Overview

The proposed mine would disturb large areas of ground, not only from the mining and processing facilities, but also from the subsidence crater and tailings storage facility. Ground disturbance has the potential to destroy native vegetation, including species given special status by the Forest Service, and encourage noxious or invasive weeds. Ground disturbance also affects soils. Soils are a nonrenewable resource and can experience long-term impacts through compaction, accelerated erosion, and loss of productivity. After closure of the mine, reclamation can partially restore the function of these disturbed areas, but success depends on the stability of the tailings, on the closure design, and on how readily vegetation can be reestablished.

3.3 Soils and Vegetation

3.3.1 Introduction

This section discusses the effects of the project on soils, soil productivity, vegetation communities, noxious and invasive weeds, and special status plant species. Soils, which comprise mineral and organic material, provide the necessary structure, water, gases, and nutrients needed to support diverse microbial communities and growth and propagation of plants. Ground disturbance would potentially remove or destroy soil cover and vegetation, directly and indirectly impacting the quality, health, integrity, and stability of a soil, thereby degrading its productivity and capacity to sustain plant growth.

Soil and vegetation work together to form and support an ecosystem. The project would fundamentally change large areas of the landscape and remove these ecosystems for decades during the life of the mine. However, during reclamation and closure, these ecosystems can be recovered to a degree in some areas, particularly at the tailings storage facility. This section identifies what these ecosystems look like today, the management vision for how these ecosystems ideally would function in the long term (also known as the desired condition), and an assessment of whether the tailings landform can reach desired conditions over the long term, through reclamation and revegetation efforts.

3.3.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

3.3.2.1 Analysis Area

This section includes a discussion of soils, revegetation, vegetation communities, special status plant species, and noxious weeds. The project area footprint (including all alternatives and facility components) is the analysis area for soils, soil productivity, and revegetation potential, as it encompasses all ground-disturbing activities. The analysis area for vegetation communities, noxious and invasive weeds, and special status plant species includes the project footprint with a 1-mile buffer, as well as areas along Queen Creek and Devil’s Canyon, where changes to vegetation communities from groundwater drawdown and changes in surface water hydrology may occur. The soils analysis area is shown in figure 3.3.2-1, and the vegetation analysis area is shown in figure 3.3.2-2.

The area beyond the project footprint is informed by the water analyses for riparian areas (analyzed in section 3.7.1), reduction in surface runoff due to the project (analyzed in section 3.7.3); air quality analyses, particularly those focused on the generation and likely dispersion of fugitive dust (analyzed in section 3.6); lighting effects (analyzed in section 3.11), and the potential for noxious weed invasion (Foxcroft et al. 2010). According to the air quality analysis, ambient air quality standards would be achieved at the project footprint boundaries; for that reason, the 1-mile buffer is

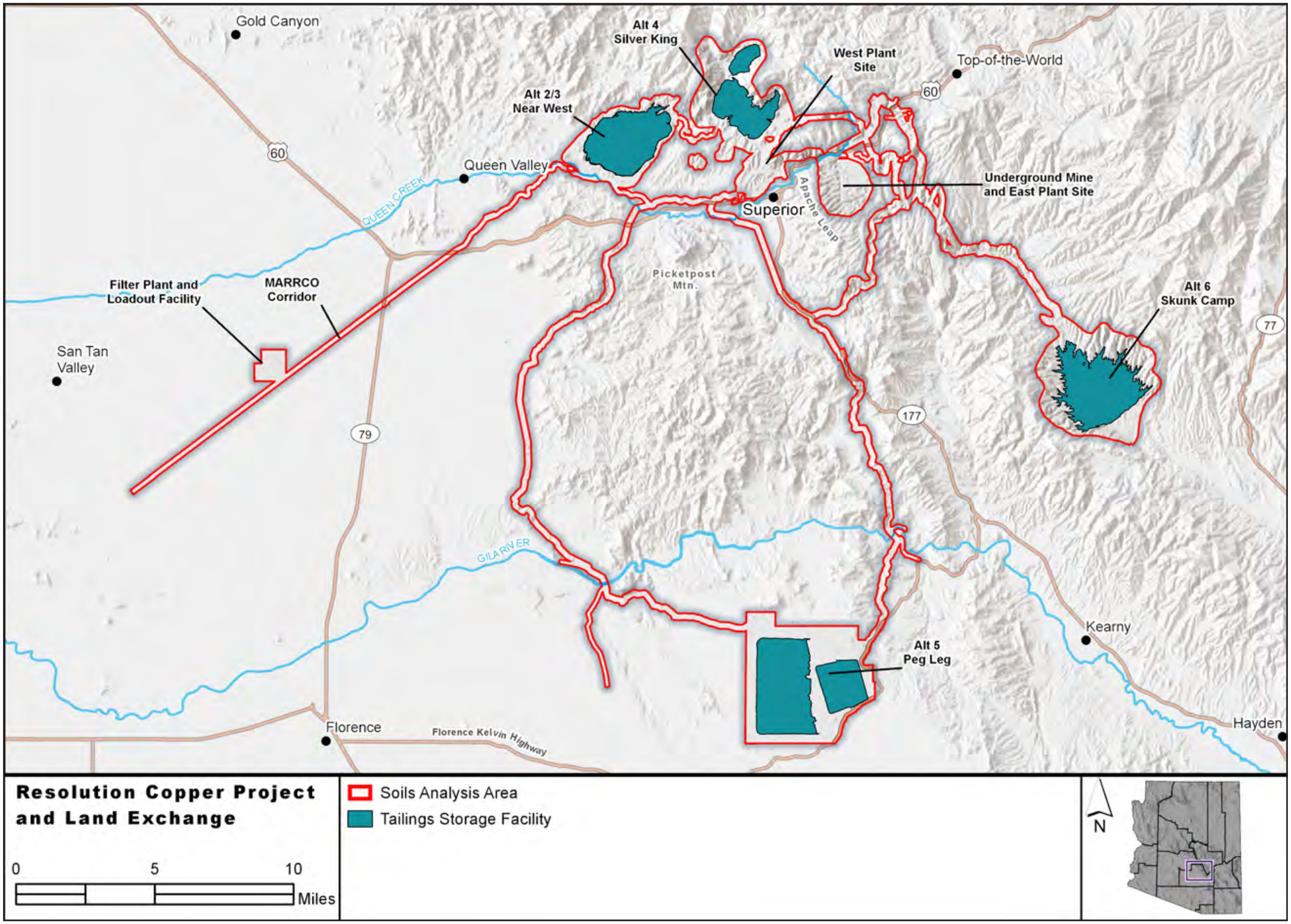

Figure 3.3.2-1. Soils analysis area

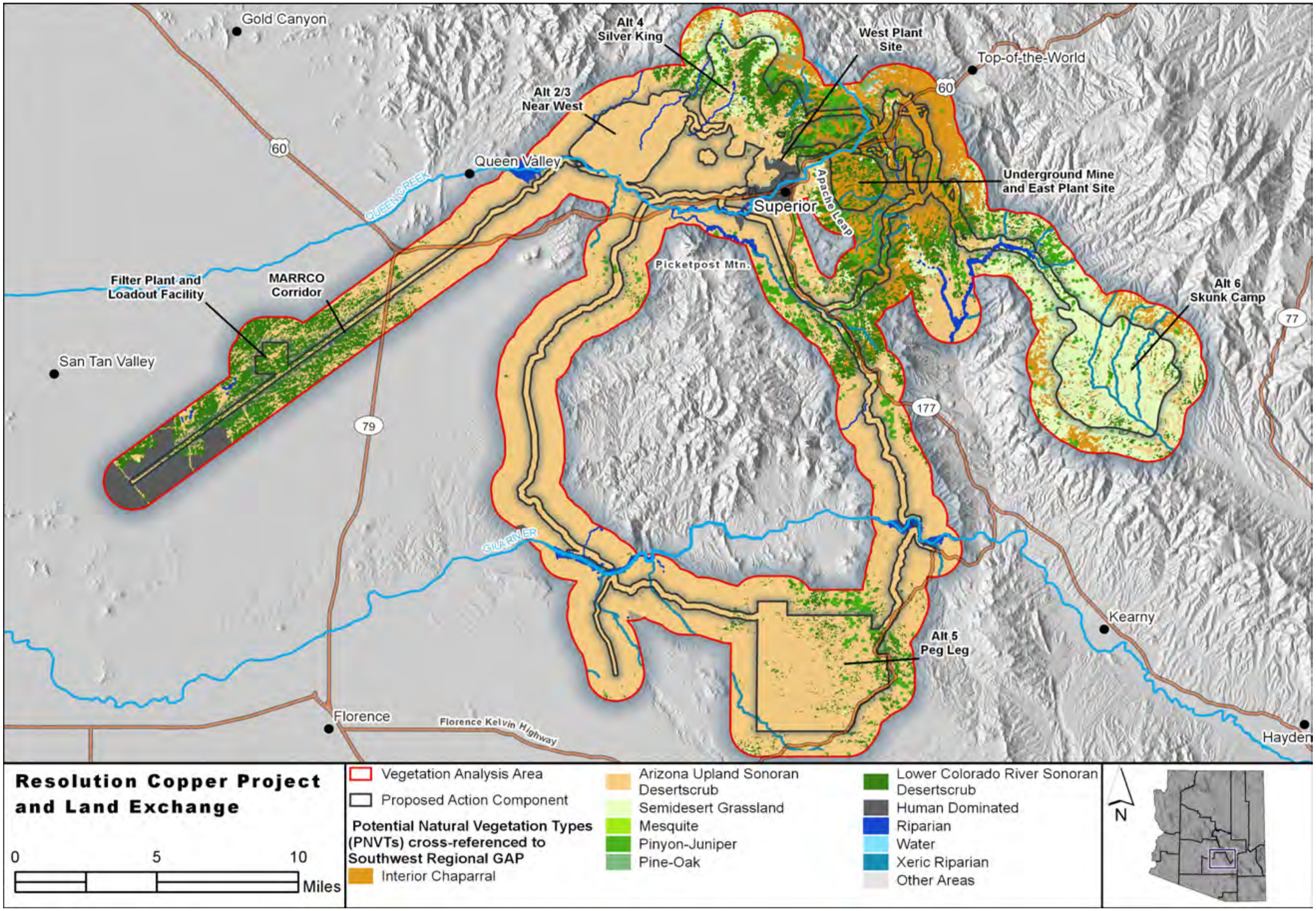

Figure 3.3.2-2. Vegetation analysis area

sufficient to address potential impacts from ambient air quality changes. Additional light associated with project construction and facilities is anticipated to increase night sky brightness by 1 to 9 percent (Dark Sky Partners LLC 2018). With the additional light increase of 1 to 9 percent over existing conditions, the 1-mile buffer would be sufficient to capture potential project-related impacts on plants from additional light.

The temporal parameters for this analysis involved the time frames for (1) construction: mine years 1 through 9; (2) operation: mine years 6 through 46; and (3) closure and reclamation: mine years 46 through 51–56. This analysis also extends to the time it takes to complete reclamation, because arid soils and vegetation communities in the analysis area can take very long periods (hundreds to thousands of years) to recover and reestablish; in some cases, complete recovery may not be possible.

3.3.2.2 Soils Analysis

The goal of the soils analysis is to identify the potential impacts on soil resources from all project activities and alternatives. In this analysis, soils are considered nonrenewable resources, as their formation in desert environments (particularly those characteristics that control biological community establishment) takes place over hundreds to thousands of years (Webb et al. 1988; Williams et al. 2013). Soil losses within the project footprint are, therefore, treated as permanent unless (1) soils are salvaged and reapplied during the construction and reclamation processes, (2) revegetation efforts successfully stabilize soils and reduce long-term erosion, and (3) soil productivity is returned to pre-mine conditions.

No single data set covers the entire project footprint; therefore, two data sources were combined for the soils analysis: (1) the U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (2017); and (2) the Forest Service General Terrestrial Ecosystem Survey (GTES) (U.S. Forest Service 2018e), applied where SSURGO data were unavailable. Where available, SSURGO data (Natural Resources Conservation Service 2017) provided information regarding general soil morphological characteristics, soil depth, soil productivity, soil fertility, and soil wind and water erosion potential (Natural Resources Conservation Service 2018b). For this analysis, soil productivity is defined as “capacity of soil, in its normal environment, to support plant growth” (Minnesota Forest Resources Council 1999). GTES data provide some information on erosion susceptibility in other areas (U.S. Forest Service 2018e). In areas lacking SSURGO data, information regarding the nature and thickness of alluvial deposits and soil cover was taken from the “Near West Tailings Storage Facility Geotechnical Site Characterization Report” (corresponding directly to Alternatives 2 and 3) and extrapolated to other alternatives (Klohn Crippen Berger Ltd. 2017). Data and interpretations could be reasonably extrapolated across alternatives, as all sites occur within similar ecosystems of central Arizona. Site-specific interpretations of soil map units and erosion potential are limited by the resolution and accuracy of GIS data, which varied by data source and survey effort. Details of the soils analysis approach are available in Newell (2018g).

3.3.2.3 Revegetation Analysis

The goal of the revegetation analysis is to provide a site-specific assessment of current conditions and guidance for future revegetation efforts throughout the life of the project. Revegetation success depends on several controlling environmental variables (precipitation or water availability, climate, soil or revegetation substrate, reclamation techniques, etc.); therefore, no individual study includes enough information to project rates of revegetation success. For this analysis, a meta-analysis drew data from many sources to model revegetation rates. The analysis does not reflect outcomes for individual project components but instead relies on conceptual reclamation plans and provides a range of possible revegetation outcomes that could be expected at a given time after reclamation has commenced. The first step in the meta-analysis was to gather relevant case studies from published scientific literature, technical reports, and semi-quantitative field observations. Two attributes were compiled from each study: (1) the number of years since reclamation commenced, and (2) the minimum and maximum observed percent vegetation cover at the given time.

The results from each study were combined into a single plot for visual interpretation. Details of the data sources and the analysis approach are provided in Bengtson (2019b).

The assessment of revegetation relies in part on the reclamation plans that have been prepared by Resolution Copper, both as part of the GPO (section 6.0) and during alternatives development for the different tailings storage facilities. These reclamation plans largely describe the expected timing, type, and location of reclamation activities and provide the reclamation goals to be achieved. These conceptual reclamation plans are briefly summarized in this section.

A further level of reclamation detail would be developed in the final reclamation plans approved by the Forest Service and used to guide bonding estimates. As an example, the GPO identifies only that reseeding would occur and proposes a likely seed mix. Details in the final reclamation plan would identify surface preparation (ripping or tilling), site amendments (straw or fertilizers), a final seed mix, whether, where, and how any direct planting would be done, the need for supplemental watering, and performance standards that would need to be met through monitoring of revegetation progress.

3.3.2.4 Vegetation Communities, Noxious Weeds, and Special Status Plant Species Analysis

This analysis identifies the potential impacts on vegetation, vegetation communities, and special status plant species from all activities associated with each project alternative, including closure and reclamation (see table E-1 in appendix E for details associated with each alternative). The analysis also evaluates the increased likelihood of introduction and/or spread of noxious weed species in the analysis area.

The factors for analysis identified during the NEPA scoping process, survey, and records data provided as part of this project, as well as a scientific examination using current literature on species and how environmental changes (human or natural) affect species and their habitat, constitute the foundation of this analysis.

The uncertainties and unknown information, as well as assumptions, of this analysis include (1) limitations in the use of geographic information system (GIS) data (e.g., mapping data may have inaccuracies and resulting calculations could be an overestimation or underestimation) or data come from different sources for different portions of the analysis area; however, the analysis area contains similar overall environments and data sources have been reasonably extrapolated to cover the entire analysis area; (2) lack of current scientific data on how certain environmental changes affect species (e.g., there are only a few studies available regarding dust effects on plants); and (3) reliance on other, previous resource analyses as informational sources for the conclusions reached in this current analysis may inadvertently reiterate the assumptions, uncertainties, or unknown information inherent in these prior studies.

The analysis of reclamation success relies in part on the desired conditions for the lands, which are the expectations for how the landscape should appear and function over the long term. For the purposes of this analysis, desired conditions were informed by internal work by the Tonto National Forest on the ongoing revision to the forest plan, which has not yet been completed or released. The desired conditions used in this section are meant to allow an assessment of reclamation success but should not be construed as management direction from the Tonto National Forest.

3.3.3 Affected Environment

3.3.3.1 Relevant Laws, Regulations, Policies, and Plans

A summary of the principal legal authorities pertinent primarily to reclamation is shown in the accompanying text box. A complete listing and brief description of the laws, regulations, reference documents, and agency guidance used in this soils and vegetation effects analysis may be reviewed in Newell (2018g).

Primary Legal Authorities Relevant to the Soils and Vegetation Effects Analysis

- Forest Service locatable mineral regulations (36 CFR 228 Subpart A), specifically:
  - Minimizing adverse environmental impacts on NFS surface resources (36 CFR 228.8)
  - Requirements for reclamation (36 CFR 228.8(g))
- Forest Service Manual 2500, Chapter 2550 – Soil Management
- Arizona Native Plant Law (ARS 3-904)
- Federal Noxious Weed Act of 1974
- Arizona Mined Land Reclamation Program
- State of Arizona Noxious Weed Statute
- Taylor Grazing Act (43 U.S.C. 315-315(o))
- Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701–1782)

3.3.3.2 Existing Conditions and Ongoing Trends

Soil Occurence and Characteristics

The project area footprint, including all components and alternatives, is characterized by Basin and Range geomorphology (Peterson 1981), with soils of formed in alluvium, eolian deposits, colluvium, and thin residuum (overlying bedrock outcrops). In general, the deepest soils are formed within expansive alluvial fan piedmonts or alluvial deposits within the bottoms of canyons. Shallower soils form as thin alluvial or colluvial deposits along ridges and hillslopes (overlying shallow bedrock), or as shallow soils overlying calcium carbonate-cemented horizons (petrocalcic horizons) that form root-restrictive layers.

