SPECIES STATUS ASSESSMENT
FOR THE
MOHAVE SHOULDERBAND SNAIL
(Helminthoglypta greggi)

Photo credits: Soledad Mountain (US Fish and Wildlife Service); (inset) Mohave shoulderband snail, E. Fiesler, BioVeyda Biological Inventories and Consulting.

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Executive Summary

The Mohave shoulderband snail is a small, desert snail found in rock outcrops and talus slopes within geological formations (plugs) primarily composed of rhyolite material, in the Mojave Desert, Kern County, California. It is currently known from three general locations in the western Mojave Desert, which is also the presumed historical range. However, systematic surveys have not been conducted across the entire range of the Mohave shoulderband snail. Based on the historical geographic and geologic conditions that developed in this region, the Mohave shoulderband snail is one of several desert snails that has adapted to a warmer and drier climate that developed following the late Pleistocene. A recent phylogeographical and anatomical study described the Mohave shoulderband snail's reproductive and morphological anatomy as a unique, but sister taxon to three other little-studied helminthoglyptid taxa found in the two mountain ranges that border the western Mojave Desert.

Very little is known about the species' life history and ecological needs. Because of the hot, arid conditions in the Mojave Desert, desert snails, including the Mohave shoulderband snail, are active primarily during the brief winter season and enter a state of dormancy during the remainder of the year, sealing themselves to rocks to prevent desiccation. They emerge during and following periods of rainfall in search of food resources or for mating and egg-laying activities. The Mohave shoulderband snail life history is therefore dependent on local precipitation and subsequent increases in humidity within rock outcrop habitats. Although water represents the primary limiting resource in desert environments, other climatic and physical factors such as temperature and topography, as well as food availability, can influence the ecology of desert snails, and a combination of these factors can be important.

Based on studies of other desert snails, saxicolous lichens (those found on rocks), represent a likely food source for the Mohave shoulderband snail. These communities are known to occupy rock environments of the Mojave Desert and are found primarily on north-facing rather than south-facing slopes, due to availability of moisture and protection from intense radiation. Desert microbiotic soil crusts, which consist of cyanobacteria, algae, microfungi, lichens, or mosses, may also be (though not confirmed) a potential food source for the Mohave shoulderband snail.

Overall, the best available information indicates that the Mohave shoulderband snail's physical and ecological needs include:

(1) Volcanic rock outcrops (primarily rhyolite) or talus slopes in the western Mojave Desert, including, *but not limited to*, north-facing slopes, which provide areas of moisture and protection from intense radiation;

(2) Adequate food source, including mosses, lichens, fungi, algae or other plant materials growing on rock surfaces or within microbiotic crusts; and

(3) Adequate water availability, which provides opportunities for dispersal, particularly after precipitation events, to locate food and for locating potential mates for reproductive activities.

In this Species Status Assessment (SSA) Report, we provide a discussion of the ecological needs of the Mohave shoulderband snail, its current conditions, and projected future conditions. We evaluate potential stressors to the species, with a particular focus on the primary impacts

associated with habitat loss, modification, or degradation currently or in the future (i.e., hard rock mining) and the potential future effects of climate change.

In our analysis, we applied the conservation biology principles of redundancy, resiliency, and representation (collectively known as the "3Rs") to evaluate the current and projected future condition of the Mohave shoulderband snail and its ability to sustain itself (as one or more populations) in the wild over time (Carroll *et al.* 1996, entire; Wolf *et al.* 2015, entire). This evaluation considers the unique demographic, distribution, and diversity characteristics unique to the species. After applying the framework of the 3Rs, we determined the following:

(1) Redundancy: The Mohave shoulderband snail occurs at three locations (with an unknown number of populations) within one geographic area encompassing an approximate 10-mile (mi) (16.09 kilometer (km)) radius. The best available information does not indicate that this species occurred beyond this range historically.

(2) Representation: The Mohave shoulderband snail is present at three locations across a large landscape, relative to the species' life history requirements. The best available information indicates that the species occupies rock outcrops and talus slopes found predominantly on north-facing slopes where conditions may be cooler and wetter; however, observations have also been documented on south-facing slopes.

(3) Resiliency: The Mohave shoulderband snail appears resilient at least since its discovery in 1931 (Willett 1931). It is likely that more snails occur in these locations than currently known given the limited survey effort to date. Population size and growth rates are unknown, although the best available information does not suggest that abundance is declining at the three known locations. Our analysis indicates these three locations reside within and are surrounded by 210 acres (ac) (85 hectares (ha)) of suitable habitat according to our spatial analysis and constructed suitable habitat model. The most significant stressor currently and in the future appears to be mining activities on a portion of Soledad Mountain, which is expected to result in the loss of 19.4 percent (40.8 ac of 210 ac) (16.5 ha)) of modeled suitable habitat at that location.

Demographic risks to the species from either known or most likely potential stressors (i.e., hard rock mining, wildland fire, vegetation type conversion, and climate change effects) were evaluated using the best available information as it applies to current and potential future conditions for the Mohave shoulderband snail across its range, and in the context of the attributes that affect its viability. The future timeframe evaluated in our analysis is approximately 40 to 50 years, which captures the range of time periods for proposed projects within the species' range, as well as our best professional judgment of the projected future conditions related to climate change, wildland fire conditions, or other potential cumulative impacts. While information is lacking for this species, the best available information does not indicate that loss, degradation, or modification of habitat both currently and in the future will result in a substantial decline in the overall population of the species across its range.

Management actions, including control of invasive plants, reclamation of mining areas, fire suppression, and restricted access to Mohave shoulderband snail habitat, currently and in the future, alleviate effects associated with impacts related to wildland fire, vegetation type conversion, and off-highway vehicle activity, but will not remove all the potential effects of habitat-related impacts. A conservation plan for the Mohave shoulderband snail, associated with anticipated impacts from hard rock mining activities at Soledad Mountain, has also been prepared by Golden Queen Mine.

Abbreviations and Acronyms Used

BLM = Bureau of Land Management
°C = degrees Celsius
CBD = Center for Biological Diversity
CCR = California Code of Regulations
CDF = California Department of Forestry and Fire Protection
CDFW = California Department of Fish and Wildlife
CEPA = California Environmental Protection Agency
DRECP = Desert Renewable Energy Conservation Plan
EIR/EIS = Environmental Impact Report/Environmental Impact Statement
°F = degrees Fahrenheit
GHG = Greenhouse gas
GQM = Golden Queen Mine
IPCC = Intergovernmental Panel on Climate Change
NCDC = National Climatic Data Center
NRC = National Research Council
PDSI = Palmer Drought Severity Index
SCP = Scientific Collecting Permit
SEIR = Supplemental Environmental Impact Report
Service = U.S. Fish and Wildlife Service
SMARA = Surface Mining and Reclamation Act
SSA = Species Status Assessment
WRCC = Western Regional Climate Center

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Introduction

The Mohave shoulderband snail, *Helminthoglypta* (*Coyote*) *greggi* Willett (1931), is a small (diameter ranging from 0.48 to 0.58 inches (in) (12.3 to 14.6 millimeters (mm)), brown desert snail. The type description was based on morphometric shell characteristics (see Willett 1931, p. 124 for details). It is currently found only in the western Mojave Desert, in Kern County, California.

A number of terrestrial snails adapted to desert environments are found in North America. These include the genera *Sonorella*, *Eremarionta*, *Cahuilus*, *Helminthoglypta*, and others, which have a discontinuous distribution across the southwestern United States (California, Nevada, Arizona, New Mexico, and Texas) and into the Baja California peninsula of Mexico, and other parts of Mexico (Waters 2011, p. 1).

Helminthoglyptids are identified and described based on their adult shell morphology and reproductive anatomy, including the presence of a dart sac and associated membranous mucous glands (see Naranjo-Garcia 1988, entire; Reeder and Roth 1988, p. 254; Gilbertson and Radke 2006, pp. 18–20; Gilbertson *et al*. 2013, pp. 59–61). Roth and Sadeghian (2006, pp. 3–7, 25–26) present a supraspecific taxonomic classification summary and checklist of land snails and slugs of California, placing the Mohave shoulderband snail in the subgenus *Coyote*, genus *Helminthoglypta*, family Helminthoglyptidae. However, many species of land snails have yet to be fully described (Miller 1981, p. 444; Roth and Sadeghian 2006, p. 2).

A manuscript submitted for publication describes the reproductive and preliminary molecular anatomy of *Helminthoglypta greggi* (Goodward *et al*. 2017)[1]. The study concluded that the Mohave shoulderband snail is most similar in appearance to *H.* (*Coyote*) *micrometalleoides*, which occupies another area of the western Mojave Desert (northern El Paso Mountains) (Goodward *et al*. 2017, p. 12). The reproductive organs for *H. greggi*, however, are longer than those of *H. micrometalleoides* and it has elongated mucus gland bulbs; otherwise, the two desert snails have reproductive anatomical characteristics that are typical of the *Coyote* subgenus (Goodward *et al*. 2017, p. 14). A scanning electron microscope analysis of *H. greggi* found unique ornamentation of the whorl patterns of its shell; for example, the papillae (numerous small bumps on shell surface) and rugae (undulations of the shell surface) were considerably smoother than is generally found for helminthoglyptids (Goodward *et al*. 2017, pp. 13–14).

Species Status Assessment Methodology

In preparing the Species Status Assessment (SSA) Report of the Mohave shoulderband snail, we reviewed available reports and peer-reviewed literature, incorporated survey information, contacted species experts to collect additional unpublished information, and participated in

[1] On September 13, 2017, the Service received a comment letter that reiterated previous comments submitted to the Service and also challenged the validity of Goodward *et al*. 2017 (Alston & Beard, pers. comm. 2017). No new data were provided; however the letter included a 2017 "peer review study" of Goodward *et al.* (2017), prepared by Dr. Rob Roy Ramey II, which we have reviewed. Based on the best available scientific information, we continue to recognize *Helminthoglypta greggi's* as a valid taxon and recognize its range to include the western region of the Mojave Desert, occurring at Middle Butte, Standard Hill, and Soledad Mountain.

multiple site visits to Soledad Mountain and the surrounding area. We identified uncertainties and data gaps in our assessment of the current and future status of the species. We also evaluated the appropriate analytical tools to address these gaps and conducted discussions with species experts. For example, we contacted researchers regarding a preliminary taxonomic study of the Mohave shoulderband snail (Goodward *et al*. 2017) and to verify locations of observations from recent surveys. Because so little is known or published about the life history requirements of the Mohave shoulderband snail, we also reviewed available relevant literature for similar species and our report states important assumptions made during our assessment of the ecological needs of the Mohave shoulderband snail. We created a conceptual model identifying key influences or processes affecting the species to illustrate these ecological needs and prepared updated maps of the species' known range.

