USGS gage upstream (09469500 – Gila River below Coolidge Dam, Arizona) with a watershed area of 12,866 square miles; however, JE Fuller ultimately did not estimate changes in peak flows at this location because of the effects of Coolidge Dam. For the Gila River at Donnelly Wash, JE Fuller calculated the upstream watershed area as 22,152 square miles, while BGC relied on flow measurements at a USGS gage upstream (09474000 – Gila River at Kelvin, Arizona) with a watershed area of 18,011square miles; however, JE Fuller similarly did not estimate changes in peak flows at this location because of the effects of Coolidge Dam. Coolidge Dam did not affect analysis by BGC, which was based on volumes, not peak flows.

Differences in Stormwater and Erosion Control between Alternatives

Stormwater controls are required to be implemented for the project and include methods not only to control and contain any runoff impacted by the project but also to reduce the amount of runoff potentially impacted by avoiding facilities. This section describes the general stormwater controls to be implemented for the project, as well as stormwater controls specific to each project facility.

Any on-site stormwater that would come into contact with project elements (tailings, ore, processing areas) would be considered "contact water." Contact water across the project would be captured and contained to be incorporated back into the process water supply system. Structural and non-structural control measures would be used to manage contact water per the Arizona Pollutant Discharge Elimination System stormwater permit and Aquifer Protection Permit (APP) (see groundwater and surface water quality section).

Note that while the assumption that contact water would not be released is true for normal operations, based on public comments on the DEIS, this topic was further explored in the FEIS. The FEIS contains an analysis of a potential stormwater release for Alternative 6 that would occur under specific circumstances of an extreme precipitation event (300-year return period or more) and operational equipment malfunctions.

General Sediment and Erosion Control Measures

Structural controls would include diversion channels/dams, and sediment traps, and detention basins for each project element as discussed below. Disturbed and newly reclaimed areas would be examined after major storm events and structural controls would be put into place as needed (as required under the Arizona Pollutant Discharge Elimination System permit).

Additional general stormwater controls that would be used across the project surface facilities include the following:

- Limit vegetation removal only to areas affected by project activities.
- Avoid off-road vehicle travel.
- When possible, remove vegetation during dry months to reduce potential for erosion.
- Design roads to incorporate drainage ditches with cross-drains. Stabilize disturbed slopes (revegetated, mulch, etc.) as soon after construction as practicable.
- Manage runoff from roads, buildings, and structures with additional structural controls (sediment traps, berms, sediment filter fabric, wattles, etc.) as appropriate based on local hydrologic conditions.
- During construction and operations, use additional structural controls (check dams, dispersion terraces, filter fences) as needed to prevent erosion.
- Revegetate or stabilize pipeline and conveyor berms to minimize erosion.
- Collect incidental precipitation falling on disturbed areas.
- Design permanent diversion channels for long-term stability.
- Implement reclamation/revegetation soon as practicable for long-term stability.

East Plant Site Facility Stormwater Controls

Contact water would be collected in naturally occurring low points within the East Plant Site facility, and the flow would be directed to one of two contact water basins constructed within an existing drainage along the eastern edge of East Plant Site or to a contact water basin excavated in the northern portion of East Plant Site (see GPO figure 4.5-1). Contact water basins would be sized to handle runoff from the 100-year, 24-hour storm event plus 1 foot of freeboard; would be constructed with earthen dams; and would be lined to the APP program BADCT standards. Contact water basins would be emptied after each storm event for reuse and would be incorporated into the supply water system.

Non-contact stormwater flow would be diverted away from the East Plant Site. Runoff would be captured from areas upstream of the East Plant Site and routed around the facility via channels, berms, or buried culverts. All non-contact flow would be conveyed to a riprap sediment basin at a common outfall where it would be released back into an existing drainage.

West Plant Site Facility Stormwater Controls

Stormwater management within West Plant Site would consist of three specific designs for each of these three features found at West Plant Site: stockpiles, concentrator complex, and ancillary facility elements.

Stockpiles

Stockpiles at West Plant Site would include two separate rock storage areas for development and intermediate rock stockpiles between the concentrator complex and ancillary facilities. Once the concentrator complex is constructed, no additional rock would be produced, and the stockpiles would be removed for processing. The stockpiles would be generated from mine excavation material, thus stormwater runoff from this stockpile would be considered contact water.

All contact water at West Plant Site would be routed to one of four constructed basins within the facility via drainage ditches, buried culverts, and berms (see GPO figure 4.5-2). Similar to East Plant Site, contact water at West Plant Site would be incorporated into the process water supply for reuse. Basins would be lined according to BADCT standards and would be emptied after each storm event.

Stormwater generated upstream of the proposed West Plant Site stockpile area currently flows following the existing topography to the Apex Tunnel and is diverted off-site, west to Silver King Wash. This method of diverting off-site, non-contact water would continue until such time that the concentrator complex is constructed.

Concentrator Complex

Once the stockpiles are removed, stormwater management in and around the concentrator complex would consist of routing off-site non-contact water around the facility and routing contact water to one of five constructed basins.

Stormwater runoff from the majority of the West Plant Site would come in contact with facility elements and thus be considered contact water. It would flow along site surface roads and would be routed by a series of berms, channels, and buried culverts to one of the HDPE-lined retention basins (see GPO figure 4.5-3). The largest basin (W1) would be designed with an emergency overflow ditch to route excess flows to the next downstream basin. Water from these basins would be incorporated into the water supply system.

Stormwater runoff from areas upstream (north and west of the concentrator complex facility) would be considered non-contact water. Runoff from these areas would be diverted via the western diversion channel or a buried culvert, then discharged to the Apex Tunnel.

Ancillary Facilities

No mining activity would occur in the ancillary facilities areas; therefore, all stormwater runoff would be considered non-contact water. The majority of flow in this area would be directed to one of four basins, the largest of which (W9) would be an HDPE-lined basin (see GPO figure 4.5-4). Remaining stormwater flow from the ancillary facilities area would be collected either in the legacy tailing ponds 1 and 2 located north of the administration building or diverted via culverts and existing drainage to off-site storage in Indian Pond. Water from the basins and legacy tailings ponds would be incorporated into the water supply system.

Filter Plant and Loadout Facility Stormwater Controls

A majority of the areas within the filter plant and loadout facility property is undisturbed and stormflow runoff would not come into contact with the facility elements. Off-site, non-contact runoff would be routed around facility elements or allowed to flow through the property's undisturbed areas. All runoff that would come into contact with facility elements would be captured in one of two contact water basins (see GPO figure 4.5-5).

All non-contact water would be diverted around or directed through the property to one of three outfalls. Along the northern boundary, a diversion channel would direct off-site, non-contact water around the facility elements located in the north. Grading and contouring in the southeast corner of the site would divert off-site, non-contact water around the southernmost facility elements. All non-contact water through the middle of the property would be allowed to flow via existing drainages and culverts.

Stormwater flow would be considered contact water if it comes into contact with elements such as concentrator filter plant, conveyor, concentrate loadout, clarifier, parking, helipad, filter plant site, CAP water pump station, or CAP water tank. All contact water flow would be directed to on-site constructed basins. Basins would be lined according to BADCT standards and would be emptied after each storm event; water would be incorporated into the water supply system for reuse.

Alternatives 2 and 3 Tailings Storage Facility Stormwater Controls

In general, upstream non-contact surface water north, west, and east of the tailings storage facility would be diverted around the facility to Robles and Potts Canyons via three diversion channels, thus maintaining hydrologic connection to Queen Creek (see GPO figure 4.5-6). Basins would be designed to accommodate the peak probable maximum flood flow and riprap sediment basins and/or spillways would be used for erosion and sediment control (see GPO figures 4.5-7 and 4.5-8).

Installation of a seepage capture and collection system of rock-filled underdrains that would be keyed into bedrock and report to one of 11 seepage dams/runoff collection ponds. These dams/collections ponds would be constructed in downgradient drainages underlain by low-permeability geological formations (Gila Conglomerate or Pinal Schist), or otherwise a grout curtain would be installed. Dams would be designed to collect runoff from the 200-year, 24-hour storm with emergency spillways designed for the 1,000-year, 24-hour storm. Seepage would be pumped back into the tailings storage facility or back to the concentrator complex for reuse.