There are 42 soil units mapped in the analysis area (including the combination of map units from SSURGO and GTES datasets), with the majority of these individual map units being minor and constituting less than 1.0 percent of the area of each alternative. These map units are delineated in figure 3.3.3-1. The predominant soil units mapped for each action alternative are detailed in table 3.3.3-2, which includes descriptions of each predominant map unit’s morphological characteristics, soil depths, soil productivity (either annual biomass production or dominant vegetation community), and soil fertility. Areas covered by SSURGO (Natural Resources Conservation Service 2017) data contain the most detailed soil descriptions, whereas data from other sources were used to extrapolate soils-related data to areas covered by GTES data (U.S. Forest Service 2018e). Data provided later in table 3.3.3-2 include only predominant soil map unit information; details of acreages of all individual map units are provided in Newell (2018g). Soil mapping is at an insufficient scale to delineate the location of each soil unit with respect to a specific disturbance feature for each alternative.

Soils across all project alternatives display characteristics that are unique to arid and semi-arid environments, which influence ecological function and response to disturbance. For example, soil resources such as water and nutrients display extreme variation through space and time, as pulses in precipitation drive pulses in biological and chemical cycles and processes (Abella 2017). Arid and semi-arid soils display distinct surface features such as desert pavements and biotic soils that provide critical

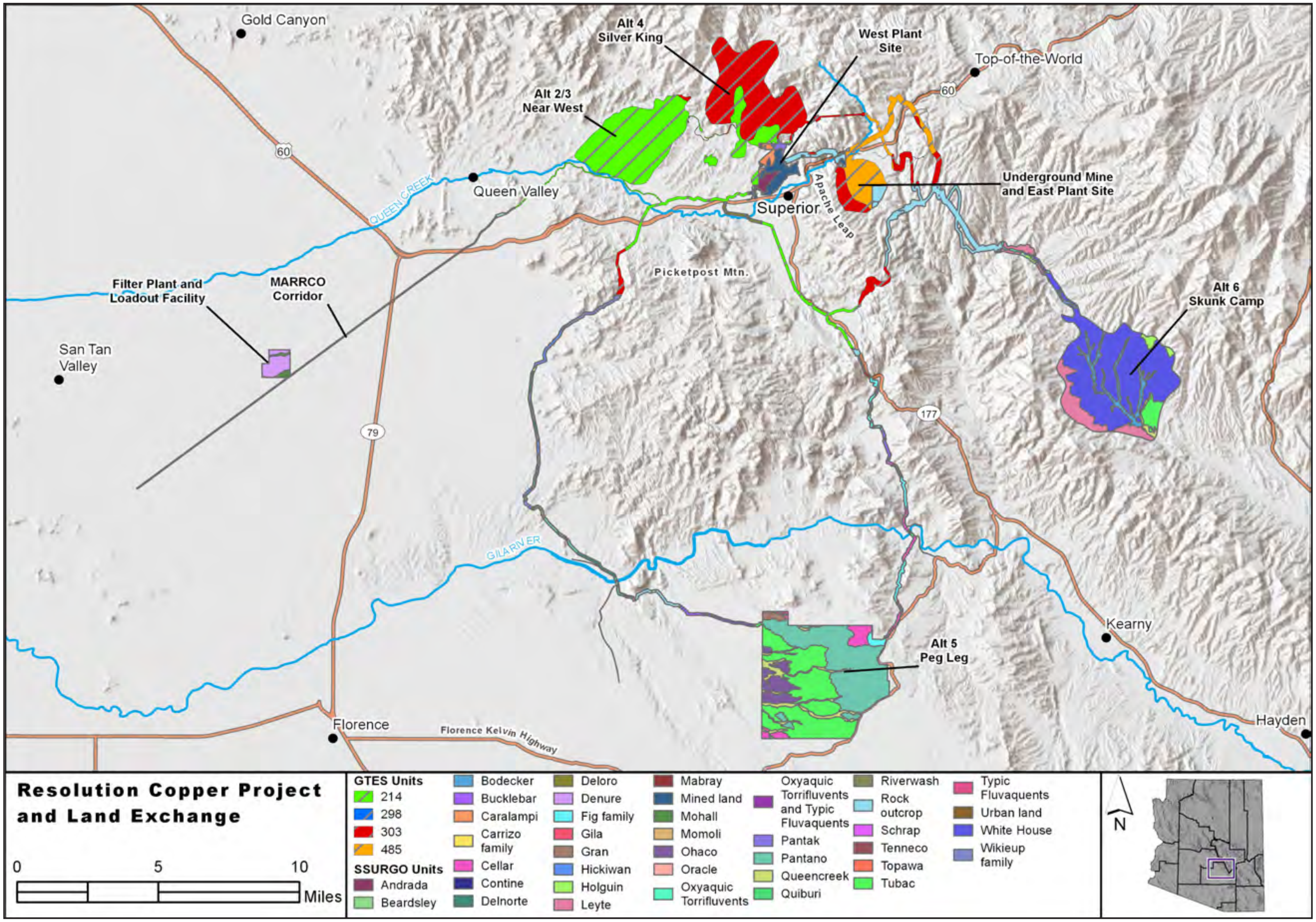

Figure 3.3.3-1. Soil map units as delineated from SSURGO (Natural Resources Conservation Service 2017) GTES (U.S. Forest Service 2018e) datasets

soil cover (in areas where vegetation is sparse) and play an active role in the capture of dust and formation of dust-rich vesicular horizons, which strongly influence the distribution and storage of water (Williams 2011; Williams et al. 2013). Desert pavements form a single layer of surface rock fragments that resemble smooth pavement surfaces (Wood et al. 2005), whereas biotic soils formed by cyanobacteria, mosses, lichens, bacteria, algae, and fungi that grow around soil mineral particles create a living soil cover (Eldridge and Greene 1994; Williams et al. 2012).

Fertile islands are also ubiquitous surface features in these soils, where nutrients, organic material, macro- and microbiological activity, and water availability are elevated in surface soils beneath the canopies of perennial vegetation as compared with the soils of surrounding plant interspaces (Schlesinger et al. 1996). Surface soils further contain soil seedbank, which in most deserts is limited to the upper 2 inches of soil (Scoles-Sciulla and DeFalco 2009). Surface topography and soil cover drive the distribution of water and infiltration across arid soil surfaces in arid environments. Soil water runs off smooth surfaces with low infiltration only to be captured along rougher surfaces with greater infiltration potential and stored where soil water-holding capacity is high (Wood et al. 2005). Similarly, slope drives the redistribution of water, with drainages capturing and storing the majority of water run-off, leading to different community composition in those areas than adjacent upland areas (Schwinning et al. 2010).

Note that where specific soil data are shown to be lacking, several mitigations are required that would provide for collection of this information (see section 3.3.4.9).

Soils Suitability for Reclamation

According to the GPO (Resolution Copper 2016d), soils within much of the project footprint (particularly those within Alternatives 2 and 3) are primarily bedrock-controlled, and only a thin veneer of soils could be salvaged for previous reclamation and revegetation efforts (Resolution Copper 2016d). The GPO states that, where possible, soil would be salvaged for reuse during reclamation. The geotechnical study for the Near West tailings storage facility (Klohn Crippen Berger Ltd. 2017) has identified thick alluvial deposits in drainages within the footprint and borrow areas of the proposed facility (alluvial deposits 6 to 35 feet thick); however, the alluvium has been allocated for construction of drains and filters. These bedrock-controlled soils (alluvium and colluvium up to 5 feet in thickness (Klohn Crippen Berger Ltd. 2017)) and thicker alluvial soils in drainages are typically capable of supporting vegetation communities ranging from Arizona Upland Sonoran Desertscrub and to Interior Chaparral Semi-desert Grassland (table 3.3.3-3).

Alternative 5 has both shallow, bedrock-controlled soils (up to 20 inches deep) and deeper soils formed along alluvial fan terraces (more than 60 inches deep). These soils have low organic matter (approximately 1 percent) and near neutral to slightly alkaline pH conditions that support annual rangeland productivity ranging from 350 to 600 lb biomass/acre/year (Natural Resources Conservation Service 2017).

Alternative 6 has both bedrock-controlled soils (alluvium and colluvium up to 5 feet in thickness (Klohn Crippen Berger Ltd. 2017) and deeper soils formed in alluvial fans (more than 60 inches deep) (Natural Resources Conservation Service 2017). These soils have low organic matter (approximately 1 percent) and slightly acidic to slightly alkaline pH conditions that support annual rangeland productivity ranging from 600 to 800 lb biomass/acre/year (Natural Resources Conservation Service 2017).

While some volume of soils would be salvaged (as practicable) for project reclamation, most of the capping material for the proposed tailings storage facility would be derived from other sources. The closure cover study completed for the Near West tailings storage facility (Klohn Crippen Berger Ltd. 2016) identified Gila Conglomerate as the preferred closure material for reclamation within the Near West tailings storage facility, which is present in sufficient quantities to be the primary capping material (for this facility's alternative). Gila Conglomerate was selected for the following reasons (Klohn Crippen Berger Ltd. 2016):

1. availability of material and ease of extraction,
2. favorable chemical and physical properties, and
3. its potential to support plant growth.

The characteristics of this material as a closure material and plant growth medium are described in more detail in Bengtson (2019a). In general, Gila Conglomerate is a neutral to slightly alkaline material (pH 7 to 8.2), is not potentially acid generating, and has a high net neutralization potential (Klohn Crippen Berger Ltd. 2016). Gila Conglomerate has both high saturated hydraulic conductivity and low water-holding capacity. Organic matter ranges from 1.6 to 3.2 percent (Klohn Crippen Berger Ltd. 2016). Total Nitrogen ranges from less than 0.02 to 0.028 percent, and organic carbon ranges from 1.6 to 3.2 percent[24] (Klohn Crippen Berger Ltd. 2016). Gila Conglomerate bedrock and soils formed from Gila Conglomerate parent material have been shown to support native and warm- and cool-season perennial grasses, annual forbs, and perennial forbs, some shrubs, and trees (Lawson 2012; Lawson 2011; Milczarek et al. 2011; Romig et al. 2006; Vinson et al. 1999). Revegetation studies on Gila Conglomerate-derived soils have shown vegetation cover may range from 2.8 to 26 percent, less than 1 year after reclamation treatments were applied (Lawson 2012; Lawson 2011). For surfaces capped by crushed Gila Conglomerate bedrock, another study showed vegetation cover varied from 11 to 71 percent 1 year after treatment, and by year 12, vegetation cover ranged from 23 to 77 percent (Milczarek et al. 2011). These studies further indicate that soil amendments, such as organic amendments and mulch treatments, may help increase the success of revegetation when crushed Gila Conglomerate bedrock is the plant growth medium, by increasing soil water-holding capacity and soil fertility and decreasing erosion susceptibility (Klohn Crippen Berger Ltd. 2016; Lawson 2011; Milczarek et al. 2011; Vinson et al. 1999).

Note that while the materials described here have been demonstrated in other situations to be theoretically suitable for reclamation, at least to a degree, several mitigations are required that would provide for collection of additional information to inform final reclamation plans, including the overall suitability of these materials (see section 3.3.4.9).

Estimates of Salvage Volumes

The GPO identified different geological units that would be salvaged during site preparation as being favorable for different uses for final cover (see table 4.6-1 in Resolution Copper (2016d)):

- Alluvial material. Primarily used for drains and filters for seepage control.
- Apache Leap Tuff. Primarily used for drains and filters, and for armoring of tailings embankment and seepage control embankments.
- Gila Conglomerate. Used for starter dams, drains and filters, and closure cover.
- Pinal Schist. Primarily used for armoring of tailings embankment, seepage control embankment, and diversion channels.

With respect to the final reclamation cover, the GPO originally estimated that over 8,000 acre-feet (13 million cubic yards) of Gila Conglomerate material would be available for cover during reclamation for the proposed action (Alternative 2), based on salvage from two borrow areas of about 350 acres, roughly to a depth of about 20 feet. With the development of different tailings alternatives, the specific borrow areas have changed. The borrow areas and estimated amounts of closure cover material are summarized in table 3.3.3-1.

24. Gila Conglomerate samples analyzed for organic matter included: (1) 30 surface samples from Near West site (organic matter ranging from 1.6 to 3.2 percent), which could have been impacted by soil formation (i.e., organic additions from soil biological activity); and (2) 25 samples from the Superior Mine stockpile (organic matter content was 1.7 percent), which were blasted, crushed, and screened (the influence of soil biological processes on organic matter contents is unknown).

Table 3.3.3-1. Estimated locations and amounts of available reclamation cover material

	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6
Proposed borrow area acreage	209 acres (one location)	247 acres (one location)	721 acres (five locations)	390 acres (two locations)
Primary geology of borrow area	Gila Conglomerate	Gila Conglomerate	Alluvium and Gila Conglomerate; some granite	Gila Conglomerate
Estimated volume of cover material available*	4,180 acre-feet (6.7 million cubic yards)	4,940 acre-feet (8 million cubic yards)	14,400 acre-feet (23.2 million cubic yards)	7,800 acre-feet (12.5 million cubic yards)
Approximate depth of cover from borrow areas for tailings storage facility†	1.3 feet	2.2 feet	2.7 feet	1.8 feet

* Assumes excavation to depth of 20 feet

† Based on planar acreage of tailings storage facility. Accounting for slopes (at 3H:1V) would require minimal additional material (less than a 5% increase)

The conceptual reclamation plans for the tailings storage facilities call for a minimum of 1.5 feet of cover, and the borrow areas proposed are roughly sufficient to provide this material for the tailings storage facility. Additional cover material would be obtained from salvage of surface soils within the footprint of the facility.

Previous investigations have looked at the possibility of the closure cover being a mix of materials, such as Gila Conglomerate and NPAG tailings (Klohn Crippen Berger Ltd. 2016). Geochemical characterization tests have been conducted on these materials and identified that there may be some potential for elevated metals in stormwater runoff. See section 3.7.2 for details of the geochemical tests conducted for NPAG tailings, and tests on Gila Conglomerate have been described in several other reports (Klohn Crippen Berger Ltd. 2016, 2017).

Note that several mitigations are required that would provide for detailed estimates of soil available for salvage, salvaged soil storage techniques, potential preparation techniques (like excavation and crushing for Gila Conglomerate), conducting of appropriate tests to identify any potential water quality concerns for the selected cover material, and preparation of detailed reclamation plans that specify the cover materials to be used (see section 3.3.4.9). The predominant soil units mapped for each action alternative are detailed in table 3.3.3-2, which includes descriptions of each predominant map unit's morphological characteristics, soil depths, soil productivity (either annual biomass production or dominant vegetation community), and soil fertility.

Vegetation Occurrence and Characteristics

VEGETATION COMMUNITIES

Eleven vegetation communities and land cover types occur within the analysis area. These communities and land cover types along with the acres of each are given in table 3.3.3-3 and are shown in figure 3.3.3-2. The vegetation community GIS data used for this analysis comprised a specialized dataset developed by the Arizona Game and Fish Department (AGFD) that is a crosswalk between the larger scale (Brown 1994; Brown et al. 2007) and Southwest Regional Gap Analysis Project (SWReGAP) vegetation communities data and, more specifically, a modified SWReGAP layer that was used in the AGFD's statewide modeling process (Morey 2018a).

A brief description of each of the vegetation communities in the analysis area is provided here, with more technical description included in Newell (2018g). Within each alternative footprint, a variety of combinations of different vegetation communities are present. Note that where specific vegetation data are shown to be lacking, several mitigations are required that would provide for collection of this information (see section 3.3.4.9).