Using the species needs identified for the Mohave shoulderband snail and location results from surveys, we conducted a geospatial analysis to estimate current potentially suitable habitat. We then evaluated our potential habitat to assess the species' current conditions. Our future condition analysis includes the potential conditions that the species or its habitat may face; that is, the most probable scenario if those conditions are realized in the future. This most probable scenario includes consideration of the sources that have the potential to most likely impact the species at the population or rangewide scales in the future, including potential cumulative impacts. Potential future impacts associated with climate change (probabilistic estimates for temperature and precipitation) and wildland fire risks were based on climate model projections downscaled to the Mojave Desert region.

For the purpose of this assessment, we generally define viability as the ability of the species to sustain locations (given the lack of information on numbers of populations or population sizes, as described in the *Population Needs* and Status–Current Condition sections) in its natural ecosystem beyond a biologically meaningful timeframe, in this case, approximately 40 to 50 years. We chose this timeframe because it is within the range of the available modeling efforts related to climate change and wildfire projections, and also includes the timeframe projected for future mining activities (approximately 12 years) at Soledad Mountain. We believe this is a reasonable timeframe to consider as it would include many (albeit an unknown number) generations of the species for observing effects to the species.

Using the SSA framework (Figure 1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of resiliency, redundancy, and representation (Wolf *et al*. 2015, entire).

- **Resiliency** is having sufficiently large populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Resilient populations are better able to

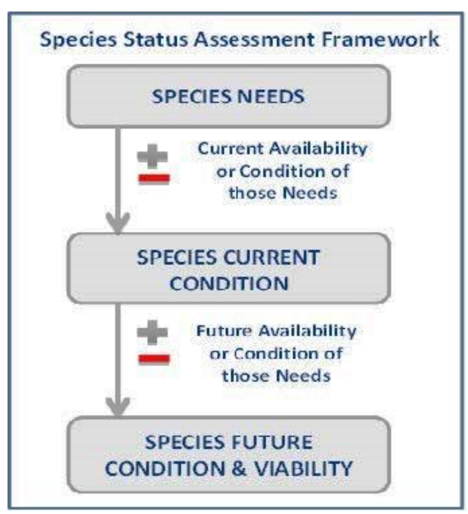

Figure 1. Species Status Assessment Framework.

withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.

- **Redundancy** is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Redundancy is about spreading the risk and can be measured through the duplication and distribution of populations across the range of the species. The greater the number of populations a species has distributed over a larger landscape, the better it can withstand catastrophic events.
- **Representation** is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species' range. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics within the geographical range.

Species' Ecological Needs

Overview

In general, there is lack of comprehensive biological, ecological, and natural history information beyond basic species descriptions for desert helminthoglyptids, including the Mohave shoulderband snail. Pulmonate snails (group of mollusks with sac-like lung) have successfully adapted to abiotic conditions, including harsh desert environments, through physiological and behavioral adaptations related to water balance and environmental temperatures (Riddle 1983, p. 432). The Mohave shoulderband snail occurs in rock outcrops and talus slopes found on volcanic formations (plugs) composed primarily of rhyolite material, in the western Mojave Desert. The region's physical and biological features relative to precipitation patterns, substrate, and availability of food largely determine the distribution of the Mohave shoulderband snail. A conceptual ecological model illustrating potential stressors and the physical and biological processes in the context of the species' ecology within the Mojave Desert ecosystem is presented in Figure 2. The blue boxes in the model represent our general approximation of the key physical, climatic, and other environmental driving forces in the natural system where the Mohave shoulderband snail is found. The stressors (orange ovals) represent the physical, chemical, and biological elements that result from the drivers, which intersect with the processes (or responses) (light tan rectangles) identified in the diagram.

Historical Range and Distribution

The Mohave shoulderband snail is found within the western region of the Mojave Desert and has been reported at Middle Butte, Standard Hill, and Soledad Mountain (Figure 3). The Mohave shoulderband snail type (#1031, Los Angeles County Museum) and 24 additional specimens collected in 1931 were described from "rock slides on the side of a hill" 3.5 mi (5.63 km) south of Mojave (Willett 1931, p. 125), in Kern County, California.

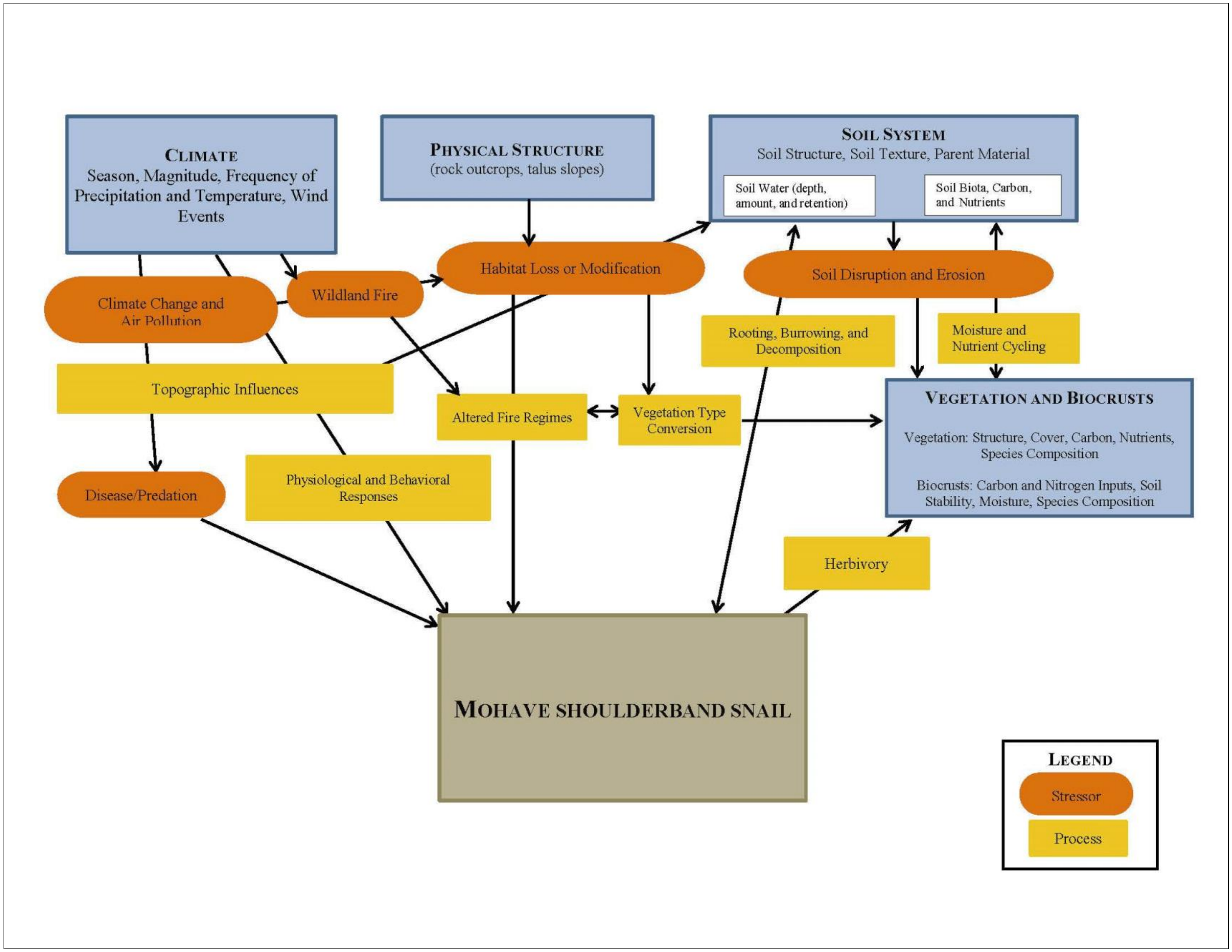

Figure 2. Conceptual model for the Mohave shoulderband snail.
Source: Modified from Belnap *et al*. (2016) and Chung-MacCoubrey *et al*. (2008)

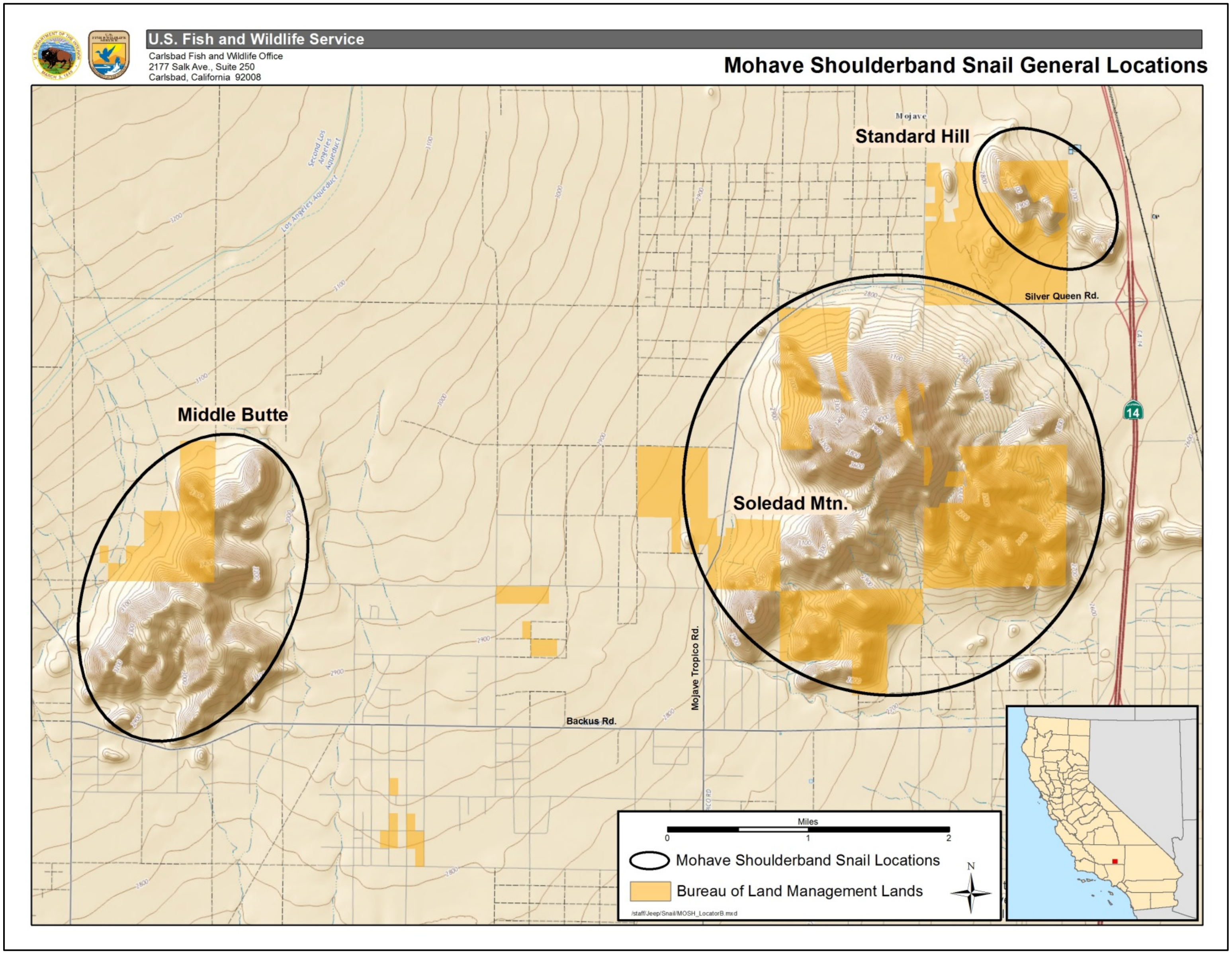

Figure 3. Location map for the Mohave shoulderband snail, western Mojave Desert, Kern County, California.