Final reclamation would include a store and release cover that limits infiltration of precipitation/ reduces seepage from facility and encourages runoff. The entire tailings surface would be revegetated at closure to reduce infiltration.

Alternative 4 Tailings Storage Facility Stormwater Controls

Surface water management for Alternative 4 would consist of the following operational and design elements:

1. Maximize tailings water recovery for reuse in milling process
2. Divert non-contact water around tailings storage facility
3. Minimize ponding on tailings storage facility
4. Collect and manage contact runoff water from scavenger and pyrite tailings piles separately
5. Provide water storage to attenuate stormwater runoff

The tailings storage facility would be constructed with an underdrain water system and low-permeability base layers to control seepage downstream. The armored surface water diversion ditches would be constructed on pile slopes to direct surface water runoff and limit erosion.

Runoff from any precipitation falling on the tailings surface would be considered contact water. To avoid ponding, the tailings surface would be sloped, and runoff would be directed to perimeter ditches, sumps, and/or underdrains. This contact water would be managed by collecting it off-site in one of five downstream water collection ponds. Four of the collection ponds would be for contact water from scavenger tailings and one would be for contact water from pyrite tailings. Collections ponds would be constructed per ADEQ BADCT design for non-stormwater ponds; they would be lined (geomembrane on prepared subgrade) and retained by earthfill dams. If expected water quality of the ponds dictates, they would instead be designed using BADCT for process solution ponds. Containment dams would be built of locally borrowed materials. Lined contact water collection ditches would collect tailings pile runoff for conveying to collection reservoirs.

Contact water from scavenger tailings would be sent back to the West Plant Site for reuse via pumps and pipelines; contact water from pyrite tailings may need to be treated prior to reuse. Any tailings storage facility system surplus contact water would likely need to be treated prior to release to the environment. To minimize contact water runoff during operations, dust would be controlled with methods other than surface wetting such as progressive reclamation of tailings pile slopes/compaction of pile surface and use of dust suppressants. Temporary slurry storage ponds would be constructed near West Plant Site as emergency disposal locations in the event of planned or unplanned shutdowns of tailings storage facility filter plants or tailings conveying system.

Non-contact stormwater runoff would be generated from 9,500 acres upstream of the tailings storage facility. This non-contact water would be managed by diverting runoff around the tailings storage facility and around two upstream diversion dams where practical. Water diversion structures would include tunnels, ditches, pipelines, and upstream reservoirs. Reservoirs would be used to attenuate and temporarily store upstream non-contact stormwater. A diversion tunnel and pipelines would be used to convey water from the reservoirs to existing drainages downstream of the tailings storage facility.

Upon closure, upstream diversion structures would remain in place in perpetuity to protect tailings storage facility from damage during extreme storms. The top of tailings piles would be reclaimed and would be sloped into the hillside to limit surface water runoff over, and erosion of, the outer slopes.

Alternative 5 Tailings Storage Facility Stormwater Controls

Similar to Alternative 4, the Peg Leg tailings storage facility would be designed to keep contact and non-contact stormwater runoff separate. Diversion channels would be constructed during the early phases of the facility to reduce mixing of contact and non-contact waters. The tailings storage facility would be specifically designed to reduce the overall footprint of the disturbed area with the use of sub-cells in the PAG facility. Design features would meet ADEQ BADCT and include the use of geomembrane liner in the reclaim pond area, toe drains on the embankment to recover deposition water, and use of pumpback wells to recover seepage losses.

Water that falls within the tailings storage facility area (contact water) would be captured within the facility or in toe drain collection ditches and ponds located on the perimeter. The tailings storage facility would be designed to contain the 72-hour probable maximum flood event during the facility life of operations. The toe channels would be lined and designed to convey runoff to seepage collection ponds located west of the embankment. This contact stormwater runoff would then be pumped to a reclaim tank for reuse.

For non-contact stormwater runoff, diversion ditches would route upstream storm runoff around the tailings storage facility and process facilities and release runoff back into natural drainage ways to maintain hydraulic connectivity to the Gila River. Three permanent non-contact water diversions (north, east, and south of the tailings storage facility) would be constructed upgradient of the tailings storage facility to divert stormwater north and south into natural drainages located outside of the tailings storage facility boundary. Temporary diversions would convey flows around the NPAG facility during startup conditions and discharge to the environment downstream of the tailings storage facility. As the tailings impoundment expands to the east, temporary diversions would be covered with tailings. Permanent diversions would be designed to convey the 200-year, 24-hour flood event; temporary diversions would be designed to convey the 10-year, 24-hour duration flood event. The tailings storage facility and diversion structures would be protected from erosion or overtopping during storm events. Locally obtained rock from the PAG tailings storage facility footprint would be used for armoring of the drainages to reduce erosion from stormwater runoff.

The pipeline corridor for Alternative 5 would potentially cross Queen Creek, the Gila River, multiple ephemeral surface drainage ways, U.S. Route 60, and the Copper Basin Railway. Stormwater controls along the pipeline corridor associated with Alternative 5 would consist of temporary erosion control measures until final stabilization.

During closure procedures, the PAG cells would be covered with a store-and-release cover to provide erosion protection. Further, a vegetated thick cover on the tailings storage facility would be developed to limit wind and water erosion. Stormwater runoff generated uphill from the tailings storage facility would continue to be diverted around the facilities.

Alternative 6 Tailings Storage Facility Stormwater Controls

Similar to other alternatives, stormwater management design features for Skunk Camp would include keeping runoff that has come into contact with the facility separate from that which has not. Further, to protect downstream water quality, two low-permeability, segregated pyrite tailings cells and a seepage collection pond would be constructed in the downstream drainage.

Contact water would be captured in a collection system consisting of seepage dams, ditches, and reclaim ponds. Seepage dams would be designed following ADEQ BADCT criteria for water dams. Collection ditches would be constructed along the embankment toe to convey water to seepage collection ponds. This contact water along with surface runoff from the embankment slope would be collected for reuse. A reclaim pond would be maintained within the pyrite cell to allow for excess water to be reclaimed to the West Plant Site. Runoff that would collect on the scavenger tailings surface would be collected and pumped to Pyrite Cell 2.

Non-contact surface water would be kept separate from contact water via upslope diversion dams, pipelines, and channels to divert non-contact water around the tailings storage facility. Diversion dams would be used to maintain a constant slope. Two surface water diversion dams would be constructed to the north in Skunk Camp and Stone Cabin washes, and three constructed on the west side of the tailings storage facility; pipelines would be used to conduct flow from diversion dams to nearby diversion channels. Four diversion channels would be constructed along the east and west of the tailings storage facility to divert stormwater runoff south to Dripping Spring Wash or north to Walnut Canyon, both of which eventually discharge to the Gila River. All diversion structures would be designed to contain the peak flow from a 24-hour, 100-year storm event. Riprap from local nearby sources would be used for erosion protection.

The pipeline corridor for Alternative 6 would cross Queen Creek and multiple ephemeral surface drainage ways. Stormwater controls along the pipeline corridor associated with Alternative 6 would consist of temporary erosion control measures until final stabilization.

Upon closure of the tailings storage facility, a dry-cover would be used on the tailings surface to reduce infiltration of precipitation over the long-term. A vegetated cover system on the tailings storage facility and over the top of the impoundment surface areas would be used to protect surface water runoff water quality and protect against erosion. Ponding of stormwater on the tailings storage facility would be minimized by shaping the tailings surface to shed water to a closure spillway. The closure spillway and diversion would be constructed to divert runoff from the natural catchment and reclaimed tailings storage facility surfaces and around the seepage collection ponds. The spillway would convey surface runoff north to Mineral Creek. If water reporting to the seepage collection ponds is not suitable for discharge, collection ponds and dams would remain in place.