Table 3.3.3-2. Predominant soils by alternative

Alternative	Total Acres	Map Unit Symbol (data source)	Map Unit Name	Map Unit Description and Soil Composition	Productivity† (pounds of biomass per acre or dominant vegetation community)	Fertility‡	Acreage within Map Unit	Percentage of Alternative
Alternative 2 – Near West Proposed Action	10,033	214 (GTES)	CEMI2, LATR	Klohn Crippen Berger Ltd. (2017) identified the majority of soils and soil parent material within the Near West project footprint to be formed in Undifferentiated Quaternary Deposits (Qs).* These surfaces are covered in slope wash and colluvium, and recent alluvium in narrow drainages low-relief areas underlain by bedrock (up to 5 feet in thickness). The material comprises gravel (10%–50%), silt and clay (28%–45%), and sand (10%–50%). Material is generally thinner along ridges and thicker along concave backslopes and toe-slopes. Active channels and drainages contain localized deposits of Recent Alluvium (Qal) and Old Alluvium (Qoa). Qal deposits are located adjacent to active channels reaches thicknesses of 6 to 35 feet (within the Near West footprint) and comprises uncemented, loose to dense sand (25%–80%) and gravel (10%–55%), silt and clay (2%–40%), and trace boulders (up to 24-inch diameter). Qoa deposits are located along the margins of active channels and include partially cemented to well-cemented gravel (40%–60%), sand (25%–40%), silt and clay (18%–30%), with some cobbles and boulders (up to 24-inch diameter). Carbonate cementation varies by deposit age. Old Lacustrine (Qoa-Lu) units occur in limited areas as 1- to 4-foot-thick deposits overlying Gila sandstone, and include gravel <10%, clay and silt (37%–78%), and sand (20%–28%).	Arizona Upland Sonoran Desertscrub	No information available	5,274	54
		485 (GTES)	QUTU2	The majority of areas are covered by Qs deposits (along ridges and hillslopes) with some of Qal and Qoa deposits (adjacent to active channels).* See unit descriptions above.	Interior Chaparral	No information available	1,457	15

continued

Table 3.3.3-2. Predominant soils by alternative *(cont'd)*

Alternative	Total Acres	Map Unit Symbol (data source)	Map Unit Name	Map Unit Description and Soil Composition	Productivity† (pounds of biomass per acre or dominant vegetation community)	Fertility‡	Acreage within Map Unit	Percentage of Alternative
Alternative 3 – Near West – Ultrathickened	10,033	214 (GTES)	CEMI2, LATR	Similar to Alternative 2 Near West Proposed Action (see above)	Arizona Upland Sonoran Desertscrub	No information available	5,274	54
		485 (GTES)	QUTU2	Similar to Alternative 2 Near West Proposed Action (see above)	Interior Chaparral	No information available	1,457	15
Alternative 4 – Silver King	10,861	214 (GTES)	CEMI2, LATR	No direct observations from Klohn Crippen Berger Ltd. (2017) were available to inform interpretations regarding soils or quaternary deposit thickness.* Based on extrapolation (from aerial imagery and geological mapping), most canyon bottoms are likely to contain Qal and Qoa deposits (adjacent to active channels) with some Qs deposits along ridges and hillslopes. See unit descriptions above, in this table.	Arizona Upland Sonoran Desertscrub	No information available	1,259	12
		303 (GTES)	FOSP2, QUTU2, GRANITE OUTCROP	No direct observations from Klohn Crippen Berger Ltd. (2017) were available to inform interpretations regarding soils or quaternary deposit thickness.* Based on extrapolation (from aerial imagery and geological mapping), most areas are covered by Qs deposits (along ridges and hillslopes) with some Qal and Qoa deposits (adjacent to active channels). See unit descriptions above, in this table.	Mix of Semi-desert Grassland and Lower Colorado River Sonoran Desertscrub	No information available	5,345	50
		485 (GTES)	QUTU2	No direct observations from Klohn Crippen Berger Ltd. (2017) were available to inform interpretations regarding soils or quaternary deposit thickness.* Based on extrapolation (from aerial imagery and geological mapping), most areas are covered by Qs deposits (along ridges and hillslopes) with some discrete Qal and Qoa deposits (adjacent to active channels). See unit descriptions above, in this table.	Interior Chaparral	No information available	1,457	14

continued

Table 3.3.3-2. Predominant soils by alternative *(cont'd)*

Alternative	Total Acres	Map Unit Symbol (data source)	Map Unit Name	Map Unit Description and Soil Composition	Productivity† (pounds of biomass per acre or dominant vegetation community)	Fertility‡	Acreage within Map Unit	Percentage of Alternative
Alternative 5 – Peg Leg East Option	17,153	74 (SSURGO)	Pantano-Anklam-Rock outcrop complex, 3 to 20 percent slopes	The Pantano soil series are well-drained soils formed on steep alluvial and colluvial slopes and have a loamy matrix with ≥ 35% rock fragments. Soils are shallow, overlying fractured bedrock at 20-inch depths. The Anklam soil series are well-drained soils formed on moderate to steep alluvial slopes and have a loamy matrix with ≥ 35% rock fragments. Soils are shallow, overlying fractured bedrock at 10- to 20-inch depths. Granite or other bedrock outcrops cover 20% of the soil surface.	Pantano: 350 lb/acre Anklam: 500 lb/acre Bedrock: negligible	Organic Matter: 0.5%–1% pH: 6.1–8.4	4,243	25
		98 (SSURGO)	Tubac-Rillino complex, 3 to 25 percent slopes	The Tubac soil series are well-drained soils formed along alluvial fan terraces and basin floors with 0%–8% slopes. Soil textures are fine clay to sandy clay loam with 2% rock fragments, with diagnostic argillic horizons from 11–44 inches. Soils reach depths of 44–60+ inches. The Rillino soil series are well-drained soils formed along alluvial fan terraces with 1%–50% slopes. Soil textures range from sandy loam to loam with 15%–35% rock fragments. Soils reach depths of 60+ inches, with calcic (calcium carbonate-rich) soils at a depth of 5–20 inches.	Tubac: 600 lb/ac Rillino: 400 lb/ac	Organic Matter: 1%	4,210	25

continued

Table 3.3.3-2. Predominant soils by alternative *(cont'd)*

Alternative	Total Acres	Map Unit Symbol (data source)	Map Unit Name	Map Unit Description and Soil Composition	Productivity† (pounds of biomass per acre or dominant vegetation community)	Fertility‡	Acreage within Map Unit	Percentage of Alternative
Alternative 5 – Peg Leg West Option	17,530	74 (SSURGO)	Pantano-Anklam-Rock outcrop complex, 3 to 20 percent slopes	Same as Alternative 5 Peg Leg East Option (above)	Pantano: 350 lb/acre Anklam: 500 lb/acre Bedrock: negligible	Organic Matter: 0.5%–1% pH: 6.1–8.4	4,381	25
		98 (SSURGO)	Tubac-Rillino complex, 3 to 25 percent slopes	Same as Alternative 5 Peg Leg East Option (above)	Tubac: 600 lb/acre Rillino: 400 lb/acre	Organic Matter: 1% pH: 6.6–8.4	4,226	25
Alternative 6 – Skunk Camp North Option	16,116	485 (GTES)	QUTU2	No direct observations from (Klohn Crippen Berger Ltd. 2017) were available to inform interpretations regarding soils or quaternary deposit thickness.* Based on extrapolation (from aerial imagery and geological mapping), most areas are covered by Qs deposits (along ridges and hillslopes) with some discrete Qal and Qoa deposits (adjacent to active channels). See unit descriptions above, in this table.	Interior Chaparral	No information available	1,856	12
		104 (SSURGO)	White House-Stronghold complex, 5 to 60 percent slopes	The White House soil series are well-drained soils formed in alluvial fans, with 0%–60% slopes. Soil textures range from sandy clay to clay with less than 35% rock fragments. Soils reach depths of 60+ inches, with argillic horizons from 3–39 inches. The Stronghold soil series are well-drained soils formed in alluvial fan remnants, with 1%–60% slopes. Soil textures range from loamy sand to loam with less than 35% rock fragments. Soils reach depths of 60+ inches, with a calcic (calcium carbonate–rich) horizon from 1–60 inches.	White House: 800 lb/acre Stronghold: 600 lb/acre	Organic Matter: >1% pH: 5.6–8.4	6,429	41

continued

Table 3.3.3-2. Predominant soils by alternative *(cont'd)*

Alternative	Total Acres	Map Unit Symbol (data source)	Map Unit Name	Map Unit Description and Soil Composition	Productivity† (pounds of biomass per acre or dominant vegetation community)	Fertility‡	Acreage within Map Unit	Percentage of Alternative
Alternative 6 – Skunk Camp South Option	16,557	485 (GTES)	QUTU2	Same as Alternative 6 Skunk Camp North Option (above)	Interior Chaparral	No information available	1,739	11
		104 (SSURGO)	White House-Stronghold complex, 5 to 60 percent slopes	Same as Alternative 6 Skunk Camp North Option (above)	White House: 800 lb/acre Stronghold: 600 lb/acre	Organic Matter: >1% pH: 5.6–8.4	6,429	40

* Soil composition data within Tonto National Forest lands are derived from the Near West Tailings Storage Facility Geotechnical Site Characterization Report (Klohn Crippen Berger Ltd. 2017). Data were specific to the Near West tailings storage facility but have been extrapolated (as appropriate) to other alternatives.

† Productivity data are reported as pounds of biomass per acre per year, as derived from SSURGO datasets where data are available (Natural Resources Conservation Service 2017). No productivity data are available for areas mapped by GTES data; dominant vegetation communities (as reported in table 3.3.3-3) are used as a proxy for productivity.

‡ Limited soil fertility data are available from SSURGO datasets (Natural Resources Conservation Service 2017). No soil fertility data are available for areas mapped by GTES data (U.S. Forest Service 2018e).

Desert Ecosystems (includes Arizona Upland Sonoran Desertscrub and Lower Colorado River Sonoran Desertscrub)

This vegetation community generally dominates in broad valleys, lower bajadas, plains and low hills of lower elevations. Trees are sparse and the understory is bare ground or sparse grass and shrubs, typically whitethorn, creosote, and bursage. Cacti are also present, such as saguaro, prickly pear, and cholla. Common trees are palo verde, catclaw acacia, mesquite, and ironwood. On slopes, plants are often distributed in patches around rock outcrops where suitable soil exists.

Semi-Desert Grasslands

Typically occurring roughly 3,000 to 5,000 feet in elevation, this vegetation community is dominated by diverse perennial grasses, which vary depending on region. Shrubs also occupy these grasslands, with predominant shrubs, including mesquite, snakeweed, creosote, and catclaw acacia.

Interior Chaparral

Typically occurring roughly 3,000 to 7,000 feet in elevation, this vegetation community consists of chaparral on side slopes that transition into pinyon-juniper woodlands. Chaparral is a term describing an ecosystem dominated by desert shrubs, grasses, and scrub oak. Interior chaparral has an open canopy and open space either bare or covered with grasses and forbs.

Table 3.3.3-3. Vegetation communities and land cover types in the analysis area

Vegetation Community or Landform Type	Alternatives 2 and 3 (acres)	Alternative 4 (acres)	Alternative 5 West Pipeline Option (acres)	Alternative 5 East Pipeline Option (acres)	Alternative 6 South Pipeline Option (acres)	Alternative 6 North Pipeline Option (acres)
Human dominated	5,511	5,511	5,620	5,547	5,123	5,511
Interior Chaparral	10,138	12,385	10,137	10,410	17,790	20,061
Lower Colorado River Sonoran Desertscrub	17,075	20,934	19,521	21,627	19,396	20,498
Mesquite	5	5	6	5	15	15
Open-Pit Mine	3	3	3	3	3	3
Pine-Oak	185	362	185	185	439	500
Pinyon-Juniper	760	1,109	1,166	1,640	1,604	1,362
Riparian	1,336	1,316	1,771	1,854	1,542	1,472
Rock	102	103	102	102	108	117
Semidesert Grassland	1,855	6,384	1,465	2,021	18,831	25,459
Arizona Upland Sonoran Desertscrub	45,110	37,250	96,987	83,365	39,982	36,886
Water	29	29	29	29	15	29
Xeric Riparian	851	1021	1,611	1,526	2,065	2,618
Total Acres	**82,960**	**86,412**	**138,603**	**128,314**	**106,913**	**114,531**

Note: Acreages in this table are rounded to the nearest whole number

Pinyon-Juniper Woodland

Typically occurring roughly 4,500 to 7,000 feet in elevation, these woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges, and are characterized by being an open forest dominated by low, bushy, evergreen junipers and pinyon pines. Annual and perennial grasses, forbs, and shrubs typically abound beneath the woodland overstories.

Ponderosa Pine-Evergreen Oak

Typically occurring roughly 5,000 to 7,500 feet in elevation, these woodlands occur on mountains and plateaus generally south of the Mogollon Rim. Ponderosa pine intermingled with oak species predominate, mingled with patchy shrublands or grasslands.

Xeric Riparian

Xeric riparian or xeroriparian vegetation typically occurs along washes or arroyos that receive concentrated runoff during storms. Although often dry, the intermittent flows in these washes greatly affect the vegetation by providing additional periodic soil moisture. Channels are often clear of vegetation, but shrubs and small trees are located along the banks, such as acacia, mesquite, palo verde, and desert broom. Xeroriparian vegetation can vary from sparse to thick, depending on the amount of moisture received.

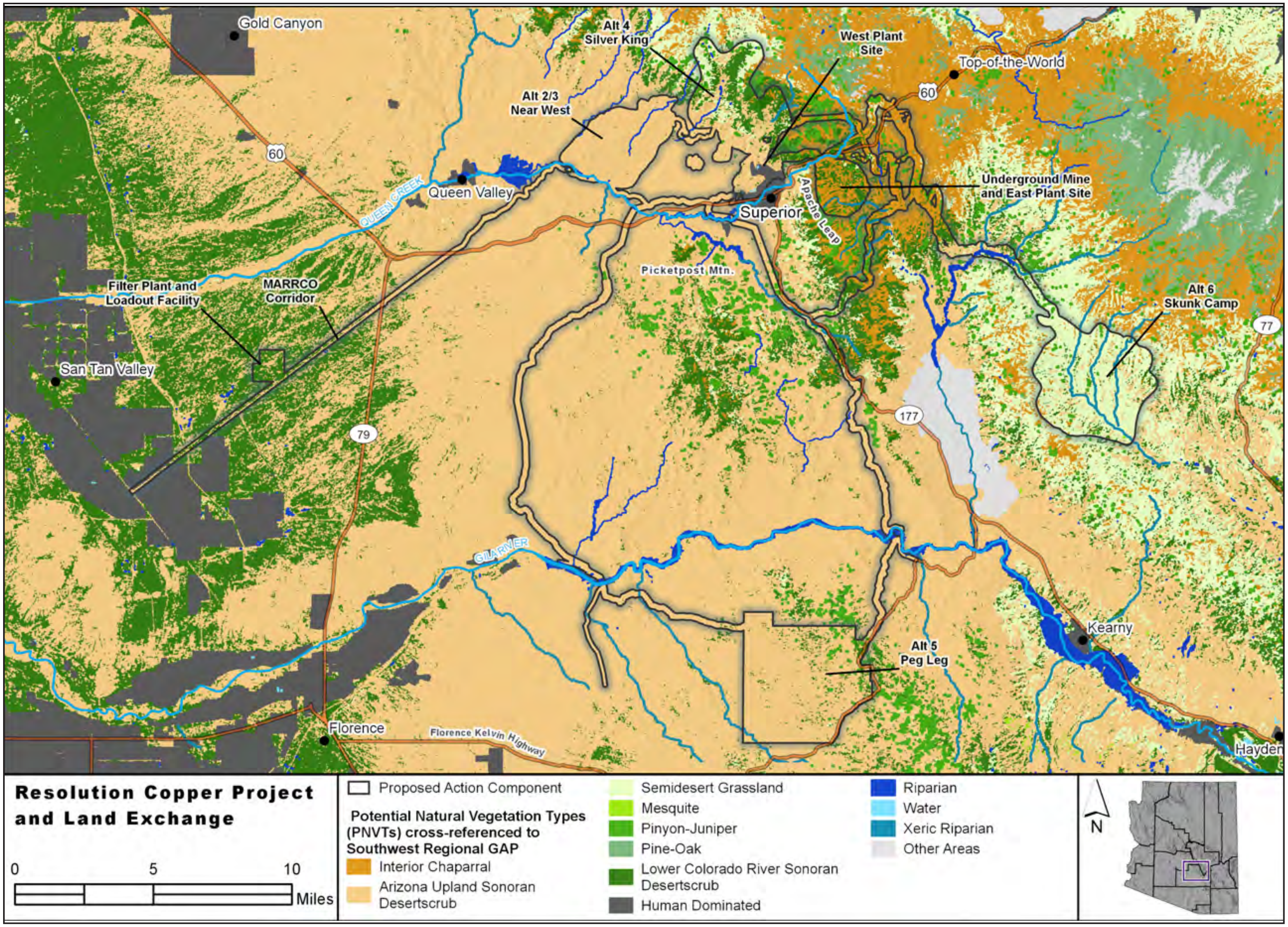

Figure 3.3.3-2. Vegetation communities and land cover types

Riparian

Riparian corridors are located along medium to large perennial streams in canyons and desert valleys, supported by the presence of persistent groundwater. Dominant trees can include willow, cottonwood, mesquite, ash, walnut, and sycamore. Understory is usually present, including herbaceous vegetation, grasses, and wetland species along streambanks. Note that a full discussion of all areas determined to be dependent on groundwater is included in section 3.7.1, including potential impacts caused by mine dewatering.

SPECIAL STATUS PLANT SPECIES

Special status plant species addressed include species listed under the Endangered Species Act (ESA) for Gila and Pinal Counties, Tonto National Forest Sensitive Plant Species, as well as BLM Sensitive Plant species for the BLM Tucson Field Office. See Newell (2018g) for a complete list of all species addressed and their potential for occurrence.

Special status plant species with the potential to occur in the analysis area are broken out by action alternative in table 3.3.3-4, including information on their habitat components and geographic ranges. Figure 3.3.3-3 depicts the designated critical habitat for ESA-listed plant species in and near the analysis area. The only special status plant species critical habitat present is for acuña cactus, which occurs in the project area for Alternative 5 for both the east and west pipeline options.

Baseline data of species-specific surveys for special status plants species included sample surveys of portions of some of the alternatives for four species: Arizona hedgehog cactus (*Echinocereus triglochidiatus var. arizonicus*), mapleleaf false snapdragon *(Mabrya [Maurandya] acerifolia*), Hohokam agave (*Agave murphey*i), and Parish's Indian mallow (*Abutilon parishii*). For Arizona hedgehog cactus, survey data from WestLand Resources Inc., Tonto National Forest, and SWCA Environmental Consultants were used for this analysis. These surveys encompassed approximately 4,738 acres and covered most of the East Plant Site and subsidence area, as well as portions of the transmission corridor from Silver King to Oak Flat, Alternative 6 (both the south and north pipeline options), and Alternative 6 north and south transmission corridor. Approximately 98 individual Arizona hedgehog cacti were located during these surveys. For mapleleaf false snapdragon, 336 acres of suitable habitat was surveyed, and none were detected. For Hohokam agave, 239 acres of suitable habitat was surveyed, and none were detected. For Parish's Indian mallow, 949 acres of suitable habitat was surveyed and approximately 90 plants were observed on and around the bluffs in the area just west of Perlite Spring in the northeastern portion of the proposed tailings facility of Alternatives 2 and 3. Some of the observed plants were outside the random sample survey area as well. Additionally, approximately 40 Parish's Indian mallow plants were also detected during survey in the area south of Roblas Canyon in the northwestern portion of the proposed tailings facility of Alternatives 2 and 3 (WestLand Resources Inc. 2017a).