The Mohave shoulderband snail's distribution and habitat conditions have been shaped by significant geological and landscape-changing changes that occurred over millions of years. During the Miocene Epoch (23 to 5 million years ago), the dominant flora in the area now occupied by the Mojave Desert was oak-scrub woodland and subtropic thorn forest with dense semi-desert sage scrub plant communities found in lower areas, and precipitation was likely at least 10 in (25.4 centimeters (cm)) annually in order to support these communities (Axelrod 1995, pp. 7–8). By the end of the Pliocene Epoch (circa (ca.) 2.6 million years ago), climatic conditions were warmer and wetter than at present, and during the subsequent Pleistocene Epoch (2.6 million to 11,700 years ago), there were alternating periods of cool, moist conditions and warm, dry conditions. During the cooler, wetter periods, a system of basin lakes and connecting streams developed in the Mojave and Great Basin Deserts (Blackwelder 1954, p. 35; Norris 1995, pp. 32, 41; Enzel *et al*. 2003, entire), likely due to Pacific storm tracks that were of lower latitude (~32° to 35° N) during the last glacial maximum (Enzel *et al*. 2003, pp. 73–74). The Mohave shoulderband snail is likely a relict species from a time in the past when this region was much wetter (e.g., Pliocene and Pleistocene pluvial episodes).

Movement of land snails is primarily dependent on conditions of adequate moisture and humidity (Naranjo-Garcia 1988, p. 76). With increasingly drier conditions by the end of the Pleistocene Epoch (17,100 to 17,850 years ago) in many of today's southwestern desert regions, land snails had to adapt "in place" in order to survive these environments.

A systematic and biogeographical study of several species of Helminthoglypta in the Sonora region of Mexico concluded that their current distribution represents relict populations that are now restricted to disjunct and fragmented locations since the changed conditions following the Pleistocene (Naranjo-Garcia 1988, pp. 86, 90; Wiesenborn 2003, p. 202). A similar radiation and subsequent restriction in distribution likely holds true for the genus Helminthoglypta found in hot, arid regions of the Mojave Desert. Reeder and Roth (1988, p. 252) describe the *Coyote* subgenus of Helminoglypta land snails found in the San Bernardino, San Gabriel, and Santa Ana Mountains, and those that occupy ranges on the periphery of the Mojave Desert as the "Mojave Desert Series" group of helminthoglyptids, which Pilsbry (1939, pp. 159–170) described as the Mohave Desert Species. The Mojave Desert Series grouping suggests an ancestral distribution along the Mojave River and its tributaries (see Blackwelder (1954) and Norris (1995) references above), prior to the development of the Transverse and Peninsular ranges (late Pleistocene) that currently border the Mojave Desert, and before arid conditions developed (Reeder and Roth 1988, p. 254).

Based on the presence or absence of certain anatomical features identified in various helminthoglyptids of the Mojave Desert region, Gilbertson *et al*. (2013, p. 63) concluded that these desert snails are "undergoing active speciation" as populations become adapted to progressively arid conditions, and other Helminthoglyptidae have been discovered and described in the Mojave Desert area beyond Willett's initial discovery in 1931 (for example, Miller 1970, entire; Miller 1981, entire). A recent preliminary genetic analysis of several helminthoglyptids using sequencing of mitochondrial genes (CO1 and 16S) concluded that the Mohave shoulderband snail belongs to a grouping (Clade 1) of the *Coyote* subgenus and is sister taxon to three other helminthoglyptid taxon found in two mountain ranges that border the western Mojave Desert (*H. micrometalleoides*, *H.* "Caliente", and *H. concolor*) (Goodward *et al*. 2017, p. 7). This study supports the name *Helminthoglypta greggi*, as originally described, based on the characteristics of its shell.

Individual Needs

A generalized life cycle for pulmonate snails is shown in Figure 4 below. The development of terrestrial snails occurs almost exclusively within the egg and hatched young snails resemble adults (Nordsieck 2016, entire).

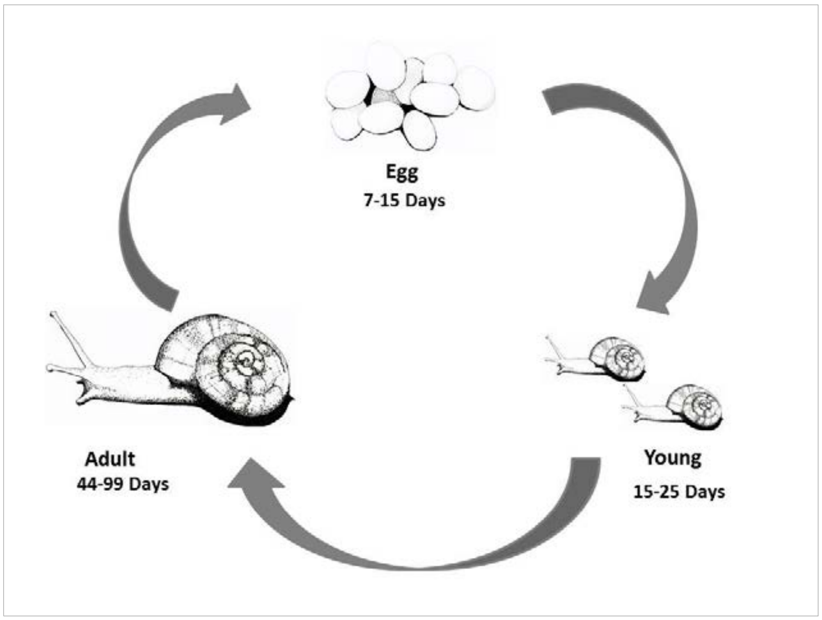

Figure 4. Life cycle of pulmonate snail.
Drawn by P. Gower; adapted from Kroll and Beecher (2016).

Individual needs related to the life history of the Mohave shoulderband snail, such as the specific physical and biological features necessary to ensure adequate dispersal patterns, clutch size, breeding age, reproductive success, and location of egg-laying, are not known. In general, the reproductive cycle of snails consists of five life stages—courtship, copulation, nest building, egg laying and development of embryo, and egg hatching—with reproductive behavior in snails initiated only when the humidity is high (80 to 85 percent) (Sallam and El-Wakeil 2012, p. 418). Biological studies of the common land snail *Eobania vermiculata* found that prior to egg laying, adult snails excavate a deep hole in moist soil, creating a circular chamber about 2.4 in (6 cm) in depth (Sallam and El-Wakeil 2012, p. 420). The eggs are then deposited and the entrance of the hole is covered with soil (Sallam and El-Wakeil 2012, p. 420). A high-elevation land snail, *Sonorella odorata*, found in the Santa Catalina Mountains near Tucson, Arizona, burrows (anteriorly) about 0.6 in (1.5 cm) below the soil surface and deposits eggs in a spiral pattern with each layer containing 6-7 eggs (Gilbertson 1969, p. 30). The egg-laying behavior of the Mohave shoulderband snail in the field has not been documented; however, eggs are likely deposited either in the soil or within small cavities in rock crevices.

Limited information related to mating behavior is available from surrogate species. Mating of terrestrial snails, in general, occurs at night, usually on soil surfaces (Salem and El-Wajeil 2012, p. 418). Pulmonate snails, such as the Mohave shoulderband snail, are hermaphrodites, in which one individual contains both male and female sex organs, while also being self-incompatible (Sallam and El-Wakeil 2012, p. 418). A hermaphrodite reproductive strategy increases an animal's chance of reproduction in areas and during times where individuals are of low density (Nordsieck 2016, entire).

Some helminthoglyptids possess a dart sac, which produces a calcareous dart that is shot into a potential mate during courtship (Gilbertson *et al*. 2013, p. 57). The dart carries a mixture of hormones that is believed to help facilitate the movement of sperm cells to the sperm pouch where they are stored until fertilization (Koene and Chase 1998a, p. 79). By influencing the female organs that are involved in the processing of foreign sperm, a snail may therefore be able to increase the chance that its sperm will successfully fertilize eggs (Koene and Chase 1998b, p. 2,319). A recent study of a hermaphroditic, dart-bearing land snail from Japan (*Bradybaena pellucida*) found that lifetime fecundity and clutch size were reduced in snails that received dart shooting by mating partners, suggesting that this reproductive behavior has an effect on long-term fitness (Kimura and Chiba 2015, pp. 3, 5). However, the strategy may also ensure "short-term fertilization success," if harming the mating partner (and thereby discouraging the recipient of the dart from mating again) allows more of the mate's eggs to be fertilized (Martins 2015, entire).

Desert snails have adapted to arid environments by developing behavioral, physiological, and morphological adaptations that ensure their survival in these dry and hot environments (Troschinski *et al*. 2014a, p. 1). In general, desert snail activity is driven by temperature and moisture to avoid dessication, and behavior patterns are seasonal (Roscoe 1961, p. 74). Desert snails are active following rainfall and also at night (Sallam and El-Wakeil 2012, pp. 422, 424).

A study of a desert-adapted land snail in southern Arizona (*Sonorella eremita*), which occupies talus slope habitat similar to the Mohave shoulder band snail, found that the fertilization and production of eggs required several days and that the eggs were held in the adult (i.e., not deposited) if rains were short-lived (Hoffman 1990, p. 10). Further, eggs did not hatch until after a soaking rain, following their development in the shell (Hoffman 1990, p. 10). For *Sonorella eremita*, the time to maturity was estimated at 3-4 years, with a reproductive life of 4-6 years, though this longevity is dependent on the relationship between the amount of time of activity (due to rainfall events) as compared to the amount of time in aestivation (Hoffman 1990, p. 10).

Because of the hot, arid conditions in the Mojave Desert, desert snails, including the Mohave shoulderband snail, are active primarily during the brief winter season (November through March). During the remainder of the year, the Mohave shoulderband snail aestivates (state of dormancy or inactivity) in deep cracks within rocky outcrops or rockslides, or in soils under rock piles, which provides protection from predators and from desiccation, using a secreted, calcareous epiphragm (flap) to seal themselves to rocks to prevent desiccation (Naranjo-Garcia 1988, p. 12; Goodfriend 1991, p. 418). Most terrestrial snails are pulmonate (have lungs for breathing), and have a respiratory pore, located on the right side of the body that closes to prevent desiccation in arid conditions (Glime 2013, p. 4-8.2). These adaptive physiological responses allow the Mohave shoulderband snail to occupy the Mojave Desert environment.