The contact water release scenario for Alternative 6 occurs when an extreme precipitation event occurs as well as operational upset conditions at the seepage collection pond downstream. This results in stormwater in contact with the NPAG cyclone tailings on the face of the main embankment being released through the seepage dam spillway into Dripping Spring Wash. The FEIS contains estimates of stormwater quality of the release, and how far downstream concentrations above numeric surface water quality standards would persist.

Full Details of Streamflow Discharge-Duration-Frequency Analysis

Streamflow discharge-duration-frequency analysis provides a detailed look at the dynamics of a stream under many conditions. For purposes of comparison in the EIS, two values from the discharge-duration-frequency analysis were selected to represent impacts at each location. The values selected are those that represent the peak instantaneous and the 30-day streamflows, each with a 50 percent level probability of exceedance. The return period was selected because it represents flows that happen with relative frequency. The short duration (peak instantaneous streamflow) was selected to represent short, intense ephemeral flows that occur, typical of monsoon events. The long duration (30-day streamflow) was selected to represent streamflow occurring over longer periods but at lesser volume, more typical of conditions affected by baseflow.

These two values do not reflect the entire regime of changes to streamflow dynamics, and while the percentage changes often bracket the full analysis results, this is not always the case. The full streamflow-discharge-duration frequency analysis conducted by (Lehman 2017, 2018) is summarized in this section:

- Table 17. Queen Creek at Magma Avenue, impacts common to all alternatives
- Table 18. Devil's Canyon at Mineral Creek, impacts common to all alternatives
- Table 19. Queen Creek at Whitlow Ranch Dam, impacts specific to Alternatives 2 and 3
- Table 20. Queen Creek at Whitlow Ranch Dam, impacts specific to Alternative 4
- Table 21. Donnelly Wash at Gila River, impacts specific to Alternative 5
- Table 22. Dripping Spring Wash at Gila River, impacts specific to Alternative 6

Table 17. Estimated changes in streamflow discharge-duration-frequency for Queen Creek at Magma Avenue – all alternatives

Condition	Duration	Flood Duration Flows (cubic feet per second) for Annual Exceedance Probability (%)							
		50	20	10	4	2	1	0.5	0.2
Existing	Peak instantaneous	356	914	1,484	2,471	3,433	4,595	5,879	8,029
Proposed		316	808	1,310	2,178	3,024	4,044	5,173	7,061
% difference		-11.24%	-11.60%	-11.73%	-11.86%	-11.91%	-11.99%	-12.01%	-12.06%
Existing	1 day	52	195	381	782	1,213	1,780	2,501	4,189
Proposed		42	161	317	654	1,108	1,499	2,112	3,568
% difference		-19.23%	-17.44%	-16.80%	-16.37%	-8.66%	-15.79%	-15.55%	-14.82%
Existing	3 day	23	96	190	377	583	846	1,174	1,959
Proposed		19	79	157	312	484	704	979	1,649
% difference		-17.39%	-17.71%	-17.37%	-17.24%	-16.98%	-16.78%	-16.61%	-15.82%
Existing	7 day	12.8	51	100	200	327	442	619	919
Proposed		10.4	42	82	165	271	367	515	768
% difference		-18.75%	-17.65%	-18.00%	-17.50%	-17.13%	-16.97%	-16.80%	-16.43%
Existing	15 day	7.5	28	55	110	169	245	343	496
Proposed		6.0	23	45	90	139	203	285	412
% difference		-20.00%	-17.86%	-18.18%	-18.18%	-17.75%	-17.14%	-16.91%	-16.94%
Existing	30 day	4.9	16	33	64	95	135	184	256
Proposed		3.9	13	27	52	78	111	152	212
% difference		-20.41%	-18.75%	-18.18%	-18.75%	-17.89%	-17.78%	-17.39%	-17.19%

Source: Lehman (2018).

Table 18. Estimated changes in streamflow discharge-duration-frequency for Devil's Canyon at Mineral Creek – all alternatives

Condition	Duration	Flood Duration Flows (cubic feet per second) for Annual Exceedance Probability (%)							
		50	20	10	4	2	1	0.5	0.2
Existing	Peak instantaneous	666	1,713	2,786	4,642	6,447	8,619	11,037	15,054
Proposed		657	1,690	2,749	4,582	6,364	8,508	10,895	14,861
% difference		-1.35%	-1.34%	-1.33%	-1.29%	-1.29%	-1.29%	-1.29%	-1.28%
Existing	1 day	141	507	960	1,892	2,896	4,208	5,864	9,577
Proposed		137	496	939	1,853	2,836	4,123	5,747	9,395
% difference		-2.84%	-2.17%	-2.19%	-2.06%	-2.07%	-2.02%	-2.00%	-1.90%
Existing	3 day	62	256	499	971	1,493	2,157	2,985	4,835
Proposed		60	250	488	949	1,460	2,110	2,922	4,736
% difference		-3.23%	-2.34%	-2.20%	-2.27%	-2.21%	-2.18%	-2.11%	-2.05%
Existing	7 day	35.3	136	266	520	835	1,134	1,580	2,333
Proposed		34.4	133	260	508	816	1,109	1,545	2,284
% difference		-2.55%	-2.21%	-2.26%	-2.31%	-2.28%	-2.20%	-2.22%	-2.10%
Existing	15 day	21.1	76.2	147	287	438	630	877	1,282
Proposed		20.5	74.3	144	281	428	616	858	1,254
% difference		-2.84%	-2.49%	-2.04%	-2.09%	-2.28%	-2.22%	-2.17%	-2.18%
Existing	30 day	13.9	42.9	87.7	167	247	350	474	670
Proposed		13.6	41.9	85.5	163	241	342	464	655
% difference		-2.16%	-2.33%	-2.51%	-2.40%	-2.43%	-2.29%	-2.11%	-2.24%

Source: Lehman (2018).

Table 19. Estimated changes in streamflow discharge-duration-frequency for Queen Creek at Whitlow Ranch Dam – Alternatives 2 and 3

Condition	Duration	Flood Duration Flows (cubic feet per second) for Annual Exceedance Probability (%)							
		50	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**
Existing	Peak instantaneous	1,280	3,246	5,245	8,679	11,949	15,829	20,289	27,415
Proposed		1,238	3,144	5,083	8,415	11,593	15,368	19,696	26,632
% difference		-3.28%	-3.14%	-3.09%	-3.04%	-2.98%	-2.91%	-2.92%	-2.86%
Existing	1 day	415	1,514	2,797	5,230	8,000	11,633	16,266	26,942
Proposed		389	1,424	2,635	4,939	7,562	11,009	15,406	25,591
% difference		-6.27%	-5.94%	-5.79%	-5.56%	-5.48%	-5.36%	-5.29%	-5.01%
Existing	3 day	163	743	1,485	2,947	4,625	6,810	9,612	15,456
Proposed		153	697	1,395	2,774	4,357	6,421	9,070	14,624
% difference		-6.13%	-6.19%	-6.06%	-5.87%	-5.79%	-5.71%	-5.64%	-5.38%
Existing	7 day	91.8	375	778	1,554	2,573	3,559	5,056	7,660
Proposed		85.8	351	729	1,461	2,424	3,352	4,766	7,229
% difference		-6.54%	-6.40%	-6.30%	-5.98%	-5.79%	-5.82%	-5.74%	-5.63%
Existing	15 day	53.9	206	412	828	1,297	1,915	2,732	4,207
Proposed		50.2	193	386	777	1,219	1,802	2,573	3,964
% difference		-6.86%	-6.31%	-6.31%	-6.16%	-6.01%	-5.90%	-5.82%	-5.78%
Existing	30 day	34.8	105.9	235	459	699	1,013	1,405	2,090
Proposed		32.4	99.2	220	430	655	952	1,321	1,965
% difference		-6.90%	-6.33%	-6.38%	-6.32%	-6.29%	-6.02%	-5.98%	-5.98%

Source: Lehman (2018).