Note that where specific data on the presence of special status plant species are shown to be lacking, several mitigations are required that would provide for collection of this information (see section 3.3.4.9).

ARIZONA NATIVE PLANT LAW SPECIES

Numerous native plant species are protected from destruction under the Arizona Native Plant Law (Title 3 Arizona Administrative Code Chapter 3); the law also encourages salvage of these species. The Arizona Department of Agriculture enforces the Arizona Native Plant Law (Arizona Department of Agriculture 2019). Within the four given categories—Highly Safeguarded, Salvage Restricted, Salvaged Assessed, and Harvest Restricted—most are common species except for within the Highly Safeguarded category, which includes rare species. Thus, most species designated as Highly Safeguarded are also ESA endangered or threatened species or sensitive species under other land management agency policies. Therefore, those species that are identified in this analysis as protected under the Arizona Native Plant Law are addressed under more stringent regulations; a separate analysis for Arizona Native Plant Law species is not considered necessary for any of the action alternatives.

Table 3.3.3-4. Special status plant species with the potential to occur in the analysis area

Common Name (Scientific Name)	Status	Habitat	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6
Acuña cactus (*Echinomastus erectocentrus* var. *acunensis*)	ESA: E with critical habitat. Found in Maricopa, Pinal, and Pima Counties	Occurs in valleys and on small knolls and gravel ridges of up to 30 percent slope in the Palo Verde-Saguaro Association of the Arizona Upland subdivision of the Sonoran Desertscrub. Elevation between 1,198 and 3,773 feet amsl (U.S. Fish and Wildlife Service 2016a).	Unlikely to occur.	Unlikely to occur.	Possible to occur where small knolls and gravel ridges of up to 30 percent slope are present near the tailings facility and along pipeline corridor routes. Critical habitat for the species is located along the west pipeline option and fencing area, adjacent to the tailings facility, and along the fence line for the east pipeline option.	Unlikely to occur.
Arizona hedgehog cactus (*Echinocereus triglochidiatus* var. *arizonicus*)	ESA: E No critical habitat. Found in Maricopa, Pinal, and Gila Counties.	Found on dacite or granite bedrock, open slopes, in narrow cracks, between boulders, and in the understory of shrubs in the ecotone between Madrean Evergreen Woodland and Interior Chaparral. Elevation between 3,300 and 5,700 feet amsl (Tonto National Forest 2000).	Known to occur, where soils of igneous origin (primarily Shultze granite and dacite) are present on the East Plant Site and subsidence area.	Known to occur at the East Plant Site and in subsidence area. Possible to occur in tailings facility area.	Known to occur at the East Plant Site and in subsidence area.	Known to occur at the East Plant Site and in subsidence area. Possible to occur along pipeline route alternatives and in tailings facility location.
Chiricahua Mountain alumroot (*Heuchera glomerulata*)	Tonto National Forest: S	Found on north-facing shaded rocky slopes, near seeps, springs, and riparian areas, often in humus soil. Elevation between 4,000 and 9,000 feet amsl (Tonto National Forest 2000).	Unlikely to occur.	Possible to occur in tailings facility area.	Unlikely to occur.	Possible to occur.

continued

Table 3.3.3-4. Special status plant species with the potential to occur in the analysis area *(cont'd)*

Common Name (Scientific Name)	Status	Habitat	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6
Mapleleaf false snapdragon (*Mabrya [Maurandya] acerifolia*)	Tonto National Forest: S	Occurs on rock overhangs and in bare rock/talus/scree, cliff, and desert habitats. Elevation around 2,000 feet amsl (Tonto National Forest 2000).	Possible to occur at tailings facility and borrow sites.	Unlikely to occur.	Unlikely to occur.	Possible to occur.
Parish's Indian mallow (*Abutilon parishii*)	Tonto National Forest: S BLM: S	Occurs in mesic situations in full sun within higher elevation Sonoran desertscrub, desert grassland, and Sonoran deciduous riparian forest. Elevation between 3,000 and 4,800 feet amsl (Tonto National Forest 2000).	Known to occur at tailings facility. Possible to occur at the West Plant Site, borrow sites, and in the MARRCO corridor.	Possible to occur at the West Plant Site, borrow sites, tailings facility area, and in the MARRCO corridor.	Possible to occur at the West Plant Site, borrow sites, and in the MARRCO corridor.	Possible to occur at the West Plant Site, borrow sites, and in the MARRCO corridor.
Pringle's fleabane (*Erigeron pringlei*)	Tonto National Forest:	Ledges of cliffs and rock crevices in canyons, near springs and in shaded canyons. Elevation between 3,500 and 7,000 feet amsl (Tonto National Forest 2000).	Possible to occur where soils of igneous and metamorphic granites are present.	Unlikely to occur.	Unlikely to occur.	Possible to occur.

Note: The analysis area for each alternative includes all project components (i.e., West Plant Site, East Plant Site, tailings storage facility, etc.).

Status Definitions

Tonto National Forest:

S = Sensitive. Species identified by a Regional Forester for which population viability is a concern, as evidenced by a significant current or predicted downward trends in population number or density or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

Endangered Species Act (ESA):

E = Endangered. Endangered species are those in imminent jeopardy of extinction. The ESA specifically prohibits the take of a species listed as endangered. Take is defined by the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to engage in any such conduct.

Bureau of Land Management (BLM):

S = Sensitive. Species that could easily become endangered or extinct in the state.

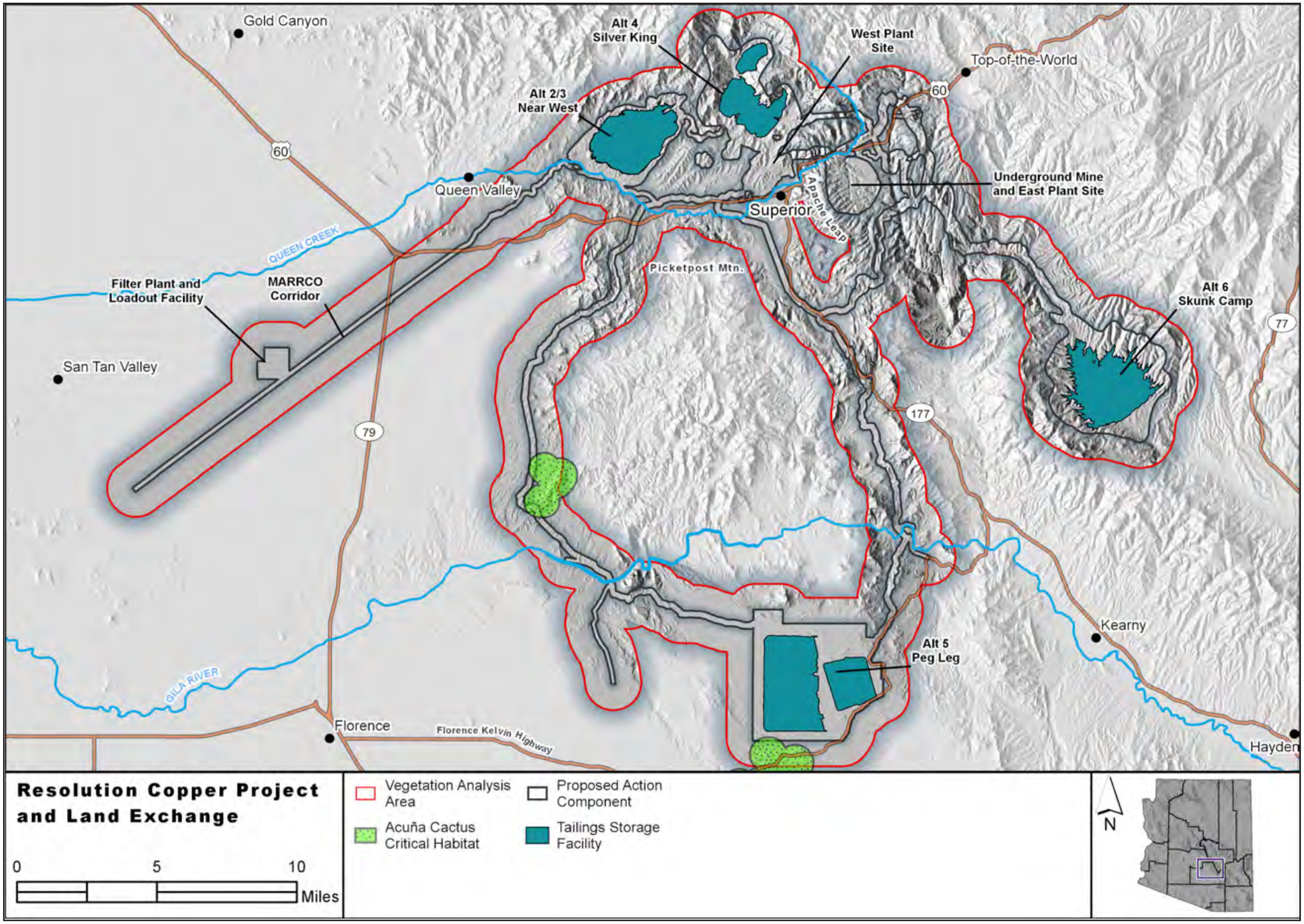

Figure 3.3.3-3. Designated and proposed critical habitat for ESA-listed plant species

NOXIOUS AND INVASIVE WEEDS (INCLUDING FEDERAL, STATE, AND TONTO NATIONAL FOREST LISTS)

Eighty-nine Federal, Tonto National Forest, and Arizona Department of Agriculture noxious and invasive weed species were evaluated for this analysis. There was overlap between the different species lists, and species numbers do not double-count species. See Newell (2018g) for a table of species and their status listings. Of those listed noxious and invasive weed species, Alternatives 2 and 3 have 33 species known to occur or possible to occur within the analysis area; Alternative 4 has 38 species known to occur or possible to occur within the analysis area; Alternative 5 has 26 species known to occur or possible to occur within the analysis area; and Alternative 6 has 31 species possible to occur within the analysis area.

Existing Disturbance within Mine Area and Selected Lands

A variety of land use disturbances have affected the condition of vegetation and soils within and near the project area footprint. Historical and ongoing mining and mineral exploration, land development, grazing, recreation, and fires have left a legacy of disturbances to the landscape (table 3.3.3-5). Total acreage of each disturbance type within the project footprint varied by alternative. Most alternatives had approximately 1,300 to 1,400 acres of previous disturbance, with the exception of Alternative 4, which had 2,719 acres of previous disturbance (which included 1,528 acres of fire disturbance). More information regarding the nature and extent of disturbance is provided in Newell (2018g).

Table 3.3.3-5. Existing disturbance acreage by alternative (calculated within the project footprint)

Alternative	Facilities Disturbance (acreage)	Road Disturbance* (acreage)	Fire Disturbance (acreage)	Total Disturbance (acreage)
Alternative 2 – Near West Proposed Action	1,086	122	61	1,270
Alternative 3 – Near West – Ultrathickened	1,086	122	61	1,270
Alternative 4 – Silver King	1,084	107	1,528	2,719
Alternative 5 – Peg Leg West Option	1,100	98	77	1,274
Alternative 5 – Peg Leg East Option	1,100	88	62	1,250
Alternative 6 – Skunk Camp North Option	1,086	131	192	1,409
Alternative 6 – Skunk Camp South Option	1,100	151	134	1,385

* Single-track recreational trails excluded from area calculations.

Existing Vegetation and Soil Trends

Relatively little long-term monitoring and evaluation of soil and vegetation health exists for the analysis area. Most of the monitoring available has been undertaken for assessment for rangeland health and livestock grazing suitability (see section 3.16 for discussion of livestock grazing).

Long-term monitoring of soil and vegetation conditions was conducted on the Millsite grazing allotment, managed by the Forest Service, which includes the area of the Alternative 2 and 3 tailings storage facility. Range monitoring has been conducted in this area from 1956 through 2003. The most recent trends between 1991 and 2003 indicate that the overall state of vegetation is in very poor to poor condition, with largely downward trends. Soils are similar, rated mostly poor condition, but with a stable trend (U.S. Forest Service 2010d). These trends in vegetation and soil conditions are likely the result of historic-era grazing and other disturbances (U.S. Forest Service 2010d).

Some additional rangeland health assessments have been conducted for the Teacup Allotment, managed by the BLM, which includes the area of the Alternative 5 tailings storage facility. In 2013, it was observed that overall the soil on the allotment was stable, and the allotment exhibited biotic integrity and was in a productive and sustainable condition (Bureau of Land Management 2017a).

3.3.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

3.3.4.1 Alternative 1 – No Action Alternative

Under the no action alternative, the proposed project would not be constructed and potential impacts on soils, vegetation communities, special status plant species, and noxious weeds would not occur. Impacts on soil and vegetation resources from existing disturbances (e.g., recreation, livestock grazing, mining and development, wildfires) would continue.

3.3.4.2 Impacts Common to All Action Alternatives

The proposed project would include three phases: construction, operations, and closure/reclamation. All phases have the potential to affect (1) soil resources, (2) revegetation potential, (3) vegetation communities, (4) special status plant species, and (5) noxious weeds, as detailed in the following text.

Effects of the Land Exchange

The selected Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on National Forest System surface resources; this includes effects on the soil and vegetation that occur on the Oak Flat Federal Parcel. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources, or manage them to achieve desired conditions, including for control of noxious and invasive weeds.

The offered parcels would come under Federal jurisdiction. Specific management of the soil and vegetation resources of those parcels would be determined by the agencies to meet desired conditions or support appropriate land uses. In general, these parcels contain a variety of ecosystems similar to those found in the analysis area, including riparian, xeroriparian, semi-desert grassland, and desert ecosystems, that would come under Federal jurisdiction.

Effects of Forest Plan Amendment

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 Forest Plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2019). A number of standards and guidelines (15 for soil, 33 for vegetation) were identified applicable to management of ecosystems and vegetation communities. None of these standards and guidelines were found to require amendment to the proposed project, either on a forest-wide or management area-specific basis. For additional details on specific rationale, see Shin (2019).

Summary of Applicant-Committed Environmental Protection Measures

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on soils and vegetation. These are non-discretionary measures, as they are currently part of the GPO, and their effects are accounted for in the analysis of environmental consequences.

From the GPO (Resolution Copper 2016d), Section 4.5, "Water Resources," Resolution Copper has outlined a variety of measures to reduce impacts on soils:

- Road embankment slopes will be graded and stabilized with vegetation or rock as practicable to prevent erosion;
- During construction and operations, diversions will be constructed around the affected areas to minimize erosion. A number of best management practices, including check dams, dispersion terraces, and filter fences, also will be used during construction and operations; and
- Off-road vehicle travel across Tonto National Forest will generally be avoided.

Resolution Copper has also developed a noxious weed plan (Resolution Copper 2019) to reduce impacts on vegetation:

- Newly reclaimed areas on Tonto National Forest will be monitored for weeds and invasive plants for the first 5 years after reclamation. Infestations of invasive species would be treated as soon as they are identified, or as soon as weather conditions are appropriate for treatment.
- Additionally, in the "Baseline EA Decision Notice," Resolution Copper stipulated that on NFS lands, seed mixes used in reclamation will be certified free of seeds listed on the Forest Service's noxious weed list and contain only species native to the project area. Seed mixes will be developed from a native species seed list approved by the Forest Service.

Desired Future Conditions

Desired future conditions were informed by internal work by the Tonto National Forest on the revised forest plan. These desired conditions are based on Ecological Response Units (ERUs), which are mapped ecosystem types that represent the range of conditions that occur under natural disturbance regimes. The desired future conditions of ERUs that occur in the analysis area are described here by ERU. The distribution and condition of these ERUs are strongly tied to the health of soils, climate, topography, and other environmental factors.

DESERT ECOSYSTEMS

The Desert Ecosystems ERU in the analysis area includes the Lower Colorado River Sonoran Desertscrub and Arizona Upland Sonoran Desertscrub, the desired future conditions of which include the following:

- Vegetation community composition and structure should include the following: 10 to 25 percent perennial grass and cacti cover, presence of saguaro (*Carnegiea gigantea)* and mesquite *(Prosopis* sp.*)* that provide habitat for cavity nesting birds, and limited infestation of non-native grasses (ideally less than 1 percent cover) to mitigate for fine-fuel potential to increase fire susceptibility.
- Fires should be infrequent and localized with return intervals greater than 100 years.
- Suitable habitat for federally listed and rare or special status animal and plant species is preserved.

SEMI-DESERT GRASSLANDS

The Semi-Desert Grasslands ERU is limited to the semi-desert grasslands vegetation community, the desired future conditions of which include the following:

- Vegetation community composition and structure should include the following: a variety of cool- and warm-season understory plants, less than 10 percent tree and shrub canopy cover, and limited cover by non-native species.
- Native herbaceous vegetation cover provides fine fuels to support stand-replacement fires; however, non-native annual vegetation cover should be limited to mitigate the spread, intensity, and severity of uncharacteristic fire.
- Habitat is preserved to support wildlife.

INTERIOR CHAPARRAL

The desired future conditions for the Interior Chaparral ERU and vegetation community include the following:

- Vegetation community composition and structure should include the following: dense thickets of closed shrub canopy cover (40 percent cover on dry sites to 80 percent cover on wet sites) dominated by shrub live oak (*Quercus turbinell*a), thick shrub litter, annual regeneration of native grasses and forbs (in most years), and low cover by non-native annual species.
- Stand-replacing fires should occur at 35- to 100-year fire return intervals to support diverse community ages at the landscape scale; native fire-adapted species resprout vigorously after fire to prevent excessive erosion; and non-native annual vegetation cover is kept to a minimum to avoid uncharacteristic fire.
- Habitat is preserved to support wildlife.