Biochemical and cellular responses to heat stress also function as physiological adaptations for desert snails. Studies of metabolic organs (e.g., hepatopancreas) in the Mediterranean snail (*Xeropicta derbentia*) (Troschinski *et al*. 2014a, p. 12), which inhabits areas with dry, hot summer conditions, demonstrate an up-regulation of heat shock protein (Hsp70) in response to increasing temperatures to protect against proteotoxic (impairment of cell function due to misfolding of proteins; see review by Parsell and Lindquist 1993) as one survival strategy. Additional research on this species also demonstrates antioxidant defense (i.e., increased catalase and glutathione peroxidase enzyme activity) in response to elevated temperatures (Troschinski *et al*. 2014b, pp. 4,400–4,401). Although we are unaware of any information on these types of responses for desert helminthoglyptids, studies have found that the Hsp70 expression levels in desert helmonthoglyptids are both species and population specific (Troschinski *et al*. 2014a, p. 12).

Behavioral responses in desert snails also help avoid desiccation and overheating. Desert helminthoglyptids are known to burrow under the soil surface under rock piles or large, flat rocks (Gregg 1961, p. 75), which provides a protective microenvironment. Desert snails will emerge near the surface of talus slopes during and following periods of rainfall, leaving their protective microhabitats in search of food resources or to otherwise move throughout their environment to engage in mating and egg-laying (Shachak and Steinberger 1980, p. 402). A study of a pulmonate desert snail from the Mineral Hills in southern Pima County, Arizona (*Sonorella eremita*) indicated that this species can aestivate for as long as 3 years, and is generally only active for 3-4 days per year (Hoffman 1990, p. 7). Similarly, a 7-year study of the desert snail *Sphincterochila zonata* in the Negev Desert in Israel found that adults were only active from 8–27 winter days annually, and aestivated during the remainder of the year (Shachak and Steinberger 1980, p. 404). Thus, the best available information from other surrogate species indicates that Mohave shoulderband snails may only be active between 3 and 27 days annually, and may aestivate in soils within rock outcrops or under large rocks for 1 to 3 years.

Mollusks feed by scraping algae and plants from rock surfaces with a chitinous radula, which is composed of rows of small calcareous teeth (Glime 2013, p. 4.8-2). Primary food sources for the Mohave shoulderband snail are not known. A study of a desert snail from a hot, arid region in eastern Riverside County, California, found that active snails preferred habitats composed of epiphyta (mosses and lichens) and smaller rocks (Wiesenborn 2003, p. 205), suggesting that the epiphyta substrate provided a source of food or moisture. Other desert snails have been found to consume lichens, mosses, algae, fungi, or other plant material (Hoffman 1990, p. 7; Yom-Tov and Galun 1971, pp. 86–87).

Although the nutritional and energy requirements for the Mohave shoulderband snail have not been studied, lichen communities, particularly saxicolous lichens, are likely food sources, and these communities are likely to be more abundant on cooler, north-facing slopes. In a 2014 petition submitted to the Service by the Center for Biological Diversity (CBD), CBD stated that the Mohave shoulderband snail was preferential to north slopes (CBD 2014, p. 11). Although we are unaware of any information as to the Mohave shoulderband snail's preferred aspect of rock outcrop and talus slopes, Knight *et al*. (2002, entire) found that lichens occupying basaltic rock environments of the Mojave Desert are found primarily on north-facing rather than south-facing slopes, likely due to availability of moisture and protection from intense radiation. Differences in species diversity of lichens were attributed, in part, to the size (height and length) of the north-facing slopes (Knight *et al*. 2002, p. 31).

Microbiotic crusts (also called biological soil crusts or biocrusts) that contain cyanobacteria or lichen are also probable sources of food for the Mohave shoulderband snail based on observations of feeding behavior of adult desert snails in Israel (Shachak and Steinberger 1980, entire). In desert environments, these crusts represent autotrophic communities (those composed of organisms that produce organic molecules for nutrition) from inorganic sources via photosynthesis or chemosynthesis (involving chemical energy) and are composed of cyanobacteria, algae, microfungi, lichens or bryophytes (mosses, hornworts, and liverworts) (Stark *et al*. 2011, p. 457; Warren 2014, p. 177). They form when filamentous cyanobacteria, algae, and fungi, and root systems from lichens and bryophytes become interwoven with soil particles, creating a stable matrix or crust (Warren 2014, p. 177). These communities perform a wide range of ecological functions, including primary production, nitrogen fixation, nutrient cycling, water redistribution, and stabilization of soils (Warren 2014, p. 177). In the Mojave Desert, the patterns of development of these microbiotic soil crust communities are influenced by microclimate, soil texture, and history of disturbance (Johansen *et al*. 2001, pp. 366–367). A study of cyanobacteria in soil crusts in the Mojave Desert described several new species of cyanobacteria, but noted that, in general, fewer taxa are found in soils in this desert region (Alwathnani and Johansen 2011, pp. 71, 86), consistent with early characterizations of poor development of these communities previously described by Johansen *et al*. (2001) given the extreme arid conditions. The best available information at this time does not indicate the extent to which biocrusts communities in the Mojave Desert region are used as a food resource for the Mohave shoulderband snail.

Predator-prey relationships in arid environments are considered to be primarily opportunistic (Louw and Seely 1982, pp. 132–133). Mammalian and avian predators of invertebrates have been described in other desert regions, including Wagner's gerbil (*Gerbillus dasyurus*) consuming the desert snail *Trochoidea (Xerocrassa) seetzeni* in the Negev desert of southern Israel (Yom-Tov 1970, pp. 907, 909), desert box turtle (*Terrapene ornata luteola*) consuming a Helminthoglyptid talussnail (*Sonorella pedregosensis*) in Arizona (Gilbertson and Radke 2006, pp. 17–18), and rodent predation of *Sonorella eremita* in Arizona (Hoffman 1990, p. 10). Snail predators can also include invertebrates such as certain types of beetles and their larvae (Gilbertson 2017, pers. comm.). A 2009 wildlife survey at Soledad Mountain reported the presence of several omnivorous mammals (antelope ground squirrel (*Ammospermophilus leucurus*), coyote (*Canis latrans*)) and various birds (common raven (*Corvus corax*), western burrowing owl (*Athene cunicularia hypugaea*), rock wren (*Salpinctes obsoletus*), loggerhead shrike (*Lanius ludovicianus*), chukar (*Alectoris chukar*)) (Sunrise Consulting 2009, p. 9). However, there is no information documenting predation of Mohave shoulderband snails.

Population Needs

The Mohave shoulderband snail has been reported from three general locations (Middle Butte, Standard Hill, and Soledad Mountain) within the western subregion of the Mojave Desert. The Mojave Desert is considered a rain-shadow desert. Moist oceanic winds flowing from the Pacific Ocean are interrupted by the Sierra Nevada and Transverse Mountain range and air is deflected upwards and cools adiabatically (cooling due to a change in air pressure), with precipitation falling on the windward slope of the mountain range and little precipitation reaching the leeward side (Louw and Seely 1982, p. 2). This loss of moisture is enhanced by compressional heating as the air mass descends into the desert region (Louw and Seely 1982, pp. 2–4).

Precipitation represents the primary climate driver in desert environments because of its scarcity and unpredictability (Louw and Seely 1982, p. 113). Precipitation in the western Mojave Desert is sparse, with an average annual precipitation (Mojave, California) of 5.93 in (15.06 cm), with most precipitation falling between November and March (Western Regional Climate Center (WRCC) 2016a). The dominance of winter precipitation in the Mojave Desert region is the result of (extratropical) cyclone or frontal activity from the North Pacific Ocean, and low winter temperature, and high summer temperature climate conditions separate this region from other U.S. southwestern deserts (Turner 1982, p. 162). In addition, the percentage of annual precipitation that falls during the winter months progressively decreases from west to east across the deserts in California (Huning 1978, p. 73), such that the western Mojave Desert region occupied by the Mohave shoulderband snail receives more winter precipitation than the Colorado Desert region (Rowlands 1995, p. 100).

Summer North American monsoon moisture and thunderstorms can also reach the Mojave Desert region (Adams and Comri 1997, p. 2,203). While highly variable, these precipitation events are often short and intense in duration, resulting in less infiltration and higher surface runoff within desert soils (Huning 1978, p. 83). However, pooling of water within rock outcrops from these rain events may provide additional moisture in these areas. In general, the eastern region of the Mojave Desert receives a higher percentage of this monsoonal rainfall than the western Mojave Desert (Huning 1978, pp. 81–82) where Mohave shoulderband snails reside, due to the influence of prevailing westerly winds and intervening mountainous terrain (Hereford *et al*. 2006, p. 18). In addition to these monsoonal events, remnants of decaying, eastern north Pacific tropical storms or hurricanes can occasionally be captured in the monsoon circulation and augment the summer precipitation totals in southern California (Tubbs 1972, p. 804; Douglas *et al*. 2004, p. 11). Both of these rainfall patterns can increase humidity levels within the normally dry desert air (Redmond 2009, p. 15). Appendix A provides additional details of temperature and precipitation patterns for Mojave, California.

Although water represents the primary limiting resource in desert environments, other factors can influence the ecology of desert species, including energy (available food) and nutrient availability (e.g., nitrogen) (Louw and Seely 1982, pp. 123–127.), and a combination of these factors can be important. For example, light (radiation), moisture, and soil structure can work together to limit the growth of algae (a potentially important food source for the Mohave shoulderband snail) to areas on soil surfaces (Louw and Seely 1982, pp. 125–126), and lichens on rocks.

A study of terrestrial snails in arid environments from southeastern Spain found that microhabitat use is affected by weather, and that humidity, not just temperature, can be important in regulating snail behavior (Moreno-Rueda *et al*. 2009, pp. 337–338, 340). This study reported that an arid-dwelling snail (*Iberus gualtieranus*) retreated to rock fissures when humidity was low, but became more active with higher humidity (Moreno-Rueda *et al*. 2009, pp. 337–338). The percent of individuals found on bare soils (the substrate likely used for mating) also greatly increased when humidity was high (Moreno-Rueda *et al*. 2009, p. 337). Therefore, it is likely that the Mohave shoulderband snail activity patterns will be affected when similar weather conditions are found in the western Mojave Desert, as described above.

The current ecological communities represented in the Mojave Desert developed around the mid-Miocene (8,000 to 5,500 years ago) after arid and drought-tolerant plant and animal species became established with warmer and drier climate conditions (Pavlik 2008, p. 212). Through a sorting of species from formerly established and more generalized vegetation, the Mohave biome is now dominated by desert scrub plant series such as creosote bush (*Larrea tridentata*), allscale salt bush (*Atriplex polycarpa*), brittlebush (*Encelia farinosa*), desert-holly (*Atriplex hymenelytra*), as well as various cacti and many endemic plants, such as the Joshua tree (*Yucca brevifolia*) (Turner 1982, p. 157). The phenological behavior (i.e., life cycle events such as flowering and growth) of many of the major plant components of the Mojave Desert ecosystem is linked to the precipitation in fall-winter months in a predictable and synchronized pattern (Beatley 1974, p. 858). Geomorphic factors such as slope, degree of exposure to sunlight and wind, underlying surfaces, including soil texture, moisture and salinity, and age of surface can also significantly influence plant community distributions in the Mojave Desert; however, steep weathered rock slopes, such as where the Mohave shoulderband snail has been observed, generally lack vascular plant cover (Huning 1978, p. 131).