Table 20. Estimated changes in streamflow discharge-duration-frequency for Queen Creek at Whitlow Ranch Dam – Alternative 4

Condition	Duration	Flood Duration Flows (cubic feet per second) for Annual Exceedance Probability (%)							
		50	20	10	4	2	1	0.5	0.2
Existing	Peak instantaneous	1,280	3,246	5,245	8,679	11,949	15,829	20,289	27,415
Proposed		1,239	3,148	5,089	8,424	11,606	15,384	19,718	26,660
% difference		-3.20%	-3.02%	-2.97%	-2.94%	-2.87%	-2.81%	-2.81%	-2.75%
Existing	1 day	415	1,514	2,797	5,230	8,000	11,633	16,266	26,942
Proposed		390	1,427	2,641	4,949	7,578	11,031	15,437	25,639
% difference		-6.02%	-5.75%	-5.58%	-5.37%	-5.28%	-5.17%	-5.10%	-4.84%
Existing	3 day	163	743	1,485	2,947	4,625	6,810	9,612	15,456
Proposed		153	699	1,398	2,780	4,367	6,435	9,089	14,654
% difference		-6.13%	-5.92%	-5.86%	-5.67%	-5.58%	-5.51%	-5.44%	-5.19%
Existing	7 day	91.8	375	778	1,554	2,573	3,559	5,056	7,660
Proposed		86.0	352	731	1,464	2,429	3,359	4,777	7,244
% difference		-6.32%	-6.13%	-6.04%	-5.79%	-5.60%	-5.62%	-5.52%	-5.43%
Existing	15 day	53.9	206	412	828	1,297	1,915	2,732	4,207
Proposed		50.4	193	387	779	1,222	1,806	2,578	3,973
% difference		-6.49%	-6.31%	-6.07%	-5.92%	-5.78%	-5.69%	-5.64%	-5.56%
Existing	30 day	34.8	105.9	235	459	699	1,013	1,405	2,090
Proposed		32.4	99.4	220	431	657	954	1,324	1,970
% difference		-6.90%	-6.14%	-6.38%	-6.10%	-6.01%	-5.82%	-5.77%	-5.74%

Source: Lehman (2018).

Table 21. Estimated changes in streamflow discharge-duration-frequency for Donnelley Wash at Gila River – Alternative 5

Condition	Duration	Flood Duration Flows (cubic feet per second) for Annual Exceedance Probability (%)							
		50	20	10	4	2	1	0.5	0.2
Existing	Peak instantaneous	866	2,220	3,605	5,997	8,307	11,076	14,188	19,296
Proposed		784	2,013	3,271	5,446	7,552	10,081	12,912	17,582
% difference		-9.47%	-9.32%	-9.26%	-9.19%	-9.09%	-8.98%	-8.99%	-8.88%
Existing	1 day	176	708	1,353	2,560	4,034	6,027	8,643	15,579
Proposed		147	594	1,143	2,175	3,439	5,153	7,408	13,462
% difference		-16.48%	-16.10%	-15.52%	-15.04%	-14.75%	-14.50%	-14.29%	-13.59%
Existing	3 day	64.3	320	678	1,421	2,326	3,554	5,187	8,899
Proposed		53.6	267	568	1,196	1,964	3,008	4,399	7,606
% difference		-16.64%	-16.56%	-16.22%	-15.83%	-15.56%	-15.36%	-15.19%	-14.53%
Existing	7 day	33.2	152	335	713	1,280	1,793	2,651	4,210
Proposed		27.4	127	279	597	1,079	1,512	2,242	3,572
% difference		-17.47%	-16.45%	-16.72%	-16.27%	-15.70%	-15.67%	-15.43%	-15.15%
Existing	15 day	17.8	78.2	168	360	594	919	1,369	2,226
Proposed		14.6	64.7	139	301	498	773	1,154	1,881
% difference		-17.98%	-17.26%	-17.26%	-16.39%	-16.16%	-15.89%	-15.70%	-15.50%
Existing	30 day	10.9	38.8	89.2	185	295	446	644	1,008
Proposed		8.9	32.2	73.9	154	246	373	540	846
% difference		-18.35%	-17.01%	-17.15%	-16.76%	-16.61%	-16.37%	-16.15%	-16.07%

Source: Lehman (2018).

Table 22. Estimated changes in streamflow discharge-duration-frequency for Dripping Spring Wash at Gila River – Alternative 6

Condition	Duration	Flood Duration Flows (cubic feet per second) for Annual Exceedance Probability (%)							
		50	20	10	4	2	1	0.5	0.2
Existing	Peak instantaneous	1,168	2,973	4,811	7,972	10,994	14,589	18,697	25,309
Proposed		1,114	2,838	4,595	7,620	10,518	13,970	17,903	24,254
% difference		-4.62%	-4.54%	-4.49%	-4.42%	-4.33%	-4.24%	-4.25%	-4.17%
Existing	1 day	356	1,234	2,269	4,290	6,499	9,370	12,986	20,853
Proposed		324	1,130	2,085	3,952	5,998	8,660	12,018	19,377
% difference		-8.99%	-8.43%	-8.11%	-7.88%	-7.71%	-7.58%	-7.45%	-7.08%
Existing	3 day	156.2	635	1,224	2,345	3,596	5,189	7,189	11,361
Proposed		143	580	1,120	2,150	3,302	4,772	6,617	10,498
% difference		-8.45%	-8.66%	-8.50%	-8.32%	-8.18%	-8.04%	-7.96%	-7.60%
Existing	7 day	90.6	336	657	1,258	2,000	2,729	3,794	5,598
Proposed		82.3	307	599	1,151	1,836	2,505	3,487	5,154
% difference		-9.16%	-8.63%	-8.83%	-8.51%	-8.20%	-8.21%	-8.09%	-7.93%
Existing	15 day	54.9	191	364	696	1,056	1,514	2,103	3,129
Proposed		49.6	174	332	636	967	1,388	1,931	2,874
% difference		-9.65%	-8.90%	-8.79%	-8.62%	-8.43%	-8.32%	-8.18%	-8.15%
Existing	30 day	36.2	105.8	216.5	404	596	842	1,138	1,639
Proposed		32.7	96.4	197	368	544	770	1,042	1,501
% difference		-9.67%	-8.88%	-9.01%	-8.91%	-8.72%	-8.55%	-8.44%	-8.42%

Source: Lehman (2018).

Regulations, Laws, and Guidance – Surface Water Quantity

Mine operations are subject to a wide range of Federal, State, and local requirements. Table 23 provides a summary of surface water quantity laws, regulations, policies, and plans at the Federal, State, and local level.

Table 23. Surface water quantity laws, regulations, policies, and plans at the Federal, state, and local level