PINYON-JUNIPER WOODLAND

The desired future conditions for the Pinyon-Juniper Woodland ERU and vegetation community include the following:

- Vegetation community composition should include the following: even-aged patches (tens to hundreds of acres) of pinyon and juniper trees forming multi-aged woodlands (including trees greater than 300 years old), closed canopy cover by trees to shade ground surfaces, structural diversity from old trees, snags, woody debris, and sparse ground cover (5 to 15 percent) of shrubs, perennial grasses, and forbs.
- Shrubs and herbaceous ground cover is sparse, supporting low-intensity ground fires.
- Habitat is preserved to support wildlife.

PONDEROSA PINE-EVERGREEN OAK

The Ponderosa Pine-Evergreen Woodland ERU includes the pine-oak vegetation community, the desired future conditions of which include the following:

- Vegetation community composition should include the following: open forest stands with diverse tree ages, sizes, and densities (at the landscape scale), some old-growth tree stands, shrub and herbaceous basal cover ranging from 5 to 15 percent.
- The landscape is a functioning ecosystem that contains all its components, processes, cycles, and conditions that result from natural disturbances (e.g., insects, diseases, fire, and wind) and as supported through human disturbance. The composition, structure, and function of vegetative conditions are resilient to the frequency, extent, and severity of disturbances and climate variability.
- Habitat is preserved to support wildlife.

XERIC RIPARIAN

The desired future conditions for Xeric Riparian ERUs include the following:

- Vegetation community composition should include xeric riparian/riparian scrubland and upland species, upland desert scrub species intergrading within riparian scrubland (reaching higher densities at drier sites), dominant shrubs reaching heights up to 10 feet, and species such as arrow-weed, burro bush (*Ambrosia* sp.), and desert broom (*Baccharis sarothroides*) dominating sandy soils on secondary floodplains.
- Soil and other environmental conditions support a diversity of healthy, deciduous desert trees and scrub vegetation.
- Habitat is preserved to support wildlife.

RIPARIAN

The desired future conditions for Riparian ERUs include the following:

- Vegetation community composition would vary based on hydrologic conditions and may include the following: facultative- and obligate-wetland species; cottonwood-willow habitats; common distributions of hackberry (*Celtis reticulata*) and mesquite, velvet ash (*Fraxinus velutina*) and Arizona sycamore (*Platanus wrighti*i) at mid- to high elevations; blue paloverde (*Parkinsonia florida*) and catclaw acacia (*Senegalia greggii*), and ironwood (*Olneya tesota*) at warmer low-elevation sites; well-established mesquite stands are located in abandoned channels or terraces, connecting riparian vegetation and the uplands to support wildlife movement; and understories with open to closed conditions, including woody species and herbaceous vegetation cover that support bank stability. Healthy riparian vegetation communities show few signs of stress, wilting, or disease; high reproductive output; and minimal soil compaction/degradation.
- Flood timing, magnitude, and frequency maintain conditions for vernal flood-adapted species, such as Gooding's willow (*Salix gooddingii*) and cottonwood (*Populus* spp.)-willow (*Salix* spp.).
- Wildfire frequency and intensity with the adjacent uplands (riparian corridor) is low, thereby reducing flooding or erosional risk to riparian areas.
- Habitat is preserved to support wildlife.

Reclamation Plans and Effectiveness

CONCEPTUAL RECLAMATION PLANS

General Reclamation Goals and Strategies

Reclamation plans are required under several regulatory programs, including by the Forest Service as part of a final mining plan of operations, by ADEQ as part of the Aquifer Protection Permit program, and by the Arizona State Mine Inspector. The primary goals of reclamation are to stabilize areas of surface disturbance, prepare areas for post-mining land use, and ensure long-term protection of the surrounding land, water, and air. Reclamation and closure standards are established by these programs that must be met by the company, and financial assurance or bonding is required to ensure the capability exists to conduct and complete reclamation activities.

The following discussion is based on the conceptual reclamation plans that have been prepared to date by Resolution Copper and are included in the GPO. Note that a mitigation measure is required that would provide for preparation of detailed reclamation plans, specific to the preferred alternative and supported by site-specific data collection, that would provide more extensive information than that produced to date (see section 3.3.4.9).

Key tenets guiding the Resolution Copper reclamation plans are implementing reclamation as soon as practicable (including concurrent reclamation while the mine is still operational, where feasible), return disturbed areas to near-natural conditions, salvage soil resources (where practicable) for later use in reclamation, and monitor to ensure that reclamation is successful and reclamation and closure standards are met.

The general reclamation steps identified by Resolution Copper in the GPO (see section 6 in Resolution Copper (2016d)) are as follows:

- Decommission facilities (remove equipment, chemicals, furnishings)
- Demolish or dismantle structures and buildings, including pipelines, storage tanks, and power lines. This includes removing foundations up to 3 feet below grade. Some facilities like pipelines, wells, or power lines may be transferred to third parties for continued use where beneficial.
- Recontour and regrade disturbed areas, including roads not needed for future uses. Many stormwater controls (diversion ditches, seepage collection ponds) need to stay in place permanently or for decades after closure of the mine to control water quality (analyzed in detail in section 3.7.2).
- Replace growth media, using salvaged soils or borrow soils (largely Gila Conglomerate)
- Seeding or planting
- Monitoring and maintenance

Tailings Reclamation Plans

The largest area of disturbance from the proposed project is from the tailings storage facility, and virtually all of the area taken up by the tailings can be reclaimed. Specific details for closure of the tailings storage facilities differ by alternative (Golder Associates Inc. 2018a; Klohn Crippen Berger Ltd. 2018a, 2018b, 2018c, 2018d, 2018e). In general, closure of the tailings storage facilities takes place in several phases:

- Final deposition of the tailings is managed so that the PAG tailings are ultimately covered with NPAG tailings to prevent contact with oxygen (not applicable to Alternative 4).
- At the same time, the recycled water pond is allowed to gradually shrink through evaporation or water use (not applicable to Alternative 4).
- Engineered seepage controls remain in place as long as monitoring indicates they are needed to protect downstream water quality. Seepage collection ponds would remain in place to collect seepage and stormwater. Until water quality is acceptable for release to the environment (this is typically determined by ADEQ through the APP program), the collected water is either pumped back to the recycled water pond while it exists, or the ponds are engineered to allow the water to evaporate once the recycled water pond is gone. Note that specific release criteria would be developed in detailed reclamation plans, which are a required mitigation by the Forest Service (see section 3.3.4.9).
- When surfaces are no longer going to be disturbed, growth media are placed on the surface and any treatments or additives are used. Generally, about 1.5 feet of growth media are planned for, but would vary across the surface, depending on needs. Rock armoring would be used in places where erosion is a concern on slopes or along stormwater conveyance channels. Seeding or planting would then take place on the growth media. Note that specific closure materials, depths, and preparations would be developed in detailed reclamation plans, which are a required mitigation by the Forest Service (see section 3.3.4.9).

Fully successful reclamation would either meet the desired conditions for the landscape or be sufficient to support the chosen post-mine land uses. A fully reclaimed tailings storage facility should be a stable landform (low risk of large slumps or collapses), have a stable surface either vegetated or armored (low risk of erosion from water or wind), have no long-term water quality concerns from runoff or seepage, and be sustainable without active management. Long-term sustainability requires a balanced interaction of growth media, water, and vegetation. The growth media act to store moisture, which supports the vegetation, but are vulnerable and have to be protected from erosion during storm events. Vegetation helps anchor the growth media and slow runoff, allowing it to infiltrate into the soil. Post-closure monitoring and comparison to clear success criteria is the means to ensure the balance of growth media, water, and vegetation is functioning properly.

Expected Timing of Reclamation Activities

Decommissioning and demolishing structures and regrading/recontouring all take place during the 5-year closure period described in the GPO. For tailings, the closure periods are longer because they depend on management of the recycled water pond:

- Alternative 2. The slopes and tailings beaches are reclaimed in the first 5 years. It is estimated to take 25 years for the recycled water pond to be drawn down and reclaimed (Klohn Crippen Berger Ltd. 2018a). Active water management would continue as long as necessary. Note that specific release criteria would be developed in detailed reclamation plans, which are a required mitigation by the Forest Service (see section 3.3.4.9).
- Alternative 3. The slopes and tailings beaches, as well as the recycled water pond, are reclaimed in the first 9 years (Klohn Crippen Berger Ltd. 2018b). Active water management would continue as long as necessary.
- Alternative 4. The slopes and tailings piles are reclaimed in the first 5 years (Klohn Crippen Berger Ltd. 2018c). Active water management would continue as long as necessary.
- Alternative 5. The slopes and tailings piles are reclaimed in the first 5 years. An estimated 30 years is needed for water quality management, but would continue as long as necessary (Golder Associates Inc. 2018a).
- Alternative 6. Similar to Alternative 2, the slopes and tailings beaches are reclaimed in the first 5 years. It is estimated to take 25 years for the recycled water pond to be drawn down and reclaimed (Klohn Crippen Berger Ltd. 2018d). Active water management would continue as long as necessary.

EXPECTED EFFECTIVENESS OF RECLAMATION PLANS

As noted, the reclamation plans prepared to date by Resolution Copper and included in the GPO are conceptual in nature. The following discussion is based on the anticipated effectiveness of the conceptual plans. Note that a mitigation measure is required that would provide for preparation of detailed reclamation plans, specific to the Preferred Alternative and supported by site-specific data collection, that would provide more extensive information than that produced to date (see section 3.3.4.9), and would support detailed estimates of reclamation effectiveness to support post-closure financial assurance estimates.

A meta-analysis was completed to constrain the level of vegetation cover (and potential variability) that could be expected at a given time point after reclamation and revegetation efforts have commenced (see analysis details and source data in Bengtson (2019b)). The analysis included case studies from Arizona and New Mexico primarily from mining or mineral exploration activities, which reflect similar characteristics in vegetation communities, climate, soils, and disturbance types to the proposed project.[25]

Results of the meta-analysis are shown in figure 3.3.4-1. Each vertical bar in the figure represents the range in vegetation cover observed from a single year in a given case study. (Some case studies provided multiple years of data.) The combined results of all analyzed case

25. The meta-analysis is meant to capture the general potential for revegetation efforts to be successful but is not specific to the Resolution Copper Project. Limitations to consider in interpreting outcomes of the meta-analysis include the following: (1) variability in revegetation outcomes, (2) semi-quantitative nature of analysis, (3) sensitivity of outcomes to the degree of initial disturbance, and (4) lack of specificity of outcomes to any project components.

studies illustrate the range in observed vegetation cover (percentage of vegetation cover) that have been recorded previously. The analysis demonstrates the following relationships (from Arizona and New Mexico case studies), which would also be expected for Resolution Copper revegetation efforts:

- Vegetation cover (by native and non-native species) of 8 percent or greater is consistently established by mine year 10.
- Vegetation can be as low as 0 percent, as observed in year 1 for one case study or a high as 100 percent in mine year 4.5 in another case study, with significant variation among and within the years after reclamation.
- From the case studies illustrated in figure 3.3.4-1, vegetation cover may plateau around mine year 12; however, analysis of additional case studies is needed to confirm this trend.

Overall, these findings indicate that, irrespective of the revegetation and reclamation methods applied, a minimum of 8 percent of vegetation cover (including both native and non-native species) can consistently be established within project disturbance areas. While this level of vegetation growth would provide some soil cover and erosion control functions, it does not necessarily reflect the desired future conditions set forth by the Forest Service. The revegetation response is expected to be influenced by the nature of the surface disturbance, while irrigation or active soil management interventions could enhance revegetation success thereby reducing erosional losses and net negative impacts on soil productivity. More specific outcomes are discussed under “Closure and Reclamation Impacts” later in this section.

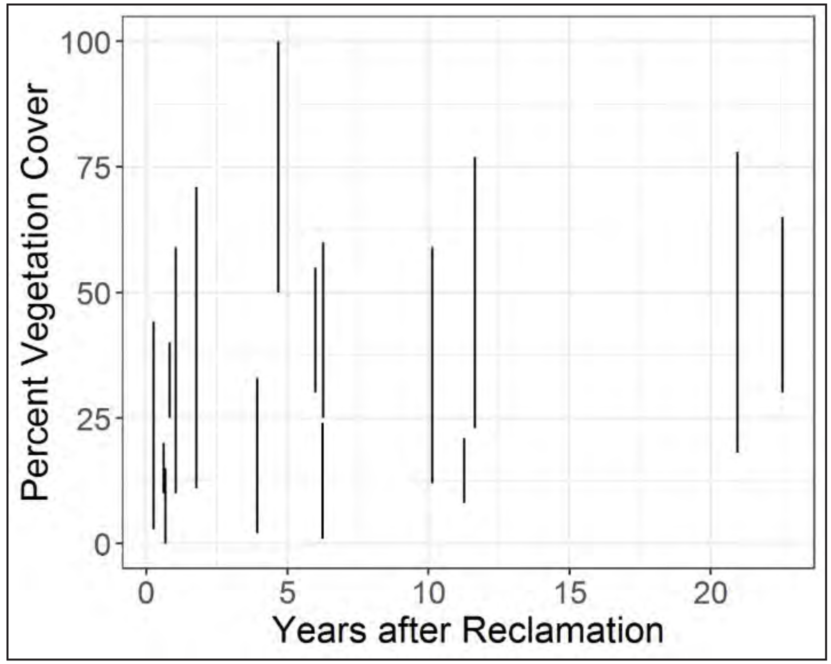

Figure 3.3.4-1. Meta-analysis summary. Each vertical bar represents the range in vegetation cover (percentage) observed from a single year (shown in years after reclamation) from a given case study. Data shown include only case studies from Arizona and New Mexico (see Bengtson (2019b)).

Construction/Operational Impacts

SOILS

Project ground-disturbing activities would potentially compact soils, accelerate erosion and soil loss, contaminate soils, and reduce soil productivity. The longevity of these impacts on soil productivity and revegetation potential would depend on the nature of the disturbance and vary by project component and alternative. Most potential impacts on soil resources are common to all action alternatives; however, the level of impact is dependent on the nature of disturbance. For this analysis, the levels of impact, soil productivity responses, and revegetation success potential are summarized as six disturbance response groups, which are detailed in tables 3.3.4-1 and 3.3.4-2. Possible impacts include the following:

- Soils exposed by grading, excavation, subsidence, and vegetation clearing would be subject to accelerated wind and water erosion—all disturbances that decrease soil productivity. Erosion may also cause sediment losses and delivery to downstream washes and streams (see Section 3.7.2, Groundwater and Surface Water Quality).
- Topsoil mixing, compaction, removal, or redistribution may cause changes or losses to soil structure, seedbank, fertility, microbial communities, biotic soils, and water availability, which can negatively affect vegetation communities and further challenge revegetation efforts and success. Likewise, soil productivity and function would be lost for any soils that are not salvaged.
- Temporary loss of habitat while vegetation and soils recover from disturbance.
- Permanent soil productivity losses would occur where soils are covered, removed, or no longer available (i.e., covered by permanent structures or not reclaimed) to support vegetation or wildlife habitat. Tailings, waste-rock materials, exposed subsurface soils, or capping media used in reclamation may further challenge vegetation reestablishment.
- Waste materials may be a source of soil contamination (if not properly contained). Ground-disturbing activities could re-expose contaminated subsurface soils.

Soil salvage is one possible mitigation to erosional soil loss and productivity losses. While there are some advantages to storing soils, long-term soil stockpiling causes a number of biological and chemical changes requiring amelioration before soils are reapplied during reclamation (Strohmayer 1999). Specifically, long-term storage causes increases in soil bulk density, decreases in a soil's water holding capacity, changes to soil chemistry and nutrient cycling (e.g., development of anaerobic conditions, accumulation of ammonium, loss of organic carbon), losses of microbial community viability, and native soil seedbank losses (reviewed in (Strohmayer 1999)). In most arid ecosystems, the soil seedbank is limited to the upper 2 inches of soil (Scoles-Sciulla and DeFalco 2009); therefore, the process of salvaging even the upper 6 to 8 inches of soil can severely dilute seed concentrations (Abella et al. 2013). Moreover, seedbank viability has been shown to diminish by 68 percent over 2 years of stockpiling (Golos and Dixon 2014) and lose all germination potential within 5 years of storage (Scoles-Sciulla and DeFalco 2009).

A detailed analysis acreages of impacts on individual soil types is available in Newell (2018g).