Brooks and Marchett (2006, p. 151) mapped the areas surrounding the Rosamond Hills area of the western Mojave Desert as middle elevation shrubland, dominated by desert shrub plant communities. At Soledad Mountain (see location map, Figure 3), vascular plant communities surrounding the rock outcrops and talus slopes include mixed shrub and grasses, dominated by species adapted to rocky substrates and cooler conditions (Kern County Planning Department (Kern County) and U.S. Bureau of Land Management (BLM) 1997, p. 221). The lower slopes of the alluvial fans and flats consist of typical desert scrub plant communities (Kern County and BLM 1997, p. 221) including *Larrea tridentata*, and white bursage (*Ambrosia dumosa*) (Kern County 2010, p. 4.3-3). Shrubs and grasses are also found on Soledad Mountain itself (Kern County 2010, p. 4.3-3). Annual grasses and weeds are established on slopes and ridges at Soledad Mountain (Bamberg 2011, p. iii; Bamberg 2007, p. 3) as a result of previous mining activities, mineral exploration, and fires (Kern County and BLM 1997, p. 234; Kern County 2010, p. 4.3-3); similar changes are also likely for surrounding areas where mining activity historically occurred (Standard Hill and Middle Butte).

Species Needs

Limited information impacts our ability to determine with certainty the entirety of the physical and ecological needs of the Mohave shoulderband snail to best understand its rangewide abundance and distribution. Based on a few surveys (described below), this species occurs in rock outcrops or talus slopes found on geological (volcanic) formations or plugs, in the western Mojave Desert (see Figure 3) and, as described above, climatic and topographical features are important determinants of this desert snail's distribution in the western Mojave Desert. The range in elevation for the known observations of the Mohave shoulderband snail is 2,850 feet (ft) (869 meters (m)) to 4,193 ft (1,278 m) above sea level. The geological formations found in the area surrounding Soledad Mountain have been described as consolidated sedimentary and volcanic rocks (Duell 1987, Plate 1) or as extrusive and intrusive volcanic rocks (Noble 1954, Map Sheet 14). The rock types within the planned open pit mine area of Soledad Mountain are Tertiary in age, and are covered with thin alluvial and talus deposits that are Quaternary in age (Abel 1995, p. 1).

According to Wright and Troxel (1954, p. 11), the intrusive rhyolite of Soledad Mountain represents the center point of an approximate 10-mi (16.09-km) radius area of volcanism, and is surrounded by smaller volcanic plugs (Rosamond Hills, Tropico and Willow Springs Hills, and Middle Buttes). Soledad Mountain consists of rugged outcrops and ridges with intervening drainage that slopes down to the alluvial desert floor (Kern County and BLM 1997, p. S-9). On the northern side of Soledad Mountain, runoff occurs by way of gullies or channels, while ephemeral drainages direct flow off Soledad Mountain in many directions (Golder Associates Inc. 2009, p. 3). These channels can provide important pathways for pooling of water in rock outcrop areas, which may provide a benefit to the Mohave shoulderband snail. The natural rock fracture orientations (strikes and steep dips) found at Soledad Mountain explain its resistance to erosional processes, and the physical and chemical properties of the rhyolite formations at this site explain the size and structure of the material that comprise the outcrops, and therefore the preservation of these features within the surrounding flat semi-desert environment (Abel 1995, p. 1).

We are unaware of any information regarding movement and dispersal patterns of the Mohave shoulderband snail. In general, movement in land snails is determined by favorable light, moisture, and temperature conditions (Riddle 1983, p. 450). Responses to seasonal changes in photoperiodism (e.g., varying daylight) and endogenous (internal origin) circadian rhythms can also influence movement patterns in land snails (Riddle 1983, p. 451). Dispersal of juvenile or adult land snails may occur via wind transport or, alternatively, via predators (e.g., passing through a bird's digestive system intact) (Wada *et al*. 2012, p. 69). Given the Mohave shoulderband snail's tendency to stay attached to rock surfaces and their size, wind is unlikely to be a significant factor in its dispersal (Gilbertson 2016, pers. comm.). There is no information documenting dispersal of the Mohave shoulderband snail by predators.

Overall, the best available information indicates that the Mohave shoulderband snail's physical and ecological needs include:

(1) Volcanic rock outcrops (primarily rhyolite) or talus slopes in the western Mojave Desert, including, but not limited to, north-facing slopes, which provide areas of moisture and protection from intense radiation;

(2) Adequate food source, including mosses, lichens, fungi, algae or other plant materials growing on rock surfaces or within microbiotic crusts; and

(3) Adequate water availability, which provides opportunities for dispersal, particularly after precipitation events, to locate food and for locating potential mates for reproductive activities.

Status – Current Condition

This section provides an overview of the Mohave shoulderband snail's current condition, including those stressors that may be impacting the species or its habitat. In this SSA Report, we identified stressors based on impacts that may negatively affect the ecological needs of the species, including temporary or permanent impacts to habitat features that the species relies on for survival and reproduction.

Population Abundance and Distribution

Other than the limited description provided in the original discovery of the Mohave shoulderband snail, with 25 snails collected (Willett 1931, entire), we are unaware of any other information prior to 2013 describing the abundance and distribution of the Mohave shoulderband snail. Survey data provided to us in 2014 reported 15 point locations where the Mohave shoulderband snail has been observed at Soledad Mountain (see Table 1) (Curry 2014, pers. comm.). The report received does not indicate whether the live animals observed were juvenile or adults. These searches were conducted on 3 days in 2013 (March 9, April 12, and May 9) (Curry 2014, pers. comm.) following these precipitation events at Mojave, California: 0.24 in (0.61 cm) on March 8; 0.14 in (0.36 cm) on March 31; and 0.05 in (0.13 cm) on May 6, 2013 (Weather Underground 2016). Survey results provided to the Service also reported the presence of the Mohave shoulderband snail at two other rhyolite outcrops that are located within 2.0 mi (3.2 km) northwest (east side of Standard Hill) and 5.22 mi (8.4 km) west (south of Middle Butte Mine), respectively, from the summit of Soledad Mountain (Curry 2014, pers. comm.). The May 9, 2013, survey at the Rosamond Hills area (located southeast of Soledad Mountain) reported negative results at 12 point locations (Curry 2014, pers. comm.). However, all of these searches represent opportunistic surveys (i.e., not statistically-based or systematic surveys) and did not encompass all potential habitats. On November 19, 2015, and February 5 and 12, 2016, nine additional observations of the Mohave shoulderband snail at Soledad Mountain were recorded during a total of 3 days of surveys following rain events of 0.06 in (0.15 cm) on November 15-16, and 0.52 in (1.32 cm) on January 31, 2016 (Weather Underground 2016).

New surveys were conducted in January (January 11–14) and February (February 22–23) 2017 at Soledad Mountain. Those surveys used a sampling method that incorporated randomly selected areas developed by WestLand Resources, Inc. (WestLand), in consultation with the Service and others (WestLand Resources Inc. 2016, entire). The survey protocol incorporated a rainfall trigger that included: a cumulative running sum of precipitation greater than or equal to 0.5 in (1.27 cm) over a 2-week period and a minimum precipitation event that triggers a survey event (i.e., the 0.5 in (1.27 cm) running sum) that is equal to or greater than 0.2 in (0.51 cm) over a 48-hour period (WestLand Resources Inc. 2016, p. 4).

Surveys in January and February were conducted at 76 rock features, with 50 of those sites randomly selected and 26 sites opportunistically selected (WestLand Resources Inc. 2017).

Results from that survey effort reported live Mohave shoulderband snails at 31 sites, shells observed at 35 sites, and 10 sites with no evidence of the Mohave shoulderband snail (WestLand Resources Inc. 2017, p. 14). Thus, 87 percent of sites surveyed recorded either live animals or shells. These observations are summarized in Table 1 and mapped on Figure 5.

Table 1. Summary of observations of the Mohave shoulderband snail—live animals and shells.

General Location	Number of Observations	Month/Year Observed	Ownership	Current Status
Soledad Mountain[a]	15	March, April, and May 2013	Bureau of Land Management and Private	Extant
	9	November 2015, February 2016	Bureau of Land Management and Private	Extant
	66*	January and February 2017	Bureau of Land Management and Private	Extant
Middle Butte[b]	1	May 2013	Private	Presumed Extant
Standard Hill[b]	1	April 2013	Private	Presumed Extant

[a]Mix of live snails and shells; [b]Shells only
*Observations in January and February 2017 were within defined polygon areas; Figure 7 depicts centroid point for these polygons.

Surveys were also conducted off Soledad, though no evidence of the Mohave shoulderband snail (live snails or shells) were found within surveyed areas at Edwards Air Force Base, Tropico Hill (south of Rosemond Hills), and directly north of Soledad Mountain near Standard Hill (WestLand Resources Inc. 2017, pp. 4, 13, 14). However, with regard to the 2017 surveys conducted at Standard Hill, it is important to note that the geographic area surveyed on Standard Hill was limited to the western side due to land ownership restrictions (WestLand Resources Inc. 2017, p. 21). Therefore, based on the 2013 observation (from southeast location of Standard Hill), we presume that Standard Hill is likely still occupied.

In addition, the February surveys were conducted to look at locations where only snail shells were previously recorded. Live snails were reported at 50 percent of the locations re-surveyed (WestLand Resources Inc., 2017, p. 21), supporting that presence of snail shells provides good evidence for occupancy by the Mohave shoulderband snail. During February 2017 surveys, snail shells were also found on the northeast side of the mountain near Middle Butte (including Cactus Gold Mine) and snail shells were reported from several locations within two of the three survey areas (WestLand Resources Inc. 2017, p. 14, Figure 6). Therefore, based on the secondary efforts conducted on Soledad Mountain, evidence of snail shells suggests that Middle Butte likely remains occupied.