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Clean Water Act Section 404	Section 404 establishes a permit program for the discharge of dredged or fill material into waters of the U.S., including wetlands. This permit program is jointly administered by the U.S. Army Corps of Engineers (USACE) and EPA. Consultation with the U.S. Fish and Wildlife Service and State Historic Preservation Officer may also be required before issuance of a permit to ensure compliance with the Endangered Species Act and National Historic Preservation Act. The immediate regulatory decision regarding which activities fall under Section 404 of the Clean Water Act lies with the USACE Los Angeles District, and Section 404 permitting is discretionary on the part of the USACE. In general, there are three methods for obtaining a permit under Section 404: authorization under a nationwide permit, authorization under a regional general permit, and issuance of an individual permit.	For Alternatives 5 and 6, Resolution Copper must obtain a permit for the discharge of dredged or fill material into waters of the U.S. An application for an individual 404 permit for Alternative 6 has been submitted to the USACE.
Executive Order 11988 (May 24, 1977)	Directs each Federal agency to take action to avoid the long- and short-term adverse impacts associated with the occupancy and modification of floodplains. Agencies are required to avoid direct or indirect support of floodplain development whenever there is a practicable alternative.	The Forest Service is required to avoid direct or indirect support of flood plan development if there is a practicable alternative.
Executive Order 11990 (May 24, 1977)	Directs Federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial value of wetlands in carrying out programs that affect land use.	The Forest Service must minimize impacts from the Resolution Copper Project to the destruction, loss, or degradation of wetlands.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Arizona Revised Statutes (ARS) 45-141, public nature of waters of the State; beneficial use; reversion to State; actions not constituting abandonment or forfeiture	The waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste, or surplus water, and of lakes, ponds and springs on the surface, belong to the public and are subject to appropriation and beneficial use.	Queen Creek, Devil's Canyon, Dripping Spring Wash, and Donnelley Wash drainages are all public surface waters within the analysis area.
ARS 45-151, right of appropriation; permitted uses; water rights in stock ponds; Federal lands	Any person, the State of Arizona, or a political subdivision thereof may appropriate unappropriated water for domestic, municipal, irrigation, stock watering, water power, recreation, wildlife (including fish), nonrecoverable water storage pursuant to Section 45-833.01 or mining uses, for his personal use or for delivery to consumers. The person, the State of Arizona or a political subdivision thereof first appropriating the water shall have the better right.	Resolution Copper is permitted to appropriate unappropriated surface water within the analysis area.
Executive Order 11988 – Occupancy and modification of floodplains	Executive Order 11988 (May 24, 1977) directs each Federal agency to take action to avoid the long- and short-term adverse impacts associated with the occupancy and modification of floodplains. Agencies are required to avoid direct or indirect support of floodplain development whenever there is a practicable alternative.	For much of the analysis area, 100-year floodplains have not been mapped, but have been estimated based on available geological mapping. Mapped floodplains for Alternatives 2, 3, and 4 total 8.5 acres, where the eastern boundary of the West Plant Site overlaps the floodplain of a tributary to Queen Creek. Most of the channels associated with these areas have not been mapped by FEMA. Floodplain impacts for Alternative 5 vary by pipeline route, with impacts of 171 acres for the east pipeline and 167 for the west pipeline. This also includes the same 8.5 acres of floodplain impacts associated with Alternatives 2, 3, and 4. Specifically, the east pipeline alternative crosses mapped floodplains associated with the Gila River and Walnut Canyon. The west pipeline alternative crosses mapped floodplains associated with the Gila River and Cottonwood Creek.

Laws, Ordinances, Regulations, and Standards	Description	Applicability
		Impacts to floodplains by Alternative 6 total 794 acres. Both pipeline alternatives cross Devil's Canyon and Mineral Creek but do not impact mapped floodplains. The south pipeline alternative also crosses Queen Creek west of Superior; floodplains have not been mapped in this area but are likely to exist. The north pipeline alternative crosses Queen Creek east of Superior; floodplains are not mapped but are unlikely to exist in this area based on existing mapped segments.
Executive Order 11990 (May 24, 1977) – Destruction, loss, or degradation of wetlands	Directs Federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial value of wetlands in carrying out programs that affect land use.	Wetland impacts by Alternative 2 and 3 include xeroriparian vegetation along ephemeral washes (92.5 acres), stock tanks (5.1 acres for six separate tanks), and wetlands near Benson Spring and in the subsidence area (1 acre). Wetland impacts by Alternative 4 include xeroriparian vegetation along ephemeral washes (86.2 acres), stock tanks (4.1 acres for five separate tanks), and a wetland in the subsidence area (0.2 acre). Impacts by Alternative 5 vary by pipeline route. Impacts for the east pipeline alternative include xeroriparian vegetation along ephemeral washes (200.9 acres), the Gila River and Queen Creek crossings, stock tanks (8.6 acres for six separate tanks), and a wetland in the subsidence area (0.2 acre). Impacts for the west pipeline alternative include xeroriparian vegetation along ephemeral washes (219.6 acres), the Gila River crossing, stock tanks (8.8 acres for five separate tanks), and a wetland in the subsidence area (0.2 acre).

Laws, Ordinances, Regulations, and Standards	Description	Applicability
		Impacts by Alternative 6 also vary by pipeline. Impacts for the south pipeline alternative include xeroriparian vegetation along ephemeral washes (232.9 acres), wetlands associated with Queen Creek, Devil's Canyon, and Mineral Creek (28.2 acres), stock tanks (11.9 acres for 15 separate tanks), and a wetland in the subsidence area (0.2 acre). Impacts for the north pipeline alternative include xeroriparian vegetation along ephemeral washes (229.6 acres), wetlands associated with Mineral Creek (25.4 acres), stock tanks (12.7 acres for 17 separate tanks), and a wetland in the subsidence area (0.2 acre).

Laws, Ordinances, Regulations, and Standards	Description	Applicability
Pinal County Floodplain Management Ordinance	Promotes and protects the health, peace, safety, comfort, convenience, and general welfare of the residents within the jurisdictional area of Pinal County, Arizona, to minimize public and private losses due to flood conditions in specific areas, and to enable Pinal County and its residents to participate in the National Flood Insurance Program, receive Federal Disaster Assistance, obtain flood insurance and reduce the cost of flood insurance by provisions designed: to protect human life and health, and property of County residents; Pinal County Floodplain Management Ordinance; to minimize expenditure of public money for costly flood control projects; to minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public; to minimize prolonged business interruptions; to minimize damage to public facilities and utilities such as water and gas mains, electric, telephone, fiber optics and sewer lines, streets and bridges located in areas of special flood hazard; to help maintain a stable tax base by regulating development of areas of special flood hazard so as to minimize future flood blight areas; take all reasonable action so that potential buyers have notice that property is in an area of special flood hazard; take all reasonable action so that those who occupy the areas of special flood hazard assume responsibility for their actions; minimize flood damages and reduce the height and violence of floods that are caused by obstructions restricting the capacity of floodways; prevent unwise encroachment and building development within floodplain areas; reduce the financial burden imposed on the community, its governmental units and its residents when such land is flooded; protect the natural and beneficial function of the floodplains; and to maintain eligibility for disaster relief.	Pinal County Flood Control District has the responsibility to adopt regulations consistent with criteria adopted by the director of ADWR pursuant to ARS Section 48-3605, designed to promote the public health, safety and general welfare of its residents. Therefore, the Pinal County Flood Control District of Pinal County, Arizona, ordains the Pinal County Floodplain Management Ordinance. Resolution Copper will operate within Pinal County and is thus subject to management under this ordinance.

Key Documents and References Cited for Surface Water Quantity

The following list is meant to highlight key process or analysis documents available in the project record. It should not be considered a full list of all available documentation considered within this process memorandum or the EIS analysis.

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Attachment 1 - Detailed Calculations of Assimilative Capacity Reductions for Queen Creek