VEGETATION COMMUNITIES, SPECIAL STATUS PLANT SPECIES, NOXIOUS WEEDS

Construction

All action alternatives would involve the removal of vegetation during construction activities, resulting in the direct loss of plant communities. Construction of tailings facilities for all alternatives would continue throughout most of mine life as areas would not be disturbed until necessary. The primary impacts on vegetation communities during construction of the action alternatives would be associated with

- removal and/or crushing of natural, native species;
- increased potential for noxious and invasive weed establishment and spread;
- decreased plant productivity from fugitive dust;

Table 3.3.4-1. Disturbance response groups

Disturbance Response Group	Disturbance Type and Description	Level and Type of Impact on Long-term Soil Productivity	Relative Revegetation Potential
No Disturbance	No disruption of soils or vegetation; e.g., areas within a facility remaining undisturbed	No impacts	Revegetation efforts are unneeded
Drive and Crush	Minimal disturbance from minor grading or vegetation mowing; surface soils and some vegetation remain intact; e.g., transmission line right-of-way	Minor impacts on soil productivity from compaction; some increased potential for erosion if vegetation is removed or soils are disrupted	High potential: Soil nutrients, cover, organic matter, microbiota, and seedbank remain intact, supporting revegetation success
Excavation with Soil Salvage	Soils are removed, salvaged, and replaced within disturbed surfaces; e.g., portions of the tailings storage facility	Moderate impacts on soil productivity due to topsoil redistribution; increased erosion potential, if revegetation is unsuccessful or delayed; potential for soil contamination in tailings or waste storage areas	Moderate potential: If salvaged soils are reapplied immediately, they will maintain some nutrients, organic matter, microbiota, and seedbank to enhance revegetation success
Excavation without Soil Salvage	Soils are removed or covered permanently, no soil salvage occurs, inert capping material used as plant growth medium; e.g., portions of the tailings storage facility	Major impacts on soil productivity due to loss of topsoils; increased erosion potential, if revegetation is unsuccessful or delayed; potential for soil contamination in tailings or waste storage areas	Low to moderate potential: Soil capping material lacks nutrients, organic matter, microbiota, and seedbank, limiting potential revegetation success
Subsidence Area	Soils and vegetation are redistributed as subsidence proceeds	Minor to moderate impacts on soil productivity, erosion potential, and existing vegetation depending on subsidence rates	Variable potential: No active revegetation planned; natural regeneration may occur as soil resources are redistributed
Structural Loss	Soils covered by a permanent structure	Soil productivity effectively lost in perpetuity; erosion losses are minimal under covered surfaces	Revegetation would not occur

Table 3.3.4-2. Disturbance, reclamation, and revegetation outcomes by facility and tailings alternative

Facility or Alternative	Facilities or Disturbance Remaining Post-decommissioning; Other Reclamation Considerations*	Primary (P) and Secondary (S) Disturbance Response Groups	Total Facility Disturbance (acres) and Impacts on Productivity†	High Water Erosion Potential (acres)‡	High Wind Erosion Potential (acres) ‡§
East Plant Site facility (all action alternatives)	Headframes and hoists for groundwater monitoring; paved or graveled roads necessary for monitoring; subsidence area; *contact water basins would be closed*	P: Subsidence Area S: Excavation without soil salvage; Structural loss; No disturbance	1,856	206	0
West Plant Site facility (all action alternatives)	Roads necessary to support the reclamation and closure; stormwater diversion infrastructure; *process water ponds and contact water basins would be closed*	P: Excavation with and without soil salvage S: Structural loss; No disturbance	940‡	153§	0
Filter plant and loadout facility and MARRCO corridor (all action alternatives)	Other MARRCO corridor or bridge infrastructure may remain (depending on other intended uses); *all tanks and ponds would be closed*	P: Excavation with and without soil salvage; Drive and crush S: Structural loss; No disturbance	1,248	939	0
Power transmission facilities (common to all action alternatives)	Power transmission facilities (e.g., electrical substations, transmission lines, power centers) to remain if post-mining use is identified	P: Drive and crush; Excavation with and without soil salvage S: Structural loss; No disturbance	670¶	274	0
Near West Proposed Action tailings storage facility (Alternative 2)	Roads and berms necessary to support the reclamation and closure; *concurrent reclamation of outer slopes; gradual reduction and closure of seepage ponds; 1.5-foot-thick rock armor (growth medium) shell on tailings*	P: Excavation with and without soil salvage S: Structural loss; No disturbance	5,084 (10,033)	4	0
Near West – Ultrathickened tailings storage facility (Alternative 3)	Roads and berms necessary to support the reclamation and closure; *concurrent reclamation of cyclone sand embankment slopes PAG ponds evaporated over time; NPAG and PAG tailings slopes and surfaces covered in in erosion-resistant capping material (growth medium)*	P: Excavation with and without soil salvage S: Structural loss; No disturbance	5,086 (10,033)	4	0

continued

Table 3.3.4-2. Disturbance, reclamation, and revegetation outcomes by facility and tailings alternative *(cont'd)*

Facility or Alternative	Facilities or Disturbance Remaining Post-decommissioning; Other Reclamation Considerations*	Primary (P) and Secondary (S) Disturbance Response Groups	Total Facility Disturbance (acres) and Impacts on Productivity†	High Water Erosion Potential (acres)‡	High Wind Erosion Potential (acres) ‡§
Silver King (Alternative 4)	Upstream stormwater diversion features (cutoff walls and channels); roads and berms necessary to support the reclamation and closure; *concurrent reclamation of sloped face of stacks; store and release cover design; tailings covered in in erosion-resistant capping material (growth medium)*	P: Excavation with and without soil salvage S: Structural loss; No disturbance	5,779 (10,861)	2	0
Peg Leg (Alternative 5)	Stormwater diversion channels, dropchutes, cutoff walls; roads and berms necessary to support the reclamation and closure; *reclamation begins at end of mine operations; PAG covered in 10 feet of NPAG material; all tailings covered in 1 to 2 feet of erosion-resistant capping material (growth medium)*	P: Excavation with and without soil salvage S: Structural loss; No disturbance	East pipeline option: 12,232 (17,153) West pipeline option:12,574 (17,530)	East pipeline option:204 West pipeline option: 562	East pipeline option: 3 West pipeline option: 47
Skunk Camp (Alternative 6)	Upstream stormwater diversion features (diversion walls, channels, and other stormwater control elements); roads and berms necessary to support the reclamation and closure; *reclamation begins at end of mine operations; PAG covered in 10 feet of NPAG material; all tailings covered in 1 to 2 feet of erosion-resistant capping material (growth medium)*	P: Excavation with and without soil salvage S: Structural loss; No disturbance	North pipeline option: 9,830 (16,116) South pipeline option: 10,269 (16,557)	North pipeline option: 7,768 South pipeline option: 8,117	North pipeline option: 735 South pipeline option: 735

* All disturbed surfaces not covered by a permanent structure would be reclaimed and revegetated; reclamation and decommissioning plans are detailed in chapter 2.

† The acreage shown in parentheses represents the total disturbed acreage for the entire project, which includes areas such as the East Plant Site and subsidence area. The acreage not in parentheses represents the disturbed acreage that is likely to be revegetated—the tailings storage facility and pipeline corridors—and represents an area that may recover productivity in the future.

‡ Wind and water erosion potential are provided as the total acreage for an entire facility or alternative. Details on how erosion susceptibility was determined are provided in Newell (2018g).

§ No wind erosion data are available where SSURGO data are unavailable.

- plant community fragmentation; and
- changes in plant growth and seasonal phenology from artificial lighting.

Vegetation Communities

Vegetation removal could have a variety of effects on vegetation communities ranging from changes in community structure and composition within the project footprint to alteration of soils. This could result in further loss of soil and vegetation, as well as increased sediment input to water resources. This impact would occur in localized areas of disturbance.

Soil disturbance may lead to the increased potential for the introduction and colonization of disturbed areas by noxious and invasive plant species, which may lead to changes in vegetation communities, including a possible shift over time to more wildfire-adapted vegetation that favors noxious or invasive exotic species over native species. This potential impact would be greatest in vegetation communities that are not adapted to fire, such as Arizona Upland and Lower Colorado River subdivisions of Sonoran Desertscrub. In more fire-adapted communities, such as Interior Chaparral and Semidesert Grasslands, these impacts could still occur, but the intensity of the impacts would decrease as native vegetation in these communities may respond positively to fire.

Fugitive dust from construction activities has the potential to affect photosynthetic rates and decrease plant productivity. Dust can have both physical and chemical impacts (Farmer 1993; Goodquarry 2011; Havaux 1992; Sharifi et al. 1997; Thompson et al. 1984; Walker and Everett 1987). Physical impacts of windborne fugitive dust on plants could include blockage and damage to stomata, shading, and abrasion of leaf surface or cuticle. Dust can increase leaf temperature; inhibit pollen germination; reduce photosynthetic activity, respiration, transpiration, and fruit set; decrease productivity; alter community structure; and contribute to cumulative impacts (e.g., drought stress on already stressed species or allow the penetration of phytotoxic gaseous pollutants, such as sulfur dioxide, nitrogen dioxide, and ozone). Some studies, however, indicate that plant species living in high light conditions are flexible to adapting to lower light conditions (e.g., desert plants) (Alves et al. 2002; Barber and Andersson 1992; Werner et al. 2002) and that some plant species show improved growth with increased dust deposition (i.e., limestone) (Brandt and Rhoades 1972). The overall impact on vegetation from fugitive dust would be localized near sources of dust and would be highest near areas of ground disturbance during construction activities and would decrease with the completion of construction activities.

The construction of project facilities would fragment vegetation communities and create edge areas. Edge areas have different microclimatic conditions and structure and may be characterized by compacted soils and increased runoff that can lead to changes in species composition and vegetation structure.

Artificial lighting associated with the construction phase of the proposed project is less defined but is assumed to be less intense that associated with the operations phase and to vary in location and intensity through the 1- to 9-year time period. Specific impacts would be similar to those described in the Operational Impacts section; impacts on species groups are also provided in subsequent sections.

Special Status Plant Species

The primary direct and indirect impacts on special status plant species during construction of the proposed project would be similar to those described in this section for vegetation communities and would be associated with

- removal and/or crushing of special status plant species from construction of project facilities,
- increased potential for noxious and invasive weed establishment and spread,
- decreased plant productivity from fugitive dust,
- plant community fragmentation,

- changes in plant growth and seasonal phenology from artificial lighting, and
- inability to reestablish pre-mining populations.

Vegetation removal and ground disturbance may affect special status plant species through decreased productivity from fugitive dust and the potential for changes to habitat from a decline in productive soils and from the increased potential for noxious and invasive weed establishment and spread.

All action alternatives would impact Arizona hedgehog cactus (*Echinocereus triglochidiatus* var. *arizonicus*) through direct loss of individual plants where they occur as well as habitat changes from subsidence at the East Plant Site and Oak Flat site as well as other ground-disturbing activities. The likelihood of reestablishment is unknown.

Noxious Weeds

The primary direct and indirect impacts associated with noxious weeds during construction of the proposed project would be associated with

- increased potential for introduction and spread of noxious and invasive weeds,
- changes to habitat from noxious and invasive weed establishment and spread, and
- direct and indirect impacts on and competition with native vegetation and special status plant species.

The proposed project, under any action alternative, would increase the potential for noxious weed cover, and produce vegetation assemblages that could alter natural fire regimes. Noxious weeds are often fire adapted and so perpetuate increased fire risk once established or following a fire. However, these impacts would be minimized on Tonto National Forest-administered lands with the implementation of the “Resolution Copper Project Noxious Weed and Invasive Species Management Plan on National Forest System Lands” (Resolution Copper 2019).

This impact would be highly likely to occur in areas disturbed by construction activities and is possible in adjacent habitats.

Operations

Vegetation Communities

Operation of the proposed mine and associated facilities would result in impacts on vegetation communities. The primary impacts of operations would be associated with

- subsidence,
- potential reduction in surface water flows and groundwater availability to riparian vegetation,
- increased potential for noxious and invasive weed establishment and spread,
- decreased plant productivity from fugitive dust, and
- changes in plant growth and seasonal phenology from artificial lighting.

During the operations phase of the proposed mine there would be impacts on vegetation communities from subsidence. Subsidence of the ground surface is anticipated to occur beginning approximately 6 years after initiation of mining activities. It is anticipated to continue until approximately 40 years after initiation of mining activities.

Within the cave zone, the development of a subsidence area would change the slope, aspect, surface water flow direction and rate; surface elevation; and would impact the seed bank on approximately 1,329 acres. This would likely modify the vegetation communities within portions of the cave limit. Within the fracture limit (1,579 acres), the potential impacts would be similar to the cave limit; however, the intensity would be decreased as this area would have reduced surface impacts. The zone of continuous subsidence (1,686 acres) would have limited potential for localized impacts on vegetation communities as it would have minimal surface impacts.

In areas near the mine site, water usage would reduce water in the regional aquifer and would reduce surface water and groundwater levels downstream of the mine in Devil’s Canyon and Queen Creek. Surface water amounts would be reduced, and timing/persistence of surface water would decrease. These potential decreases in groundwater and surface water would occur over a long period of time but could cause changes in riparian vegetation extent or health, and the reduction in stream flow could impact aquatic plant species, which need standing or flowing water or moist soils. As a result, the amount or volume of water within perennial pools or moisture in soils could decrease, which could result in indirect impacts on riparian vegetation and sensitive plant species through long-term habitat alteration, causing changes in the health of individual plants or populations, or even death and long-term elimination of certain plant species at these locations. Potential impacts from all action alternatives on vegetation communities in the analysis area could result from decreased surface water flow and groundwater drawdown, which could convert vegetation communities to those that are better adapted to drier conditions and result in long-term changes in the health of and reductions in the extent of riparian vegetation. Impacts on these groundwater-dependent ecosystems are analyzed in detail in section 3.7.1.

No impacts on vegetation communities are anticipated from water quality impacts at any of the tailings locations during operations as any stormwater that comes in contact with the tailings piles would be contained in the tailings facilities or in seepage ponds downstream. Water quality impacts associated with seepage that potentially could reach surface waters is analyzed in detail in section 3.7.2; specific impacts on vegetation communities are not anticipated from the potential increases in metals in surface water described in that section.

Potential impacts on vegetation communities from increased noxious and invasive weed establishment and spread would be similar in nature to those described earlier in this section for the construction phase; however, as ground-disturbing activities would be reduced during the operations phase, the magnitude of potential impacts would be greatly reduced.

Potential impacts on vegetation communities from fugitive dust would be similar in nature to those described earlier in this section for construction; however, the magnitude of impacts would be reduced as dust-producing activities would be less during the operations phase.

Artificial lighting associated with the operations phase of the proposed project would increase overall brightness in the night sky by 1 to 9 percent; therefore, impacts on plant species may occur. However, these impacts are not well understood or researched in current literature since much of the literature focuses on non-light-emitting diode (LED) lights. One thing that is known about LED lights and plants is that LED lights are best for growing plants indoors (Mitchell and Sutte 2015). Additionally, the potential impacts, if realized, would be associated within the direct vicinity of the main operations areas, i.e., where the most lights are concentrated to increase overall night-sky brightness. The potential impacts from light would lessen with distance from the light source. The main impact on plant species of lighting associated with the operations phase of the proposed project is through the plants’ photoreceptors, and since plants are not mobile, they cannot move away from stimuli like this. The addition of artificial light at night could impact seed germination, stem elongation, leaf expansion, induce flowering, flower development, fruit development, and leaf senescence, i.e., loss of a cell’s power of division and growth (Briggs 2006). In addition, artificial night lighting may lead to changes in plant growth and seasonal phenology as well as the interaction between some species and pollinators (Bennie et al. 2016). This may lead to decreased fitness of some plant species and could lead to changes in plant community structure over time near areas with artificial lighting. These impacts would be greatest near light sources and would decrease with distance from the sources.

Special Status Plant Species

Under all action alternatives, special status plant species, including Arizona hedgehog cactus, may be impacted during operations through subsidence; increased potential for noxious and invasive weed establishment and spread; fugitive dust; and changes in plant growth and seasonal phenology from artificial lighting.

Within the subsidence area, individual Arizona hedgehog cactus may be destroyed during subsidence events in the cave limit and to a lesser extent within the fracture limit. Within the cave limit and to a lesser extent the fracture limit, the changes to existing habitat could create and/or remove habitat suitable for Arizona hedgehog cactus and other species status plant species.

Potential impacts on special status plant species from noxious and invasive weed establishment and spread, fugitive dust, and artificial lighting would be similar in nature to those described earlier in this section for vegetation communities; however, the magnitude of impacts would be greater for special status plant species as they generally have more specific habitat requirements, smaller ranges, and smaller population size.

Noxious Weeds

Potential impacts from noxious weeds during operations would be similar in nature to those previously described for the construction phase; however, as there would be less ground disturbance during operations, the magnitude of impacts would be reduced. However, these impacts would be minimized on Tonto National Forest–administered lands with the implementation of the “Resolution Copper Project Noxious Weed and Invasive Species Management Plan on National Forest System Lands” (Resolution Copper 2019).

Closure and Reclamation Impacts

Closure and reclamation of the proposed mine and associated facilities would result in short- and long-term impacts on vegetation and soil resources. During this phase, facilities would be decommissioned, sites would be regraded (as needed) and reclaimed, soil or capping material would be applied along tailings and other surfaces (as needed), erosion control measures would be implemented, and disturbed areas would be revegetated. The goal of this phase would be to reestablish vegetation on all disturbed areas, to reduce soil erosion potential, and, over time, create stable, functioning ecosystems. Specific details regarding the potential to reestablish stable, functioning ecosystems as they relate to the desired future conditions identified by the Forest Service (described earlier) are discussed in the following sections. Note that the physical stability and safety of the tailings facility are described in section 3.10.1.

POTENTIAL TO ACHIEVE DESIRED FUTURE CONDITIONS

Projecting the outcomes of reclamation and the potential to achieve desired future conditions can be challenging for any project because several factors, including precipitation, temperature, topography, existing native and non-native seedbank), type and magnitude of disturbance, and reclamation methods (e.g., planting/seeding methods, weed management, soil salvage or capping media), all interact to influence success of revegetation efforts (see Bengtson (2019b)). While the meta-analysis does provide some constraint on revegetation trends that could be expected on a mining facility (see “Expected Effectiveness of Reclamation Plans” earlier in this section and Bengtson (2019b)), this analysis only addresses potential vegetation cover, and not the function of the ecosystem as a whole, including all of its biotic and abiotic components. A conservative strategy to estimate the time required to reach desired future conditions is to constrain natural rates of recovery from disturbance (in the absence of revegetation or other management interventions), because natural recovery estimates reflect the potential outcomes if reclamation efforts fail to accelerate vegetation reestablishment.

In a comprehensive investigation of natural recovery from 47 studies in the Mojave and Sonoran Deserts, Abella (2010) estimated that perennial plant cover requires 76 years to recover, and complete recovery of pre-disturbance species compositions would require, on average, 215 years. Another literature review from the Mojave and Sonoran Deserts estimated that biomass recovery may require 50 to 300 years, and complete recovery of the functioning ecosystem could require up to 3,000 years (Lovich and Bainbridge 1999). These two studies include results from many types of disturbance with differing levels of disturbance magnitude (Abella 2010; Lovich and Bainbridge 1999) with varying environmental conditions that can impact recovery rates (e.g., soil type, landform, and physical attributes of the site); see Lathrop and Archbold (1980). Despite the disparate estimates in natural recovery rates, there are two notable observations that have implications for projecting trends toward desired future conditions.