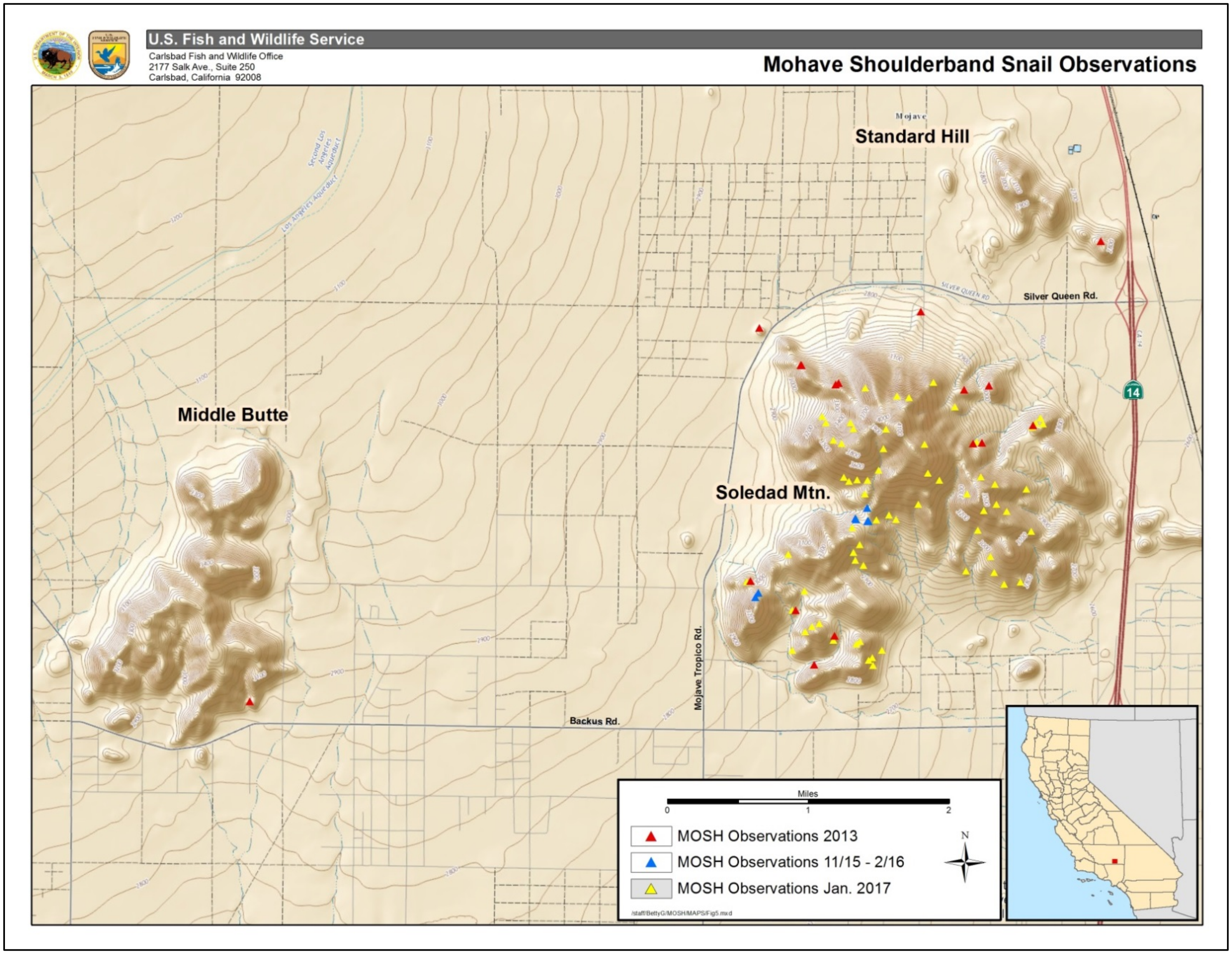

Figure 5. Observations of the Mohave shoulderband snail, western Mojave Desert, California.
Note: Due to the scale of the map, observations in close approximately to one another may not be visible.

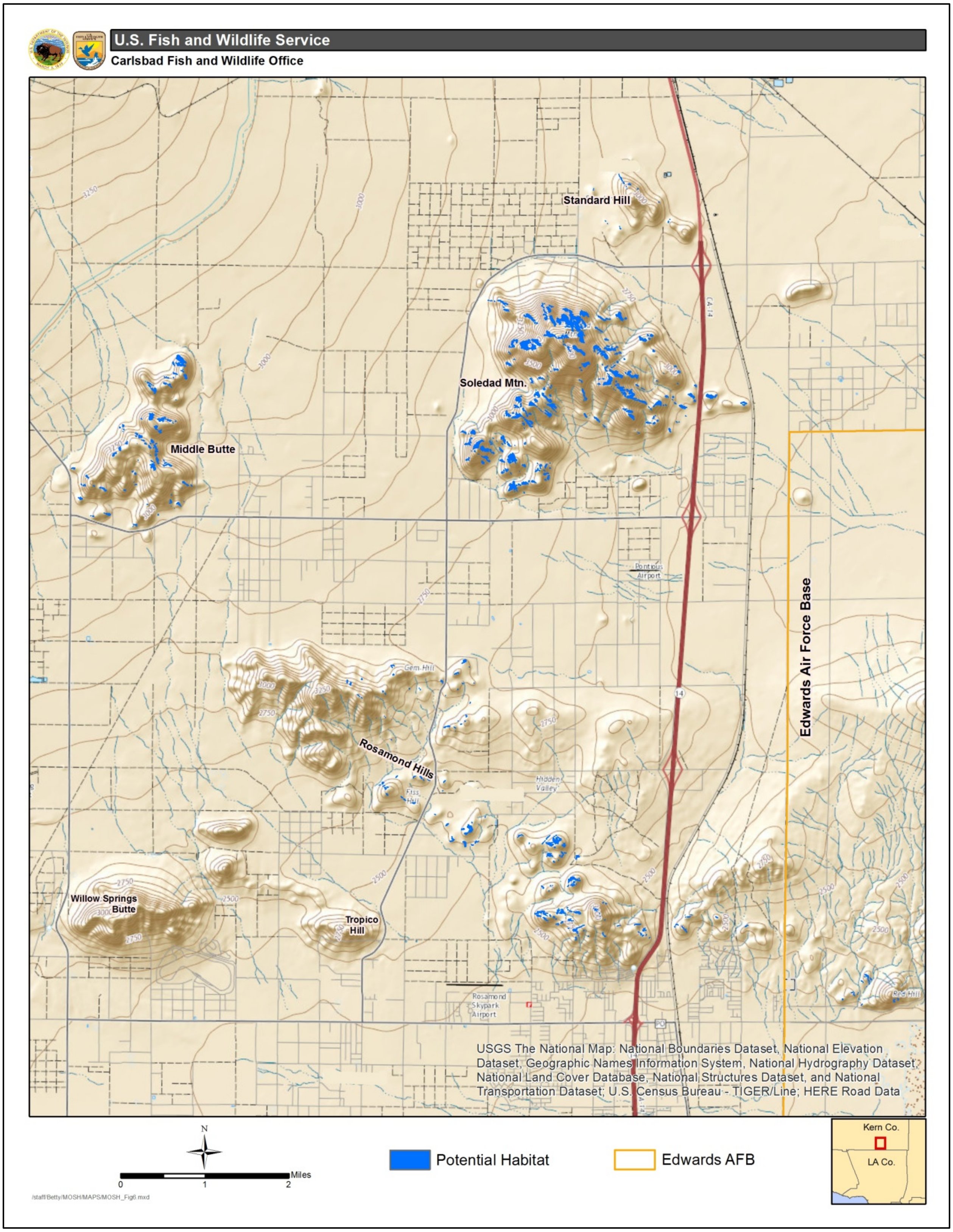

Figure 6. Potentially suitable habitat for the Mohave shoulderband snail, western Mojave Desert, California.

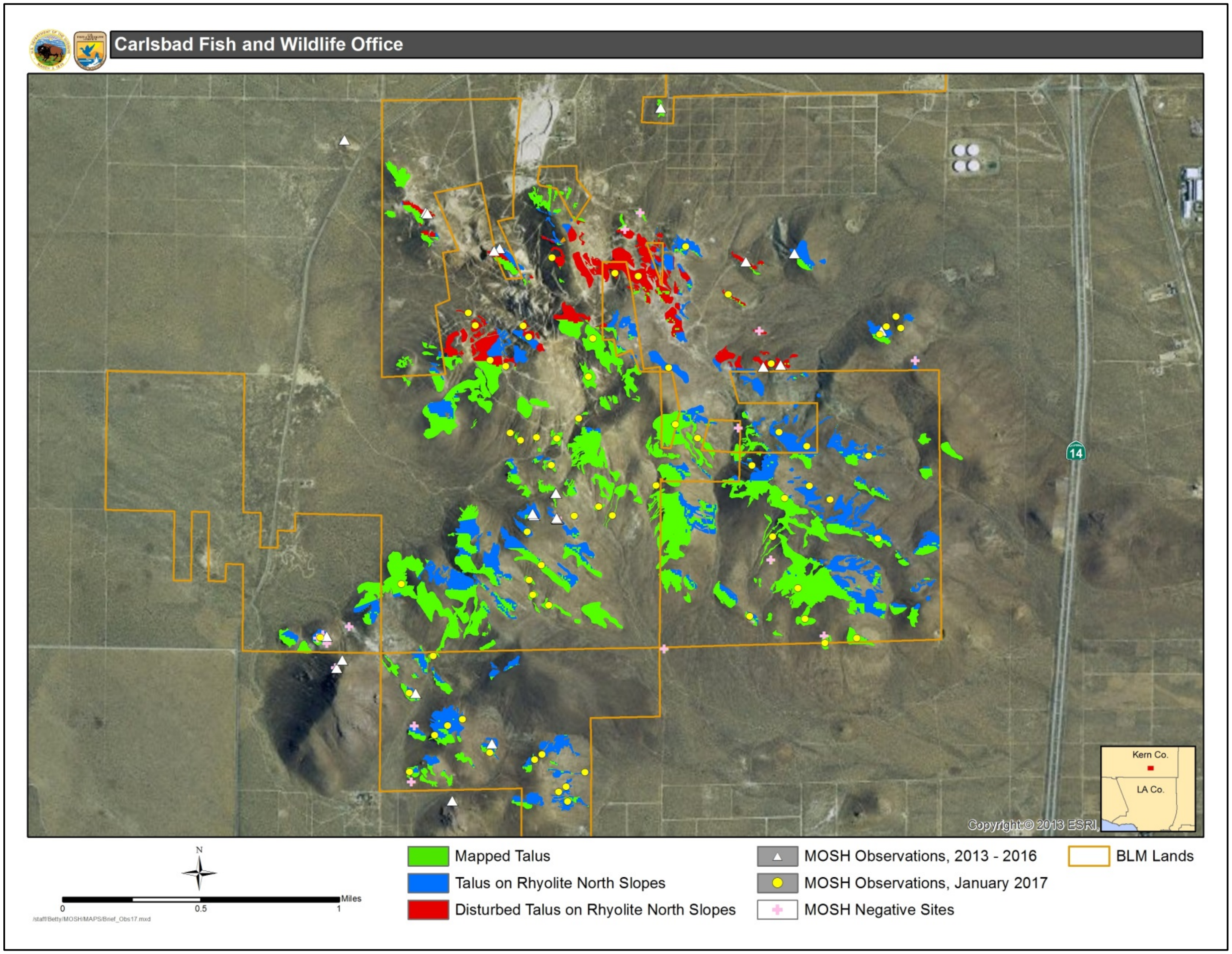

Figure 7. Potentially suitable habitat for the Mohave shoulderband snail, Soledad Mountain. Red areas are those likely to be disturbed by mining activities.