Table 1-A. Calculations for Reduction in Assimilative Capacity for Queen Creek at Whitlow Ranch Dam												
Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**	**Column I**	**Column J**	**Column K**	**Column L**	**Column M**
	Surface Water Quality Standard for Most Restrictive Use (Queen Creek)*	**Current Median Water Quality for Queen Creek at Whitlow Ranch Dam (WRD)†**	**Calculated Assimilative Capacity [Column B minus Column C]**	**Predicted Water Quality at WRD (Alternative 2)**	**Predicted Water Quality at WRD (Alternative 3)**	**Predicted Water Quality at WRD (Alternative 4)**	**Incremental Change in Water Quality (Alternative 2) [Column E minus Column C]**	**Incremental Change in Water Quality (Alternative 3) [Column F minus Column C]**	**Incremental Change in Water Quality (Alternative 4) [Column G minus Column C]**	**Percent of Assimilative Capacity Used (Alternative 2) [Column H divided by Column D]**	**Percent of Assimilative Capacity Used (Alternative 3) [Column I divided by Column D]**	**Percent of Assimilative Capacity Used (Alternative 4) [Column J divided by Column D]**
Antimony	0.03	0.00052	0.029480	0.00065	0.00053	0.0008	0.000130	0.000010	0.000280	0.44%	0.03%	0.95%
Arsenic	0.03	0.00235	0.027650	0.0024	0.0024	0.0026	0.000050	0.000050	0.000250	0.18%	0.18%	0.90%
Barium	98	0.035	97.965000	0.035	0.035	0.035	0.000000	0.000000	0.000000	0.00%	0.00%	0.00%
Beryllium	0.0053	0.001	0.004300	0.001	0.001	0.001	0.000000	0.000000	0.000000	0.00%	0.00%	0.00%
Boron	1	0.057	0.943000	0.066	0.057	0.069	0.009000	0.000000	0.012000	0.95%	0.00%	1.27%
Cadmium	0.0051	0.00005	0.005050	0.0002	0.00006	0.00023	0.000150	0.000010	0.000180	2.97%	0.20%	3.56%
Chromium, Total	1	0.0015	0.998500	0.0023	0.0015	0.0021	0.000800	0.000000	0.000600	0.08%	0.00%	0.06%
Copper	0.0234	0.0023	0.021100	0.0045	0.0024	0.0049	0.002200	0.000100	0.002600	10.43%	0.47%	12.32%
Fluoride	140	0.4	139.600000	0.43	0.41	0.43	0.030000	0.010000	0.030000	0.02%	0.01%	0.02%
Iron	1	0.048	0.952000	0.048	0.048	0.048	0.000000	0.000000	0.000000	0.00%	0.00%	0.00%
Lead	0.0083	0.00008	0.008220	0.0001	0.00008	0.00012	0.000020	0.000000	0.000040	0.24%	0.00%	0.49%
Manganese	10	0.15	9.850000	0.169	0.151	0.194	0.019000	0.001000	0.044000	0.19%	0.01%	0.45%
Mercury	0.00001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	0.1343	0.0027	0.131600	0.005	0.0028	0.006	0.002300	0.000100	0.003300	1.75%	0.08%	2.51%
Nitrate	3,733.33	1.9	3731.433000	1.97	1.9	1.92	0.070000	0.000000	0.020000	0.00%	0.00%	0.00%
Nitrite	233.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	0.002	0.0007	0.001300	0.0038	0.0009	0.0046	0.003100	0.000200	0.003900	238.46%	15.38%	300.00%
Silver	0.0221	0.000036	0.022064	0.00071	0.00007	0.00074	0.000674	0.000034	0.000704	3.05%	0.15%	3.19%
Thallium	0.0072	0.00003	0.007170	0.00008	0.00003	0.00008	0.000050	0.000000	0.000050	0.70%	0.00%	0.70%
Uranium	2.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	0.3031	0.003	0.300100	0.0353	0.0045	0.0428	0.032300	0.001500	0.039800	10.76%	0.50%	13.26%

Note: N/A = not analyzed in seepage modeling.

* See appendix N, table N-5 of the DEIS for a detailed assessment of applicable standards.

† Results shown represent median values from water quality measurements.

Attachment 2 - Detailed Calculations of Assimilative Capacity Reductions for Gila River

Table 2-A. Calculations for Reduction in Assimilative Capacity for Gila River at Donnelly Wash and Dripping Spring Wash

Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K	Column L	Column M
	Surface Water Quality Standard for Most Restrictive Use (Gila River below Donnelly Wash)*	Surface Water Quality Standard for Most Restrictive Use (Gila River below Dripping Spring Wash)‡	Current Water Quality for Gila River below Donnelly Wash*	Current Water Quality for Gila River below Dripping Spring Wash†	Calculated Assimilative Capacity below Donnelly Wash [Column B minus Column D]	Calculated Assimilative Capacity below Dripping Spring Wash [Column C minus Column E]	Predicted Water Quality in Gila River below Donnelly Wash (Alternative 5)	Predicted Water Quality in Gila River below Dripping Spring Wash (Alternative 6)	Incremental Change in Water Quality (Alternative 5, below Donnelly Wash) [Column H minus Column D]	Incremental Change in Water Quality (Alternative 6, below Dripping Spring Wash) [Column I minus Column E]	Percent of Assimilative Capacity Used (Alternative 5) [Column J divided by Column F]	Percent of Assimilative Capacity Used (Alternative 6) [Column K divided by Column G]
Antimony	0.03	0.03	0.00023	0.00023	0.029770	0.029770	0.00025	0.00025	0.000020	0.000020	0.07%	0.07%
Arsenic	0.03	0.03	0.00889	0.00861	0.021110	0.021390	0.0089	0.0086	0.000010	-0.000010	0.05%	-0.05%
Barium	98	98	0.0826	0.0749	97.917400	97.925100	0.083	0.075	0.000400	0.000100	0.00%	0.00%
Beryllium	0.0053	53	0.0017	0.0017	0.003600	52.998300	0.0017	0.0017	0.000000	0.000000	0.00%	0.00%
Boron	1	1	0.19	0.196	0.810000	0.804000	0.191	0.197	0.001000	0.001000	0.12%	0.12%
Cadmium	0.0049	0.0043	0.00006	0.00006	0.004840	0.004240	0.00009	0.00009	0.000030	0.000030	0.62%	0.71%
Chromium, Total	1	1	0.002	0.002	0.998000	0.998000	0.0021	0.0021	0.000100	0.000100	0.01%	0.01%
Copper	0.0222	0.0191	0.00408	0.00207	0.018120	0.017030	0.0099	0.0028	0.005820	0.000730	32.12%	4.29%
Fluoride	140	140	0.987	1	139.013000	139.000000	1	1.04	0.013000	0.040000	0.01%	0.03%
Iron	1	1	0.056	0.071	0.944000	0.929000	0.056	0.071	0.000000	0.000000	0.00%	0.00%
Lead	0.0078	0.0065	0.00015	0.00014	0.007650	0.006360	0.00016	0.00015	0.000010	0.000010	0.13%	0.16%
Manganese	10	10	0.028	0.029	9.972000	9.971000	0.033	0.032	0.005000	0.003000	0.05%	0.03%
Mercury	0.00001	0.00001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	0.128	0.1098	0.0023	0.0023	0.125700	0.107500	0.003	0.0026	0.000700	0.000300	0.56%	0.28%
Nitrate	3,733.33	3,733.33	0.091	0.305	3733.242000	3733.028000	0.11	0.31	0.019000	0.005000	0.00%	0.00%
Nitrite	233.333	233.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	0.002	0.002	0.0004	0.0004	0.001600	0.001600	0.001	0.0009	0.000600	0.000500	37.50%	31.25%
Silver	0.0201	0.0147	0.000061	0.000061	0.020039	0.014639	0.00018	0.00016	0.000119	0.000099	0.59%	0.68%
Thallium	0.0072	0.0072	0.00008	0.00008	0.007120	0.007120	0.00009	0.00009	0.000010	0.000010	0.14%	0.14%
Uranium	2.8	2.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	0.2888	0.2477	0.005	0.0055	0.283800	0.242200	0.0109	0.0099	0.005900	0.004400	2.08%	1.82%

Note: N/A = not analyzed in seepage modeling.

* See appendix N, table N-5 of the DEIS for a detailed assessment of applicable standards.

† Assumed concentrations are based on single sample collected on November 9, 2018, and are, therefore, approximate.

‡ Assumed concentrations are based on single sample collected on November 13, 2018, and are, therefore, approximate.