First, recovery generally follows natural succession, which is the “sequential, directional changes in species composition of a vegetation assemblage” (Webb et al. 1988). While short-lived, early-succession communities may recovery in a matter of a few years to decades (Abella 2010; Lathrop and Archbold 1980; Prose et al. 1987), recovery for some long-lived, late-succession plant communities could require thousands of years, following the sequence of soil development (Lovich and Bainbridge 1999; Webb et al. 2003; Webb et al. 1988).

Second, the type and magnitude of disturbance strongly influences the nature and rates of ecosystem recovery (Abella 2010; Webb et al. 1987). For example, recovery of ground-clearing disturbances requires more time than other non-ground-clearing disturbances, because ground clearing can severely compact soils or remove surface resources (e.g., seedbank, microbial communities, fertile islands, nutrients, biotic soils, desert pavements, etc.) (Abella 2010). Likewise, the type and intensity of ground disturbance can influence recovery (Abella 2010; Lovich and Bainbridge 1999). For example, excavation disturbance generally requires approximately 100 years to recover pre-disturbance levels of biomass, and less-intense disturbance that only disrupts surface soils may require only around 20 years for biomass recovery (Lathrop and Archbold 1980). Ground disturbance impacts may be species specific, as soil compaction, topsoil removal, and changes to ephemeral drainages seems to hinder recovery of longer lived species or those sensitive to soil compaction (Prose et al. 1987). The shape of the disturbance footprint may also play a role, as some research suggests that recovery of linear disturbances (i.e., roads, pipeline corridors, transmission line corridors), is accelerated by the availability of seeds and propagules from adjacent undisturbed areas, whereas wider or larger disturbance areas lack nearby propagule sources (Abella 2010).

The findings of these natural recovery studies, the outcomes of the meta-analysis (Bengtson 2019b), and species-specific resource studies have been used to constrain the potential for reclamation efforts to achieve desired future conditions. Trends toward desired future conditions largely vary based on the level and nature of disturbance across all project components (see table 3.3.4-1). In general, fast-growing and early-successional plant species and those tolerant of a variety of conditions would be the first to reestablish after reclamation, recovering over years to decades. In contrast, some slower growing, late-successional species may also reestablish but may require centuries or even millennia to reach pre-disturbance levels of ecosystem function. In areas where ground disturbance is relatively low, and soil resources (e.g., nutrients, organic matter, microbial communities) and vegetation propagules (e.g., seedbank or root systems to resprout) remain relatively intact, it would be expected that vegetation communities could rebound to similar pre-disturbance conditions in a matter of decades to centuries. In contrast, the tailings storage facility, which would be covered in non-soil capping material (such as Gila Conglomerate) would provide, at best, some habitat structure for generalist wildlife species. It is expected that biodiversity and ecosystem function of the tailing storage facility may never reach the original, pre-disturbance conditions even after centuries of recovery. The following sections detail the estimated potential, as well as some time constraint, for individual vegetation communities to reach their respective desired future conditions and potential impacts on soil resources, special status plant species, and noxious weeds.

Soils

Healthy soils are the basis for a stable, functioning ecosystem—providing a plant growth medium, habitat for burrowing animals, water and nutrients to support plant communities, and harboring seeds and plant propagules. During the closure and reclamation project phase, the reestablishment of vegetation and improvements to soil conditions (through soil management or application of amendments) would offset impacts from construction, operations, and maintenance.

Even with optimal soil management intervention, the legacy of impacts on soil health and productivity may last centuries to millennia, impacting the ability of the ecosystem to meet its desired future conditions. For example, natural recovery from compaction (associated with heavy equipment traffic) is estimated to require 92 to 124 years (Webb 2002). Similarly, biotic soils and desert pavements, which trap fine-grained dust to form vesicular soil horizons, naturally prevent erosion, influence the distribution of soil nutrients, and control soil water dynamics, develop over hundreds to thousands of years (Anderson et al. 2002; Felde et al. 2014; Haff and Werner 1996; Williams 2011; Williams et al. 2012; Williams et al. 2013). The following impacts on soils would be expected during and in the years following closure and reclamation:

- Losses of topsoil resources (e.g., fine-grained soil particles, soil fertility, compaction, natural soil structure, water-holding capacity, biotic soils) during construction, operations, and maintenance may be considered permanent, as these resources accumulate over hundreds to thousands of years of soil formation. It is expected that erosion control and revegetation efforts during closure and reclamation would stop the continued loss of these resources.
- Some soil function may be enhanced through application of soil amendments (e.g., mulch, organic matter application) by increasing soil fertility, erosion resistance, and soil water-holding capacity, which would improve soil productivity.
- Over time, as soil formation proceeds (over hundreds to thousands of years), soil health and function would improve as dust accretes to increase natural soil fertility and water-holding capacity, soil structure redevelops and improves soil hydrologic function, organic matter and nutrients accumulate, bioturbation mixes soil resources, plants and microorganisms continue to colonize soils, biotic soils and desert pavements reform, and carbon and nitrogen are fixed within the soil.
- The productivity of the soil and its ability to support healthy and resilient vegetation communities (which meet an ecosystem's desired future conditions) would increase as soil formation proceeds over centuries and millennia.

These changes to soil function and productivity through time are considered in the following sections that detail the potential to achieve desired future conditions. The time frames for the recovery of soil function would largely depend on the initial level of disturbance (see table 3.3.4-1), with those soils that have had the least-impacted disturbance type (and have the greatest soil resources remaining) recovering the fastest.

Desert Ecosystems

Under optimal conditions, and with sufficient revegetation efforts and resource inputs (e.g., soil amendments and watering), fast-growing perennial shrubs, forbs, grasses, cacti, and mesquite trees would rebound within a few years to a few decades. Saguaro are slow-growing, and larger (older) individuals have low transplant survival rates (Elliot 2003). Managing the fine fuels associated with non-native grasses to maintain fire intervals greater than 100 years may not be possible, even in undisturbed and low-disturbance areas. Overall, the habitat may be suitable for generalist wildlife and plant species, but rare plants and wildlife with specific habitat requirements would be unlikely to return.

Semi-desert grasslands

Under optimal conditions, and with sufficient revegetation efforts and resource inputs (e.g., soil amendments and watering), many native grasses would return within a few years to a few decades. Tree and shrub canopy cover can be limited with management intervention. Managing non-native vegetation cover to limit the intensity of uncharacteristic fires may not be possible on the landscape scale. Because many important grass species would recover in the short-term, much of the habitat function of these ecosystems would be likely to return.

Interior Chaparral

Under optimal conditions, and with sufficient revegetation efforts and resource inputs (e.g., soil amendments and watering), recovery of shrubs (particularly shrub live oak, see (Tirmenstein 1999)), shrub litter, and regeneration of grasses and forbs should be achievable over decades to centuries on most disturbance types other than the tailings storage facility. While management of non-native species may not be achievable, support of stand-replacing fires at 35- to 100-year intervals that promote resprouting of fire-adapted species may be achievable with management interventions. Much of the habitat function should return to these habitats after decades to centuries for generalist species but may not return for sensitive species with specific habitat requirements.

Pinyon-Juniper Woodland

Under optimal conditions, reestablishment of multi-aged woodlands with complex structure and sparse ground cover of shrubs, perennial grasses, and forbs would be achievable with management intervention and resource inputs for most disturbance types, with the exception of the tailings storage facility. However, very old trees would take centuries to reestablish. Support of low-intensity ground fires should be possible with management intervention. Habitat structure would return for most generalist wildlife species but would likely require decades to centuries.

Ponderosa Pine-Evergreen Oak

Given optimal conditions, revegetation efforts, management interventions, and resource inputs, reestablishment of old-growth tree stands with sparse shrub and herbaceous groundcover should be achievable on most disturbance types with the exception of the tailings storage facility. Recreating a functional ecosystem that is resilient to a variety of human and natural disturbances may be challenging to achieve, even with intense management interventions. Habitat structure would return for most generalist wildlife species but would likely require decades to centuries.

Xeroriparian

With maintenance or recovery of the optimal hydrologic conditions, and with some management interventions, the reestablishment of most xeroriparian communities would return for all disturbance types with the exception of the tailings storage facilities. However, these communities may recover around the tailings facilities, under the appropriate conditions. Habitat structure would return for most generalist wildlife species but would likely require decades to centuries.

Riparian

Riparian community composition is expected to vary based on soil and hydrologic conditions, however, in general site-appropriate communities are expected to reestablish (given suitable management intervention and revegetation efforts) on all disturbance types with the exception of the tailings storage facilities. However, these communities may reestablish adjacent to the tailings storage facility. Habitat structure would return for most generalist wildlife species but would likely require decades to centuries.

Special Status Plant Species

Impacts on special status plant species during closure/reclamation would be similar to those described for vegetation communities. However, as special status plant species generally have specific habitat requirements, it is unlikely that reclaimed areas would retain or develop those habitat requirements over more than a small portion of the areas previously disturbed.

Noxious Weeds

Reclamation of disturbed areas would decrease but not eliminate the likelihood of noxious weeds becoming established or spreading in and adjacent to the project area. In areas where reclamation activities would occur, there would likely be reduced soil stability and an initial increase in the potential for noxious and invasive weed establishment and spread due to ground disturbance and decreased competition for space, light, and water. Efforts to reclaim these areas would lessen the potential for weed establishment and spread in the long term; however, it is anticipated that reclaimed areas would have a higher density of these non-native species than were present before ground-disturbing activities, even at completion of reclamation activities.

3.3.4.3 Alternative 2 – Near West Proposed Action

Potential impacts on soils, vegetation communities, and special status plant species, as well as impacts from noxious weeds, would be as described earlier under "Impacts Common to All Action Alternatives" and "Potential to Achieve Desired Future Conditions." Alternative 2 would remove or modify approximately 10,033 acres of vegetation and impact 10,033 total acres of soils (see table 3.3.4-2). Of the disturbed area, 5,084 acres would potentially be revegetated and would recover productivity to some extent, as described under "Impacts Common to All Action Alternatives." The acres of potential impacts on vegetation communities and special status plant species habitat by alternative are given in tables 3.3.4-3 and 3.3.4-4.

Financial Assurance for Closure and Post-Closure Activities

Alternative 2 potentially involves long time periods of post-closure maintenance and monitoring related to revegetation and reclamation of the tailings storage facility. This raises the concern for the possibility of Resolution Copper going bankrupt or otherwise abandoning the property after operations have ceased. If this were to happen, the responsibility for these long-term activities would fall to the Forest Service. The Forest Service would need to have financial assurance in place to ensure adequate funds to undertake these activities for long periods of time—for decades or even longer.

The authority and mechanisms for ensuring long-term funding is discussed in section 1.5.5. The types of activities that would likely need to be funded could include the following:

- Monitoring of the success of revegetation
- Implementing remedial actions if revegetation success criteria are not met
- Monitoring of the post-closure landform for excessive erosion or instability, and performance of any armoring
- Maintenance and monitoring of post-closure stormwater control features
- Monitoring the water quality of stormwater runoff associated with the closure cover, to determine ability to release stormwater back to the downstream watershed

Additional financial assurance requirements for long-term maintenance and monitoring are part of the Arizona APP program and include the following:

> The applicant or permittee shall demonstrate financial responsibility to cover the estimated costs to close the facility and, if necessary, to conduct postclosure monitoring and maintenance by providing to the director for approval a financial assurance mechanism or combination of mechanisms as prescribed in rules adopted by the director or in 40 Code of Federal Regulations section 264.143 (f)(1) and (10) as of January 1, 2014. (Arizona Revised Statutes 49-243; also see Arizona Administrative Code R18-9-A203 for specific regulations and methods allowed for financial assurance)

Table 3.3.4-3. Acres of vegetation communities to be disturbed within each action alternative footprint

Vegetation Community or Landform Type	Alternative 2 (acres)	Alternative 3 (acres)	Alternative 4 (acres)	Alternative 5 West Pipeline Option (acres)	Alternative 5 East Pipeline Option (acres)	Alternative 6 South Pipeline Option (acres)	Alternative 6 North Pipeline Option (acres)
Total Acres	**10,033**	**10,033**	**10,861**	**17,530**	**17,153**	**16,557**	**16,116**
Human dominated	410	410	410	423	423	423	410
Interior Chaparral	1,251	1,251	1,379	1,251	1,257	2,564	2,654
Lower Colorado River Sonoran Desertscrub	1,619	1,619	3,592	2,399	2,451	2,572	2,535
Pine-Oak	2	0	3	2	2	18	48
Pinyon-Juniper	44	0	83	118	133	92	116
Riparian	28	28	44	35	35	92	90
Semidesert Grassland	137	135	1,417	143	149	7,041	7,045
Arizona Upland Sonoran Desertscrub	6,393	6,393	3,706	12,976	12,494	2,866	2,438
Water	14	15	15	15	15	15	15
Xeroriparian	135	135	184	171	195	813	766

Note: Acreages in this table are rounded to the nearest whole number.

The Arizona State Mine Inspector also has authority to require a mine reclamation plan and financial assurance for mine closure (Arizona Administrative Code Title 11, Chapter 2). The regulations for these focus primarily on surface disturbance and revegetation.

3.3.4.4 Alternative 3 – Near West – Ultrathickened

Potential impacts on soils, vegetation communities, special status plant species, and noxious weeds would be the same in magnitude and nature as those described for Alternative 2 as they have the same footprint, and differences in the tailings facility construction and operation would not increase or decrease potential impacts between the two alternatives.

Financial assurance for closure and post-closure activities would be the same as described for Alternative 2.

3.3.4.5 Alternative 4 – Silver King

Potential impacts on soils, vegetation communities, special status plant species, and from noxious weeds would be as described under "Impacts Common to All Action Alternatives" and "Potential to Achieve Desired Future Conditions." Alternative 4 would remove or modify approximately 10,861 acres of vegetation and impact 10,861 total acres of soils (see table 3.3.4-2). Of the disturbed area, 5,779 acres would potentially be revegetated and would recover productivity to some extent, as described under "Impacts Common to All Action Alternatives" and "Potential to Achieve Desired Future Conditions." The acres of potential impacts on vegetation communities and special status plant species habitat by alternative are given in tables 3.3.4-3 and 3.3.4-4.

Financial assurance for closure and post-closure activities would be the same as described for Alternative 2.

Table 3.3.4-4. Acres of modeled habitat for special status plant species potentially occurring within each action alternative footprint

Common Name (Scientific Name)	Status	Alternatives 2 and 3 (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 4 (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 5 West Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 5 East Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 6 South Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 6 North Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area
Acuña cactus (*Echinomastus erectocentrus* var. *acunensis*)	ESA: E with critical habitat. Found in Maricopa, Pinal, and Pima Counties	N/A 0% 0%	N/A 0% 0%	14,531 82% 5%	14,130 65% 5%	N/A 0% 0%	N/A 0% 0%
Arizona hedgehog cactus (*Echinocereus triglochidiatus* var. *arizonicus*)	ESA: E No critical habitat. Found in Maricopa, Pinal, and Gila Counties	2,2,594 13% 4%	2,857 17% 4%	2,594 21% 5%	52,617 20% 5%	2,698 17% 7%	5,597 18% 7%
Chiricahua Mountain alumroot (*Heuchera glomerulata*)	Tonto National Forest: S	0 0% 0%	94 19% 1%	0 0% 0%	0 0% 0%	133 22% 1%	110 19% 1%

continued

Table 3.3.4-4. Acres of modeled habitat for special status plant species potentially occurring within each action alternative footprint *(cont'd)*

Common Name (Scientific Name)	Status	Alternatives 2 and 3 (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 4 (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 5 West Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 5 East Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 6 South Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area	Alternative 6 North Pipeline Option (acres) Percentage of Modeled Habitat in Analysis Area Percentage of Modeled Habitat in 5-Mile Buffer Area
Mapleleaf false snapdragon (*Mabrya [Maurandya] acerifolia*)	Tonto National Forest: S	0 0% 0%	0 0% 0%	737 3% 1%	319 3% 1%	0 0% 0%	0 0% 0%
Parish's Indian mallow (*Abutilon parishii*)	Tonto National Forest: S BLM: S	1,463 23% 4%	4,999 99% 17%	4,874 39% 18%	5,011 29% 8%	3,395 23% 7%	3,245 33% 8%
Pringle's fleabane (*Erigeron pringlei*)	Tonto National Forest: S	1,305 20% 4%	1,439 16% 3%	1,305 20% 4%	1,310 19% 4%	2,676 16% 5%	2,770 18% 5%

Notes: Modeled habitat includes areas outside of the current range of some species and is used here as a conservative estimate of impacts. It was necessary to use modelled habitat since the only baseline survey and suitable habitat data available were only for four species within Alternatives 2 and 3. Acreages in this table are rounded to the nearest whole number.

Status Definitions

Tonto National Forest:

S = Sensitive. Species identified by a Regional Forester for which population viability is a concern, as evidenced by a significant current or predicted downward trends in population number or density or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

Endangered Species Act (ESA):

E = Endangered. Endangered species are those in imminent jeopardy of extinction. The ESA specifically prohibits the take of a species listed as endangered. Take is defined by the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to engage in any such conduct.

Bureau of Land Management (BLM):

S = Sensitive. Species that could easily become endangered or extinct in the state.