In order to estimate potentially suitable habitat for the Mohave shoulderband snail, we reviewed soil surveys and historical geological maps (e.g., Noble 1954; Dibblee 1967; Duell 1987). We used physical features described in these sources (i.e., rock outcrops; soil type Torriorthents-rock outcrop complex, very steep) and ecological needs (e.g., preference for north facing slopes) that support the species' known needs, and base maps created by WestLand (Cerasale 2016, pers. comm.) of rock outcrops. A summary of these steps and results is provided below.

- As an initial step, we chose an approximately 10-mi (16.09-km) radius from the center of Soledad Mountain based on the presence of geological features described by Wright and Troxel (1954, p. 11). We included a measure of "northness" based on a digital elevation model in this analysis in an effort to capture areas that provide refugia habitat from desert conditions and potential areas for food sources (e.g., saxicolous lichen communities). This initial mapping identified approximately 3,401 ac (1,376 ha) of potentially suitable habitat, of which 512 ac (207 ha) is found on land managed by BLM.
- We then used a base map created by WestLand, in which rock outcrops were visually identified from 2014 aerial images (at 1 ft (30.5 cm) resolution) and incorporated rhyolite geological features. Thus, using rock outcrops, "northness," and geology (rhyolite formation), we estimated **210 ac** (85 ha) of potentially suitable habitat, rangewide, with approximately 51 ac (20.6 ha) managed by BLM, 1.2 ac (0.5 ha) within Edwards Air Force Base, and 157.8 ac (63.8 ha), or 75 percent, of private lands. This modeled habitat includes 35 observations and is shown in Figure 6.
- Finally, based on more detailed mapping of talus slopes on Soledad Mountain *only*, as identified by WestLand (Cerasale 2016, pers. comm.), we added talus rock areas to the area described in the previous bullet, since potentially suitable habitat may also occur on talus slopes (Cerasale 2016, pers. comm.). We therefore estimated **187 ac** (76 ha) of potentially suitable habitat at Soledad Mountain using this refined model. This estimate includes 82 observations and is shown in Figure 7.

In sum, the potentially suitable habitat modeled here contains the physical and biological features that provide the ecological needs of the Mohave shoulderband snail. In our subsequent discussions, we report two different results based on the habitat modeling described in the second (western Mojave Desert region) and third (Soledad Mountain location only) analyses.

We also received results of a spatial analysis from personnel at Edwards Air Force Base (Watts 2016a, pers. comm.) describing potential Mohave shoulderband snail habitat based on a digital elevation model, which incorporated slope (2.25 to 42.42 percent) and northwest through northeast aspect (see map in Appendix E). Potentially suitable habitat was estimated at 13 ac (5.26 ha) for this facility (Watts 2016b, pers. comm.).

Habitat Loss/Habitat Modification or Degradation

We reviewed the best available information to identify current conditions and potential stressors that may be affecting the Mohave shoulderband snail or its habitat. Sources of this impact to the species include habitat loss or destruction resulting from hard rock mining activities, wildland fire, vegetation type conversion, and off-highway vehicles.

Hard Rock Mining

Hard rock mining, especially open pit mining, impacts land surfaces and has varying effects on groundwater, surface water, aquatic and terrestrial vegetation, wildlife, soils, air, and cultural resources (National Research Council (NRC) 1999, p. 149). In general, hard rock mining proceeds through the following phases: exploration, mine development, mining (extraction), mineral processing (beneficiation), and reclamation (for closure) (NRC 1999, p. 138). Of these phases, mine development and extraction operations generally result in the most significant impacts to wildlife habitat. Mine development activities prepare the deposit for extraction or mining, and include developing infrastructure and support facilities (NRC 1999, p. 25). For open pit mines or surface mining, the near-surface deposits are then prepared for production through removal of the overlying waste material (or overburden), which is transported to waste dumps on the surface (NRC 1999, p. 25). Extraction of the mineralized material and associated waste rock for both surface and underground mines consists of drilling, blasting, mucking/loading, and hauling (NRC 1999, p. 25). These operations result in direct impacts to the landscape and ecosystems, such as habitat loss (e.g., removal of rock) and modification (e.g., hauling roads), as well as other potential impacts, including generation of fugitive dust, soil disruption and alteration (increased erosion), and generation of noise, which can disrupt wildlife (NRC 1999, p. 30).

Hard rock mining occurs where minerals are concentrated in economically viable deposits and these ore deposits are created as variants of geologic processes such as volcanism, weathering, and sedimentation (NRC 1999, p. 23). Hydrothermal ore deposits, such as those found in the western Mojave Desert, including those within the range of the Mohave shoulderband snail, often have "haloes" of low-grade mineralization surrounding the ore, and implementation of improved mining methods (or higher prices) allows for low-grade waste rock to be processed as ore (NRC 1999, p. 136). Heap leaching processes have allowed the economic recovery of gold from low-grade ores (NRC 1999, p. 136).

Mining activity within the observed locations of the Mohave shoulderband snail began in 1894 at Standard Hill, and from 1894 to 1910 there was extensive prospecting and development at Soledad Mountain, located approximately 5 mi (8 km) south of the town of Mojave (Kern County and BLM 1997, p. 234). A second exploration and development period began in the 1930s and continued until 1942 (Kern County and BLM 1997, p. 234), with over 1 million tons of ore mined at the Soledad Mountain site between 1935 and 1942 using underground mining methods (Kern County 2010, p. 3-1). From 1942 to the late 1990s, there was little mining and exploration activity at Soledad Mountain (Kern County and BLM 1997, p. 234). The mining activities at Standard Hill and Middle Butte (gold and other precious metals) began operations in the mid-1980s (Kern County and BLM 1997, p. 268). At Middle Butte, the Cactus Gold Mine (heap-leach mining) was mined until 1992 (Kern County and BLM 1997, p. 412) and is undergoing reclamation (Kern County 2010, p. 3-12). The Standard Hill site is currently idle.

Tailings (gravel, dirt, and rocks with no gold), abandoned mine shafts and adits (tunnels driven horizontally into a hillside), accumulated waste rock and low-grade ore, non-mining wastes, and open mines from earlier mining activities are still present at the Soledad Mountain site (Kern County and BLM 1997, pp. 151, 273, Kern County 2010, p. 3-12). The historically recent and current production from the gold and silver mines in the Soledad Mountain area is from the epithermal veins and mineralized zones associated with Tertiary intrusive rock formations (McCulloch 1954, p. 23).

Soledad Mountain Project

One mining operation that occurs on Soledad Mountain has the potential to negatively impact the Mohave shoulderband snail individuals and suitable habitat. As noted above (see *Population Abundance and Distribution* section), we defined, geospatially, potentially suitable habitat across the western Mojave Desert (210 ac (85 ha), based on rock outcrops, “northness,” and geology (rhyolite formations). Using our refined geospatial model for only Soledad Mountain (incorporating mapped talus slope features), we defined a total of 187 ac (63.8 ha) (see Figure 7) at this location.

A Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was prepared by Kern County and BLM in 1997 to address potential environment impacts of the Golden Queen Mining, Co., Inc. (GQM) Soledad Mountain Project (Project) and was released for public review and comment, with a Final EIR/EIS certified for the Project in 1997 (Kern County and BLM 1997, entire). At that time, the Project was described as a surface open pit gold mine (extraction of minerals from the subsurface), processing of ore by chemical leaching, and placement of waste rock in adjacent processing and mining areas (overburden material piles) (Kern County and BLM 1997, p. S-7). The Project proposed to disturb a total of 930 ac (376 ha) within a Project area of approximately 1,690 ac (684 ha) (Kern County and BLM 1997, p. S-7). Disturbance to the upper slope area of Soledad Mountain from the Project was estimated at 560 ac (227 ha) due to excavation of the mine and the creation of the overburden material piles (Kern County and BLM 1997, p. 223). As originally described, the open pit mine would have resulted in disturbance to 265 ac (107 ha), with 44 ac (18 ha) of that total to be reclaimed (Kern County and BLM 1997, p. 95). Estimated soil loss was projected to be 910 ac (368 ha) (minus proposed salvage of 200,000 cubic yards (15,291 cubic meters)) (Kern County and BLM 1997, p. 173). Residential build-out and the proposed aggregate quarry increased the projected cumulative disturbance at the Soledad Mountain site to 1,230 ac (498 ha) over the originally proposed 15 years life of the Project (Kern County and BLM 1997, p. 224).

The Project proposed to mine up to 60 million U.S. tons (54 million metric tons) of ore and 230 million U.S. tons (209 million metric tons) of overburden materials through open pit, hard rock mining methods (Kern County and BLM 1997, p. S-10). The project design included cyanide heap leach pads (with internal solution control) to recover gold and silver from the ore (Kern County and BLM 1997, p. S-11). Although surface disturbance was anticipated to be minimized to the extent possible (Kern County and BLM, p. S-31), the Project would have permanently altered the topography at Soledad Mountain, and created mine high walls, heap leach piles, and overburden piles.

Following the Final 1997 EIS/EIR, additional environmental studies (e.g., air quality emissions and health risk assessments, update to biological resources and hydrology/water quality assessments), financial evaluations, and feasibility analyses were prepared by the GQM, which resulted in engineering and design changes to the Project. In response to a new application to Kern County for a revised Surface Mining and Reclamation Plan, a Draft Supplemental EIR (SEIR) for a Revised Project was prepared by the lead agency, Kern County (Kern County 2010, entire). The Revised Project Draft SEIR addressed new information from additional studies related to changes in the Surface Mining and Reclamation Act (SMARA) of 1975, such as backfilling of mined-out phases of the open pit, State of California climate change legislation, and detection of the western burrowing owl (*Athene cunicularia hypugaea*) (Kern County 2010, pp. 2-9–2-10). The Revised Project included modifications to locations of facilities, and design modifications and new technologies (Kern County 2010, p. 1-12) and resulted in a reduction of 144 acres (58 ha) from the original proposed Project. Appendix C provides a map illustrating primary changes in the footprint of the 1997 Project and the Revised Project. As with the original Project, the topography of Soledad Mountain within disturbed areas will be permanently altered by the Revised Project (Kern County 2010, p. 5-6).

As shown in Figure 8, the Revised Project will encompass 12 years of open pit mining in phases (Phases 1 through 5). With additional activities (leaching, aggregate production) overlapping mining actions, and reclamation and post-closure monitoring, the total time period from construction to reclamation is approximately 30 years (Kern County 2010, p. 1-7). Construction of the Revised Project began in 2013; the GQM has been actively operating since late 2015, and pouring gold since March 2016 (Clay 2016, pers. comm.)