Attachment 3 – Potential for Reduced Assimilative Capacity Because of Flow Reductions in Queen Creek

Table 3-A. Calculations for Reduction in Assimilative Capacity due to Flow Reductions on Queen Creek at Whitlow Ranch Dam											
Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K	Column L
	Surface Water Quality Standard for Most Restrictive Use (Queen Creek)* (mg/L)	Current Median Water Quality for Queen Creek at Whitlow Ranch Dam† (mg/L)	Calculated Assimilative Capacity [Column B minus Column C]	Median Flow Value (cfs)	Current Daily Load (kg) [Column C multiplied by Column E multiplied by unit conversion {2.445}]	Predicted New Flow Value (cfs) - Alternative 2/3‡	Predicted New Flow Value (cfs) - Alternative 4‡	Predicted New Flow Value (cfs) - Alternative 5/6‡	Predicted New Median Concentration for Alternative 2/3 (mg/L) [Column F divided by Column G multiplied by unit conversion {0.408}]	Predicted New Median Concentration for Alternative 4 (mg/L) [Column F divided by Column H multiplied by unit conversion {0.408}]	Predicted New Median Concentration for Alternative 5/6 (mg/L) [Column F divided by Column I multiplied by unit conversion {0.408}]
Antimony	0.03	0.00052	0.02948	1.43	0.00182	1.34	1.30	1.38	0.00056	0.00057	0.00054
Arsenic	0.03	0.00235	0.02765	1.43	0.00822	1.34	1.30	1.38	0.00251	0.00258	0.00244
Barium	98	0.035	97.965	1.43	0.12238	1.34	1.30	1.38	0.03743	0.03842	0.03627
Beryllium	0.0053	0.001	0.0043	1.43	0.00350	1.34	1.30	1.38	0.00107	0.00110	0.00104
Boron	1	0.057	0.943	1.43	0.19930	1.34	1.30	1.38	0.06096	0.06257	0.05907
Cadmium	0.0051	0.00005	0.00505	1.43	0.00017	1.34	1.30	1.38	0.00005	0.00005	0.00005
Chromium, Total	1	0.0015	0.9985	1.43	0.00524	1.34	1.30	1.38	0.00160	0.00165	0.00155
Copper	0.0234	0.0023	0.0211	1.43	0.00804	1.34	1.30	1.38	0.00246	0.00252	0.00238
Fluoride	140	0.4	139.6	1.43	1.39861	1.34	1.30	1.38	0.42781	0.43908	0.41451
Iron	1	0.048	0.952	1.43	0.16783	1.34	1.30	1.38	0.05134	0.05269	0.04974
Lead	0.0083	0.00008	0.00822	1.43	0.00028	1.34	1.30	1.38	0.00009	0.00009	0.00008
Manganese	10	0.15	9.85	1.43	0.52448	1.34	1.30	1.38	0.16043	0.16465	0.15544
Mercury	0.00001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	0.1343	0.0027	0.1316	1.43	0.00944	1.34	1.30	1.38	0.00289	0.00296	0.00280
Nitrate	3,733.33	1.9	3731.433	1.43	6.64339	1.34	1.30	1.38	2.03209	2.08562	1.96891
Nitrite	233.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	0.002	0.0007	0.0013	1.43	0.00245	1.34	1.30	1.38	0.00075	0.00077	0.00073
Silver	0.0221	0.000036	0.022064	1.43	0.00013	1.34	1.30	1.38	0.00004	0.00004	0.00004
Thallium	0.0072	0.00003	0.00717	1.43	0.00010	1.34	1.30	1.38	0.00003	0.00003	0.00003
Uranium	2.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	0.3031	0.003	0.3001	1.43	0.01049	1.34	1.30	1.38	0.00321	0.00329	0.00311

Notes: cfs = cubic feet per second; N/A = Not analyzed in seepage modeling

* See appendix N, table N-5 of the DEIS for a detailed assessment of applicable standards.

† Results shown represent median values from water quality measurements.

‡ Percent reductions in average annual flow reductions (cfs) (see EIS section 3.7.3): Alternatives 2/3 = 6.5 percent; Alternative 4 = 8.9 percent; Alternatives 5/6 = 3.5 percent.

Table 3-A. Calculations for Reduction in Assimilative Capacity due to Flow Reductions on Queen Creek at Whitlow Ranch Dam (Continued)						
Column A	**Column M**	**Column N**	**Column O**	**Column P**	**Column Q**	**Column R**
	New Calculated Assimilative Capacity for Alternative 2/3 [Column B minus Column J]	**Percent Change in Assimilative Capacity for Alternative 2/3 [Column M divided by Column D, subtracted from 1]**	**New Calculated Assimilative Capacity for Alternative 4 [Column B minus Column K]**	**Percent Change in Assimilative Capacity for Alternative 4 [Column O divided by Column D, subtracted from 1]**	**New Calculated Assimilative Capacity for Alternative 5/6 [Column B minus Column L]**	**Percent Change in Assimilative Capacity for Alternative 5/6 [Column Q divided by Column D, subtracted from 1]**
Antimony	0.02944	0.12%	0.02943	0.17%	0.02946	0.06%
Arsenic	0.02749	0.59%	0.02742	0.83%	0.02756	0.31%
Barium	97.96257	0.00%	97.96158	0.00%	97.96373	0.00%
Beryllium	0.00423	1.62%	0.00420	2.27%	0.00426	0.84%
Boron	0.93904	0.42%	0.93743	0.59%	0.94093	0.22%
Cadmium	0.00505	0.07%	0.00505	0.10%	0.00505	0.04%
Chromium, Total	0.99840	0.01%	0.99835	0.01%	0.99845	0.01%
Copper	0.02094	0.76%	0.02088	1.06%	0.02102	0.40%
Fluoride	139.57219	0.02%	139.56092	0.03%	139.58549	0.01%
Iron	0.94866	0.35%	0.94731	0.49%	0.95026	0.18%
Lead	0.00821	0.07%	0.00821	0.10%	0.00822	0.04%
Manganese	9.83957	0.11%	9.83535	0.15%	9.84456	0.06%
Mercury	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	0.13141	0.14%	0.13134	0.20%	0.13150	0.07%
Nitrate	3731.30091	0.00%	3731.24738	0.00%	3731.36409	0.00%
Nitrite	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	0.00125	3.74%	0.00123	5.26%	0.00127	1.95%
Silver	0.02206	0.01%	0.02206	0.02%	0.02206	0.01%
Thallium	0.00717	0.03%	0.00717	0.04%	0.00717	0.02%
Uranium	N/A	N/A	N/A	N/A	N/A	N/A

Table 3-A. Calculations for Reduction in Assimilative Capacity due to Flow Reductions on Queen Creek at Whitlow Ranch Dam (Continued)						
Column A	**Column M**	**Column N**	**Column O**	**Column P**	**Column Q**	**Column R**
	New Calculated Assimilative Capacity for Alternative 2/3 [Column B minus Column J]	**Percent Change in Assimilative Capacity for Alternative 2/3 [Column M divided by Column D, subtracted from 1]**	**New Calculated Assimilative Capacity for Alternative 4 [Column B minus Column K]**	**Percent Change in Assimilative Capacity for Alternative 4 [Column O divided by Column D, subtracted from 1]**	**New Calculated Assimilative Capacity for Alternative 5/6 [Column B minus Column L]**	**Percent Change in Assimilative Capacity for Alternative 5/6 [Column Q divided by Column D, subtracted from 1]**
Zinc	0.29989	0.07%	0.29981	0.10%	0.29999	0.04%

Notes: cfs = cubic feet per second; N/A = not analyzed in seepage modeling

* See appendix N, table N-5 of the DEIS for a detailed assessment of applicable standards.

† Results shown represent median values from water quality measurements.

‡ Percent reductions in average annual flow reductions (cfs) (see EIS section 3.7.3): Alternatives 2/3 = 6.5 percent; Alternative 4 = 8.9 percent; Alternatives 5/6 = 3.5 percent.