3.3.4.6 Alternative 5 – Peg Leg

Potential impacts on soils, vegetation communities, special status plant species, and from noxious weeds would be as described under "Impacts Common to All Action Alternatives." Alternative 5 would remove or modify approximately 17,153 acres of vegetation with the east pipeline route option and 17,530 acres with the west pipeline route option. The disturbance would impact 17,153 acres of soils in the east pipeline route option and 17,530 acres of soils for the west pipeline route option (see table 3.3.4-2). Of the disturbed area, just over 12,000 acres would potentially be revegetated and would recover productivity to some extent, as described under "Impacts Common to All Action Alternatives" and "Potential to Achieve Desired Future Conditions." The acres of potential impacts on vegetation communities and special status plant species habitat by alternative are given in tables 3.3.4-3 and 3.3.4-4. Within Alternative 5, both the east and west pipeline options would impact critical habitat. The west pipeline option would disturb around 103 acres of acuña cactus critical habitat, and the east pipeline option would disturb about 12 acres of critical habitat.

The regulatory framework under the State of Arizona to require financial assurance for long-term closure activities is the same as described for Alternative 2. However, for the tailings facility, financial assurance requirements would be required by BLM, not the Forest Service. Like the Forest Service, BLM also has regulatory authority to require financial assurance for closure activities, contained in their surface management regulations (43 CFR Subpart 3809). BLM considers that the financial assurance must cover the estimated cost as if BLM were hiring a third-party contractor to perform reclamation of an operation after the mine has been abandoned. The financial assurance must include construction and maintenance costs for any treatment facilities necessary to meet Federal and State environmental standards.

3.3.4.7 Alternative 6 – Skunk Camp

Potential impacts on soils, vegetation communities, special status plant species, and from noxious weeds would be as described under "Impacts Common to All Action Alternatives" and "Potential to Achieve Desired Future Conditions." Alternative 6 would remove approximately 16,557 acres of vegetation for the south pipeline route option and 16,116 acres for the north pipeline route option. The disturbance would impact 16,116 acres of soils in the north pipeline route and 16,557 acres of soils for the south pipeline route (see table 3.3.4-2). Of the disturbed area about 10,000 acres would potentially be revegetated and would recover productivity to some extent, as described under "Impacts Common to All Action Alternatives." The acres of potential impacts on vegetation communities and special status plant species habitat by alternative are given in tables 3.3.4-3 and 3.3.4-4.

The regulatory framework under the State of Arizona to require financial assurance for long-term closure activities is the same as described for Alternative 2. However, Alternative 6 differs from the other alternatives because the tailings facility would not be located on lands managed by the Forest Service (as in Alternatives 2, 3, and 4) or BLM (Alternative 5). For Alternative 6, the Federal financial assurance mechanisms would not be applicable.

3.3.4.8 Cumulative Effects

The assessment area for cumulative impacts on soils and vegetation in conjunction with the Resolution Copper Project is broadly defined as the "Copper Triangle" region of south-central Arizona (generally understood as encompassing lands from the Globe-Miami area southwest to the town of Superior and southeast to the towns of Hayden and Winkelman), as well as adjacent watersheds.

In assessing cumulative effects on soils and vegetation, it should be understood that all forms of surface disturbance have the potential to remove or damage vegetation and increase soil erosion in the immediate vicinity of the disturbance and possibly beyond. Loss of vegetation leads to potential habitat losses that may last hundreds or thousands of years, as natural recovery proceeds. Intensified or accelerated erosion may occur through the effects of wind, or water, or both, causing permanent losses of soils and soil resources. Vegetation destruction, habitat loss, and increased erosion may occur whether the surface disturbance is intentional, such as that resulting from a construction project, or incidental, such as that arising from OHV use or other recreational activity in previously undisturbed areas.

The Tonto National Forest identified the following list of reasonably foreseeable future actions as likely to occur in conjunction with development of the Resolution Copper Mine and as having potential to contribute to incremental changes to soils and vegetation. As noted in section 3.1, past and present actions are assessed as part of the affected environment; this section analyzes the effects of any RFFAs, to be considered cumulatively along with the affected environment and Resolution Copper Project effects.

- *Pinto Valley Mine Expansion.* The Pinto Valley Mine is an existing open-pit copper and molybdenum mine located approximately 8 miles west of Miami, Arizona, in Gila County. Pinto Valley Mining Corporation is proposing to expand mining activities onto an estimated 1,011 acres of new disturbance (245 acres on Tonto National Forest land and 766 acres on private land owned by Pinto Valley Mining Corporation) and extend the life of the mine to 2039. EIS impact analysis is pending. However, it is assumed that the proposed action as described in the recently amended mining plan of operations would result in the direct short-term (less than 5 years) or long-term (20–30 years) loss of soils and vegetation through surface disturbance of up to 1,011 acres. Some areas could later be reclaimed and revegetated, but there would also be the permanent, irreversible loss of other areas that would, for example, be buried beneath expanded tailings impoundments or waste-rock stockpiles or would be permanently lost to expansion of the pit area. In addition, given what is known of the historical environmental effects of similar mining operations elsewhere, the potential exists for adverse effects on both soils and riparian vegetation communities downgradient of the mine due to contamination or decreased water availability. A more accurate assessment of the potential for downstream seepage or other contamination would not be known until the environmental effects analysis of the proposed mine expansion is complete and mitigation measures and other environmental controls are agreed upon between the Tonto National Forest, Pinto Valley Mining Corporation, and other Federal and State regulatory agencies.

- *Ripsey Wash Tailings Project.* Mining company ASARCO is planning to construct a new tailings storage facility to support its Ray Mine operations to replace the existing Elder Gulch tailings storage facility near Hayden, which is now nearing its maximum capacity. The environmental effects of the project were analyzed in an EIS conducted by the USACE and approved in a ROD issued in December 2018. As approved, the proposed tailings storage facility project would occupy an estimated 2,574 acres and be situated in the Ripsey Wash watershed just south of the Gila River approximately 5 miles west-northwest of Kearny, Arizona, and would contain up to approximately 750 million tons of material (tailings and embankment material). Development of the new facility would result in the permanent loss (i.e., burial) of existing soils and vegetation within the tailings storage facility boundary. Other existing surface soils and vegetation would, for approximately the next 50 years, be overlain by tailings storage facility maintenance roads, slurry and water pipeline corridors, and other supporting tailings facility infrastructure. Following facility closure, however, the majority of these linear facilities would be removed and the underlying soils and vegetation reclaimed. Cumulative effects with the Resolution Copper Project would be most pronounced for Alternative 5 – Peg Leg, which would result in large areas of impact on soil and vegetation in the same general vicinity and watershed.

- *Superior to Silver King 115-kV Relocation Project.* At the request of Resolution Copper, SRP intends to relocate an approximately 1-mile segment of the existing Superior-Silver King 115-kV transmission line, located on Resolution Copper–owned private property, approximately 0.25 mile to the northwest to accommodate future Resolution Copper Mine–related facilities. This relocation of the transmission line would directly affect relatively small areas of previously undisturbed soil and vegetation to allow for installation of footings for transmission line poles and possibly of other areas for maintenance access. These activities could increase the potential for introduction and establishment of noxious weeds and invasive species along this portion of the transmission line corridor.

- *Silver Bar Mining Regional Landfill and Cottonwood Canyon Road.* A private firm, Mineral Mountain LLC, is proposing to develop a landfill on land the company owns approximately 6 miles southeast of Florence Junction and 4 miles due east of SR 79. This private land lies entirely within an area of BLM-administered lands and cannot be accessed without crossing Cottonwood Canyon Road, located on BLM lands. The company received Master Facility Plan Approval for the proposed landfill from ADEQ in 2009 and a BLM right-of-way grant in 2017. The firm's proposed construction on Cottonwood Canyon Road and on the landfill property could increase the potential for introduction and/or spread of noxious weeds and invasive plants. Approximately 4 acres of creosotebush-bursage vegetation and 11 acres of Arizona Upland Desertscrub would be removed to expand Cottonwood Canyon Road. Development of the landfill would result in the clearing of 350 acres of vegetation on private lands.
- *APS Herbicide Use within Authorized Power Line Rights-of-Way on NFS lands.* Arizona Public Service Company (APS) has proposed to include Forest Service-approved herbicides as a method of vegetation management, in addition to existing vegetation treatment methods, on existing APS transmission rights-of-way within the Tonto National Forest. An environmental assessment (EA) with a Finding of No Significant Impact (FONSI) was published in December 2018. The EA determined that environmental resource impacts would be minimal, and the use of herbicides would be useful in preventing and/or reducing fuel buildup that would otherwise result from rapid, dense regrowth and sprouting of undesired vegetation. No residual effects on underlying soils are anticipated as a result of use of these herbicides.
- *ADOT Vegetation Treatment***.** Like the APS vegetation control program, Arizona Department of Transportation (ADOT) plans to conduct annual treatments using EPA-approved herbicides to contain, control, or eradicate noxious, invasive, and native plant species that pose safety hazards or threaten native plant communities on road easements and NFS lands up to 200 feet beyond road easement on the Tonto National Forest. No residual effects on underlying soils are anticipated as a result of use of these herbicides.
- *Ray Land Exchange and Proposed Plan Amendment.* ASARCO is also seeking to complete a land exchange with the BLM by which the mining company would gain title to approximately 10,976 acres of public lands and federally owned mineral estate located near ASARCO's Ray Mine in exchange for transferring to the BLM approximately 7,304 acres of private lands, primarily in northwestern Arizona. It is known that at some point ASARCO wishes to develop a copper mining operation in the "Copper Butte" area west of the Ray Mine; however, no details are currently available for specific mine development plans or how these may directly or indirectly affect existing soils and vegetative communities in the Copper Butte area.
- *AGFD Wildlife Water Catchment Improvement Projects*. These individual catchment projects are part of a larger, longer term cooperative effort between the Tonto National Forest and Arizona Game and Fish Department to improve wildlife habitat throughout the Tonto National Forest, and specifically to benefit mule deer populations (although access to water provided by the catchments would also benefit elk, javelina, Gambel's quail, and other species). Each catchment array (including water storage tanks, a large "apron" to gather and direct precipitation to the storage tanks, drinking trough, and fencing) would disturb no more than 0.5 acre, causing minimal cumulative disturbance of soils and vegetation.

- *Tonto National Forest Travel Management Plan*. The Tonto National Forest is currently in the process of developing a Supplemental EIS to address certain court-identified deficiencies in its 2016 Final Travel Management Rule EIS. This document and its implementing decisions are expected within the next 2 years. This document will have substantial impacts on current recreational uses of Tonto National Forest lands and transportation routes, which in turn would have some impact on disturbance of soils and vegetation for new road construction or decommissioning of other roads.

Nearly all forms of human development activity involve some amount of short- or long-term surface disturbance of existing soils and vegetation. These activities may include agriculture, mining, roadbuilding, utility construction, private residential and commercial land development, rangeland improvements, and many other actions beyond the specific projects described here. Many of these types of earth-disturbing activities are certain to occur in this area of south-central Arizona during the foreseeable future life of the Resolution Copper Mine (50–55 years), including developments that have yet to be imagined or planned. In some instances, the disturbed soils and vegetation are eventually returned to approximately pre-disturbance conditions, but in most cases they are not.

3.3.4.9 Mitigation Effectiveness

The Forest Service is in the process of developing a robust mitigation plan to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation concepts being considered and known to be effective, as of publication of the DEIS. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness. As noted in chapter 2 (section 2.3), the full suite of mitigation would be contained in the FEIS, required by the ROD, and ultimately included in the final GPO approved by the Forest Service. Public comment on the EIS, and in particular appendix J, will inform the final suite of mitigations.

This section contains an assessment of the effectiveness of design features from the GPO and mitigation and monitoring measures found in appendix J that are applicable to soils and vegetation.

Mitigation Measures Applicable to Soils and Vegetation

Salvage of select vegetation and trees within the tailings storage facility footprint (RC-208): To the extent practicable, Resolution Copper will salvage select vegetation and select suitable trees within the tailings storage facility footprint. This measure would be applicable to all alternative tailings storage facility locations and would be noted in the final ROD or final mining plan of operations as a requirement by the Forest Service.

Conduct soil surveys within the area to be disturbed by the preferred alternative tailings storage facility (FS-223): While adequate soil and vegetation information exists to conduct an assessment for the purposes of disclosing impacts under NEPA and comparing between alternatives, the level of information may not be sufficient to support detailed final reclamation plans and a final mining plan of operations. To support these documents, soil surveys need to be conducted within the disturbance footprint of the preferred alternative tailings storage facility. The specific purpose of the surveys would be to identify general soil characteristics, estimate the amount of soil or unconsolidated material that would be available for salvage to support reclamation activities, and inform the ability of salvaged material to support reclamation efforts. The appropriate level of detail for the soil survey would be determined in conjunction with the Tonto National Forest. The Forest Service is requiring that these surveys be conducted between the DEIS and FEIS. This exercise will inform the requirements to be specified in the ROD and ultimately incorporated into a final mining plan of operations.

Conduct appropriate testing of soil materials within the preferred alternative tailings storage facility (FS-224): Similarly, in order to support detailed final reclamation plans and a final mining plan of operations, appropriate testing would be conducted on soil samples collected from within the Preferred Alternative footprint. These tests could include such parameters as soil organic carbon, moisture capacity, nutrients, pH/acidity/alkalinity. Tests would also include those appropriate to estimate post-closure water quality of stormwater runoff interacting with the salvaged soil. The appropriate suite of tests to be conducted would be determined in conjunction with the Tonto National Forest. The Forest Service is requiring that these tests be conducted between the DEIS and FEIS. This exercise will inform the requirements to be specified in the ROD and ultimately incorporated into a final plan of operations.

Conduct vegetation surveys within the preferred alternative disturbance footprint (FS-225): Also, in order to support detailed final reclamation plans and a final mining plan of operations, vegetation surveys need to be conducted within the disturbance footprint of the preferred alternative tailings storage facility. These surveys would identify general vegetation present, density, abundance of native/non-native species, and any special status plant species for which site characteristics are appropriate for occurrence. The appropriate level of detail for these surveys would be determined in conjunction with the Tonto National Forest. The Forest Service is requiring that these surveys be conducted between the DEIS and FEIS. This exercise will inform the requirements to be specified in the ROD and ultimately incorporated into a final plan of operations.

Preparation of detailed reclamation plans for the preferred alternative (FS-226): Information derived from the soil surveys, vegetation surveys, and soil testing would be used to develop detailed reclamation plans for the preferred alternative. These reclamation plans would be more specific than those included in the GPO, and would include such details as maps of the post-closure landform depicting the type of final closure cover for each area (depth of material, type of material, anticipated source of material and preparation methods like crushing or sorting, and need for/presence of armoring); anticipated reclamation techniques such as surface preparation, seeding, planting, watering (if any), soil amendments; soil salvage storage locations and storage management techniques; maps of the post-closure landform or the landform over time, depicting phasing of revegetation or reclamation activities; monitoring details including proposed success criteria and the potential use of comparison reference plots. The detailed reclamation plans would also include more specific information on post-closure stormwater controls, the anticipated longevity of engineered control systems, and criteria for when stormwater would be deemed appropriate for release back to the downstream drainages. The appropriate level of detail for the final reclamation plans would be determined in conjunction with the Tonto National Forest. The Forest Service is requiring that these plans be prepared between the DEIS and FEIS. This exercise will inform the requirements to be specified in the ROD and ultimately incorporated into a final mining plan of operations.

Mitigation Effectiveness and Impacts

The salvage of vegetation would not result in any additional ground disturbance and would be effective at offsetting some loss of vegetation through salvage and replanting. Not all salvaged vegetation would likely survive transplantation, and many decades might be required before areas are available for replanting. The amount of vegetation salvaged would be a small portion of that lost.

Soil surveys, soil testing, vegetation surveys, and preparation of detailed reclamation plans would not result in any additional ground disturbance and would be effective at developing information and techniques that would allow revegetation activities to be as successful as possible. These would also inform monitoring requirements that would ensure that revegetation activities are performing over time as predicted.

Unavoidable Adverse Effects

The mitigation described would only minimally offset project impacts. The unavoidable adverse effects remain as described earlier in this section, including the complete loss during operations of soil productivity, vegetation, and functioning ecosystems within the area of disturbance, and eventual recovery after reclamation (though not likely to the level of desired conditions or potentially over extremely long time frames). Impacts on special status plant species, where they occur, and the spread of noxious and invasive weeds (though reduced by applicant-committed environmental protection measures) would also be unavoidable adverse effects.

3.3.4.10 Other Required Disclosures

Short-Term Uses and Long-Term Productivity

Productivity loss for soils would be limited to the disturbed areas affected by land clearing, grading, and construction; subsidence; and areas permanently occupied by tailings. It is not expected that the tailings would ever be removed, or that the subsidence crater would be filled, and effects on soils and some land uses would be permanent.

Reclamation efforts are anticipated to reestablish vegetation in all areas other than the subsidence crater.

Test plots at the West Plant Site have demonstrated that it is possible to successfully revegetate under certain conditions and research has demonstrated successful revegetation on Gila Conglomerate in the same geographic area; however, it is not known whether the areas would return to current conditions or the length of time that would be needed to successfully reclaim the site. However, the goal of reclamation is to create a self-sustainable ecosystem that would promote site stability and repair hydrologic function, and while pre-project habitat conditions are not likely to be achieved, it is likely that some level of wildlife habitat would eventually be reestablished in most areas, reestablishing some level of long-term productivity.

Irreversible and Irretrievable Commitment of Resources

Soils are a finite resource, and any loss of soils resulting from their removal for tailings storage and from erosion and delivery to downstream channels is irreversible. The loss of soil productivity is effectively irreversible because a stable new plant community would take an extremely long time to redevelop on the surface of the tailings and waste-rock facilities (decades or centuries). The area of the subsidence crater and tailings storage facility would constitute an irreversible loss of soil that would be lost in perpetuity.

Irretrievable effects on soils and vegetation would take place at disturbed areas where reclamation is successfully accomplished or only temporary in nature, particularly along rights-of-way. Soils and vegetation in these areas would eventually return to full functionality, possibly within years or decades.