Attachment 4 – Potential for Reduced Assimilative Capacity Because of Flow Reductions in the Gila River

Table 4-A. Calculations for Reduction in Assimilative Capacity due to Flow Reductions on the Gila River at Donnelly Wash and at Dripping Spring Wash

Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K
	Surface Water Quality Standard for Most Restrictive Use (Gila River below Donnelly Wash)* (mg/L)	**Surface Water Quality Standard for Most Restrictive Use (Gila River below Dripping Spring Wash)* (mg/L)**	**Current Water Quality for Gila River below Donnelly Wash[†]**	**Current Water Quality for Gila River below Dripping Spring Wash[†]**	**Calculated Assimilative Capacity below Donnelly Wash [Column B minus Column D]**	**Calculated Assimilative Capacity below Dripping Spring Wash [Column C minus Column E]**	**Median Flow Value (cfs) below Donnelly Wash**	**Median Flow Value (cfs) below Dripping Spring Wash**	**Current Daily Load (kg) below Donnelly Wash [Column D multiplied by Column H multiplied by unit conversion {2.445}]**	**Current Daily Load (kg) below Dripping Spring Wash [Column E multiplied by Column I multiplied by unit conversion {2.445}]**
Antimony	0.03	0.03	0.00023	0.00023	0.02977	0.02977	240.6	231	0.13531	0.12991
Arsenic	0.03	0.03	0.00889	0.00861	0.02111	0.02139	240.6	231	5.22995	4.86312
Barium	98	98	0.0826	0.0749	97.9174	97.9251	240.6	231	48.59324	42.30522
Beryllium	0.0053	0.0053	0.0017	0.0017	0.0036	0.0036	240.6	231	1.00010	0.96020
Boron	1	1	0.19	0.196	0.81	0.804	240.6	231	111.77622	110.70525
Cadmium	0.0049	0.0043	0.00006	0.00006	0.00484	0.00424	240.6	231	0.03530	0.03389
Chromium, Total	1	1	0.002	0.002	0.998	0.998	240.6	231	1.17659	1.12965
Copper	0.0222	0.0191	0.00408	0.00207	0.01812	0.01703	240.6	231	2.40025	1.16918
Fluoride	140	140	0.987	1	139.013	139	240.6	231	580.64803	564.82272
Iron	1	1	0.056	0.071	0.944	0.929	240.6	231	32.94457	40.10241
Lead	0.0078	0.0065	0.00015	0.00014	0.00765	0.00636	240.6	231	0.08824	0.07908
Manganese	10	10	0.028	0.029	9.972	9.971	240.6	231	16.47228	16.37986
Mercury	0.00001	0.00001	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	0.128	0.1098	0.0023	0.0023	0.1257	0.1075	240.6	231	1.35308	1.29909
Nitrate	3,733.33	3,733.33	0.091	0.305	3733.242	3733.028	240.6	231	53.53492	172.27093
Nitrite	233.333	233.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	0.002	0.002	0.0004	0.0004	0.0016	0.0016	240.6	231	0.23532	0.22593
Silver	0.0201	0.0147	0.000061	0.000061	0.020039	0.014639	240.6	231	0.03589	0.03445
Thallium	0.0072	0.0072	0.00008	0.00008	0.00712	0.00712	240.6	231	0.04706	0.04519
Uranium	2.8	2.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	0.2888	0.2477	0.005	0.0055	0.2838	0.2422	240.6	231	2.94148	3.10652

Note: cfs = cubic feet per second; N/A = not analyzed in seepage modeling

* See appendix N, table N-5 of the DEIS for a detailed assessment of applicable standards.

† Results shown represent single water quality measurements made in November 2018.

‡ Percent reductions in average annual flow reductions (cfs) (see EIS section 3.7.3): Alternative 5 = 0.2 percent; Alternative 6 at Donnelly Wash = 0.3 percent; Alternative 6 at Dripping Spring Wash = 0.5 percent.

Table 4-A. Calculations for Reduction in Assimilative Capacity due to Flow Reductions on the Gila River at Donnelly Wash and at Dripping Spring Wash (Continued)												
Column A	**Column L**	**Column M**	**Column N**	**Column O**	**Column P**	**Column Q**	**Column R**	**Column S**	**Column T**	**Column U**	**Column V**	**Column W**
	Predicted New Flow Value (cfs) below Donnelly Wash - Alternative 5‡	**Predicted New Flow Value (cfs) below Donnelly Wash - Alternative 6‡**	**Predicted New Flow Value (cfs) below Dripping Spring Wash - Alternative 6‡**	**Predicted New Concentration for Alternative 5 at Donnelly Wash (mg/L) [Column J divided by Column L multiplied by unit conversion {0.408}]**	**Predicted New Concentration for Alternative 6 at Donnelly Wash (mg/L) [Column J divided by Column M multiplied by unit conversion {0.408}]**	**Predicted New Concentration for Alternative 6 at Dripping Spring Wash (mg/L) [Column K divided by Column N multiplied by unit conversion {0.408}]**	**New Calculated Assimilative Capacity for Alternative 5 at Donnelly Wash [Column B minus Column O]**	**Percent Change in Assimilative Capacity for Alternative 5 at Donnelly Wash [Column R divided by Column F, subtracted from 1]**	**New Calculated Assimilative Capacity for Alternative 6 at Donnelly Wash [Column B minus Column P]**	**Percent Change in Assimilative Capacity for Alternative 6 at Donnelly Wash [Column T divided by Column F, subtracted from 1]**	**New Calculated Assimilative Capacity for Alternative 6 at Dripping Spring Wash [Column C minus Column Q]**	**Percent Change in Assimilative Capacity for Alternative 6 at Dripping Spring Wash [Column V divided by Column G, subtracted from 1]**
Antimony	240.1	239.9	229.8	0.00023	0.00023	0.00023	0.02977	0.00%	0.02977	0.00%	0.02977	0.00%
Arsenic	240.1	239.9	229.8	0.00891	0.00892	0.00865	0.02109	0.08%	0.02108	0.13%	0.02135	0.20%
Barium	240.1	239.9	229.8	0.08277	0.08285	0.07528	97.91723	0.00%	97.91715	0.00%	97.92472	0.00%
Beryllium	240.1	239.9	229.8	0.00170	0.00171	0.00171	0.00360	0.09%	0.00359	0.14%	0.00359	0.24%
Boron	240.1	239.9	229.8	0.19038	0.19057	0.19698	0.80962	0.05%	0.80943	0.07%	0.80302	0.12%
Cadmium	240.1	239.9	229.8	0.00006	0.00006	0.00006	0.00484	0.00%	0.00484	0.00%	0.00424	0.01%
Chromium, Total	240.1	239.9	229.8	0.00200	0.00201	0.00201	0.99800	0.00%	0.99799	0.00%	0.99799	0.00%
Copper	240.1	239.9	229.8	0.00409	0.00409	0.00208	0.01811	0.05%	0.01811	0.07%	0.01702	0.06%
Fluoride	240.1	239.9	229.8	0.98898	0.98997	1.00503	139.01102	0.00%	139.01003	0.00%	138.99497	0.00%
Iron	240.1	239.9	229.8	0.05611	0.05617	0.07136	0.94389	0.01%	0.94383	0.02%	0.92864	0.04%
Lead	240.1	239.9	229.8	0.00015	0.00015	0.00014	0.00765	0.00%	0.00765	0.01%	0.00636	0.01%
Manganese	240.1	239.9	229.8	0.02806	0.02808	0.02915	9.97194	0.00%	9.97192	0.00%	9.97085	0.00%
Mercury	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	240.1	239.9	229.8	0.00230	0.00231	0.00231	0.12570	0.00%	0.12569	0.01%	0.10749	0.01%
Nitrate	240.1	239.9	229.8	0.09118	0.09127	0.30653	3733.24182	0.00%	3,733.24173	0.00%	3,733.02647	0.00%
Nitrite	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	240.1	239.9	229.8	0.00040	0.00040	0.00040	0.00160	0.05%	0.00160	0.08%	0.00160	0.13%
Silver	240.1	239.9	229.8	0.00006	0.00006	0.00006	0.02004	0.00%	0.02004	0.00%	0.01464	0.00%
Thallium	240.1	239.9	229.8	0.00008	0.00008	0.00008	0.00712	0.00%	0.00712	0.00%	0.00712	0.01%
Uranium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	240.1	239.9	229.8	0.00501	0.00502	0.00553	0.28379	0.00%	0.28378	0.01%	0.24217	0.01%

Notes: cfs = cubic feet per second; N/A = not analyzed in seepage modeling

* See appendix N, table N-5 of the DEIS for a detailed assessment of applicable standards.

† Results shown represent single water quality measurements made in November 2018.

‡ Percent reductions in average annual flow reductions (cfs) (see EIS section 3.7.3): Alternative 5 = 0.2 percent; Alternative 6 at Donnelly Wash = 0.3 percent; Alternative 6 at Dripping Spring Wash = 0.5 percent.