Within Soledad Mountain, the site of the approximate 1,440-acre (583-ha) Revised Project is located within 2,500 acres (1,012 ha) of land owned or otherwise under the control of GQM (Kern County 2010, p. 3-15). This acreage consists of private lands (fee land and patented lode mining claims and millsites) (approximately 72 percent) and Federal lands (unpatented mining claims and millsites) administered by the BLM (28 percent) (Kern County and BLM 1997, p. S-7; Norwest and Amec 2012, p. 4-1). Either through direct ownership or mining lease agreements with landholders, the GQM controls a total of 33 patented load mining claims, 134 unpatented lode mining claims, 1 patented millsite, 12 unpatented millsites, and 1 unpatented placer claim and approximately 980 ac (396 ha) of fee land (also referred, collectively, as the Property) (Norwest and Amec 2012, p. 1-2).

The Revised Project mining activities are essentially the same as the previously proposed Project—an open pit mining operation using conventional open pit methods (including drilling, blasting, loading and hauling), and cyanide heap leach and Merrill-Crowe processes to recover precious metals (gold and silver) from crushed ore (Kern County 2010, pp. 3-21, 3-25). These methods are described in more detail in the 2010 Draft SEIR (Kern County 2010, pp. 3-25–3-31). The Revised Project is now estimated to mine 108.4 million tons (98.34 million metric tons) of waste rock, and 51.2 million tons (46.45 million metric tons) of ore (Kern County 2010, p. 3-4).

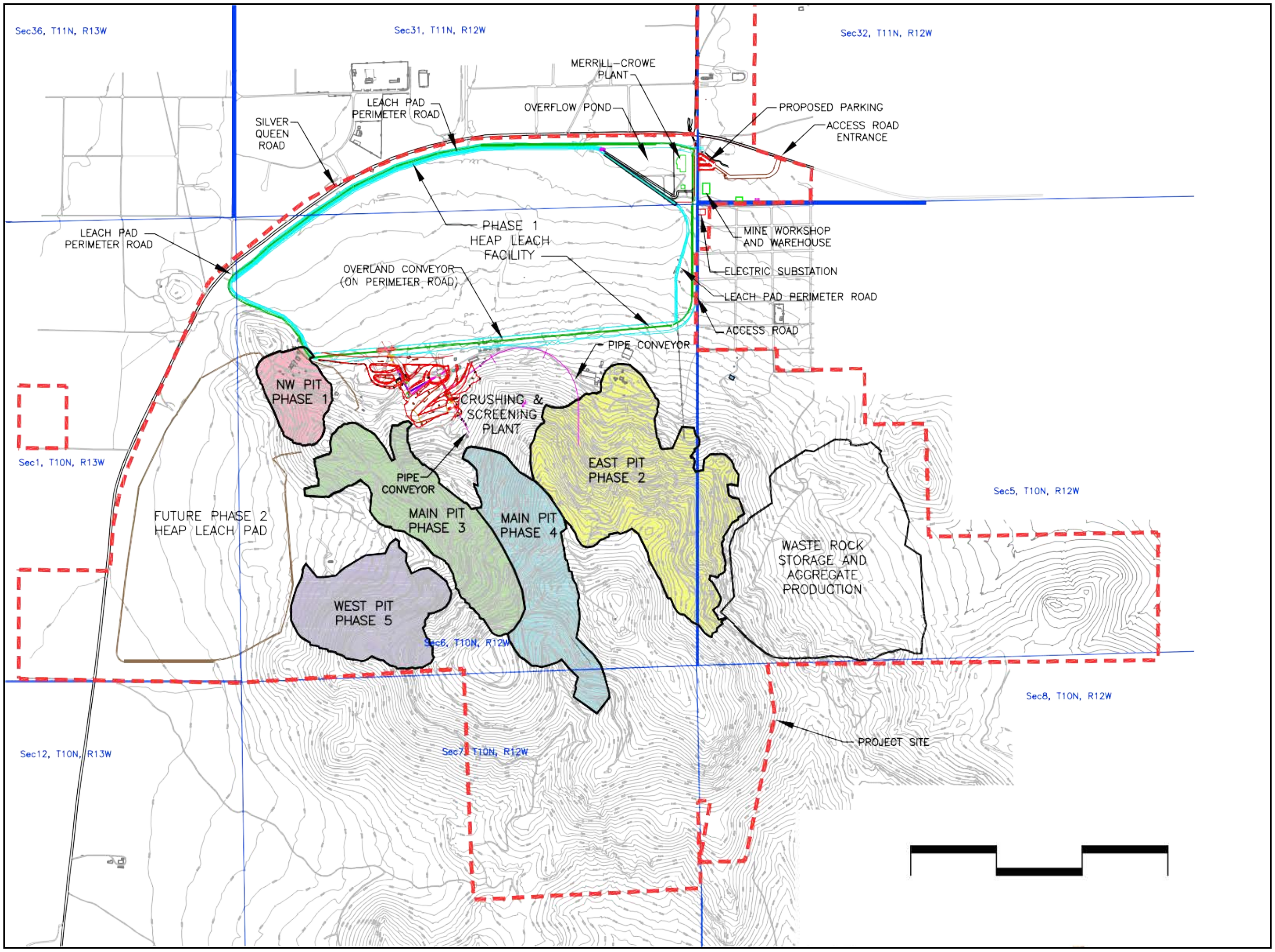

Figure 8. Open Pit Mining Phases at Golden Queen Mine, Soledad Mountain.
Source: Kern County Planning Department, 2010.

Overall, open mining pit areas for the Revised Project are projected to disturb approximately 242 ac (98 ha) (Kern County 2010, Appendix B, Attachment O, Table O-3 Proposed Disturbance). However, the collective area to be disturbed by mining, waste rock disposal, the construction of the heap leach pads and the heap, and associated facilities is approximately 912 ac (369 ha) of which approximately 835 ac (338 ha) will be reclaimed during and at the end of the mine life (Norwest and Amec 2012, p. 4-1).

Mining activities will result in the loss or modification of several (but not all) rock outcrops or talus slopes found on Soledad Mountain. This area is currently considered to be occupied or potentially occupied habitat for the Mohave shoulderband snail. Loss of biocrusts and other food sources is likely to occur due to construction activities related to the Golden Queen Mine Revised Project at the Soledad Mountain location. Although we are unaware of any biocrust salvage actions planned for the Soledad Mountain location, reestablishment of these communities through salvage of desert biocrusts is known to be successful within 2 years when used as an inoculant after disturbance in the eastern Mojave Desert (Nevada) (Chiquoine *et al*. 2016, p. 1,266).

Potentially Suitable Habitat Affected by Mining Activities

Based on our geospatial analyses to determine potentially suitable habitat (described above) for the Mohave shoulderband snail (210 ac (85 ha)), we determined the habitat loss or modification (disturbed or degraded areas) expected after completion of all five phases of the GQM project (see Figure 8). We estimated 40.8 ac (16.5 ha) of potentially suitable habitat would be lost, or 19.4 percent. Of this acreage, 5.3 ac (2.2 ha) or 2.5 percent is found on lands managed by BLM (see Figure 6).

We also overlaid the GQM project footprint (all five planned phases) for Soledad Mountain only, incorporating the talus slope features (provided by WestLand Resources, Inc.; Cerasale 2016, pers. comm.) in our defined geospatial habitat features (rock outcrops, "northness," and geology). At Soledad Mountain, we estimated 48 ac (19.4 ha) or 25.7 percent of this refined potentially suitable habitat would be disturbed or lost to mining activities, assuming all of the modeled habitat is occupied. Of the 48 ac (19.4 ha), 6 ac (2.4 ha) are lands managed by BLM. Thus, 87.5 percent of estimated suitable habitat on Soledad Mountain is considered private land and encompasses 22.5 percent of the total habitat estimated to be disturbed from mining activities (see Figure 7). The habitat loss on Soledad Mountain encompasses 15 of the 90 Mohave shoulderband snail observations at this location.

We also evaluated the best available information to determine if there are any additional mining activities within the Mojave/Rosamond Hills areas of Kern County. We discovered two additional proposed projects: Blue Eagle Lode Mining Company at the Cactus Queen mine (Middle Butte), and California Portland Cement Company 9 mi (14.5 km) to the northeast of Soledad Mountain (Cates 2016, pers. comm.). The Blue Eagle Lode Mining Company (owner of the Tropico Gold Mine near Rosamond) is reopening *underground* mining operations at the Cactus Queen mine (Cates 2016, pers. comm.). The proposed surface development activities (stormwater pond, water tanks, stockpile areas for ore and waste rock, access roads, and office and shop trailers) for the Cactus Queen mine are anticipated to disturb approximately 2.45 acres

(0.99 ha) of a total of 260 ac (105 ha), of which 200 ac (81 ha) has been previously disturbed from historical mining activities (Kern County 2014, p. 28). The California Department of Fish and Wildlife determined that the project will not include any new surface disturbance of special-status species habitat (Kern County Planning and Natural Resources Department 2016, Letter contained in Exhibit A). The California Portland Cement Company is in the early environmental review phase. The company has applied for an expansion of its operations in the Mojave Desert (Cates 2016, pers. comm.). The footprint of that proposed expansion does not incorporate the geological features (volcanic plugs) where the Mohave shoulderband snail has been found. Based on this information, neither of these two proposed mining operations is anticipated to impact the Mohave shoulderband snail or its habitat.

Reclamation and Other Conservation Measures at Soledad Mountain

Most of the historical mining features at Soledad Mountain will be removed or reclaimed (Kern County 2010, p. 3-1), including disturbed areas both outside and within the Revised Project area (Kern County and BLM 1997, p. 88). A revised Surface Mining and Reclamation Plan and an updated Revegetation Plan (Bamberg 2007, entire) were prepared as part of the Draft SEIR (see Appendix B in Kern County 2010), and activities described within those plans are intended to return the heap leach facility and waste rock dumps/piles to open space and wildlife habitat post mining land use (Kern County 2010, p. 3-31; Kern County 2010, Appendix B, Attachment H, pp. 9-5–9-7). Because surface drainage at the Revised Project site will be altered, a Site Drainage Plan (Golder Associates Inc. 2009, entire) has also been prepared that includes design features to reduce impacts and all runoff will be routed either into open pit areas or to sediment ponds on the Revised Project; thus, no runoff diversion from the Project area is expected for areas outside the limits of disturbance (Golder Associates Inc. 2009, p. 2). As an example, runoff from areas of mining will be separated from runoff from non-mining areas, and the SMARA reclamation plan now incorporates a Stormwater Pollution Prevention Plan (Kern County 2010, pp. 3-43, 3-45).

The Reclamation Plan for the Soledad Mountain Project also describes the recontouring of the pit areas with the goal of producing slopes that mimic former topographical features (Kern County 2010, Appendix B, entire). The re-sloping will incorporate ripping and dozing patterns will be used on surfaces typical of those that have been conducted at other mining operations in the California deserts (Golder Associates Inc. 2009, p. 15). This micro-contouring is designed to create micro-basins that can trap moisture and seeds (Golder Associates Inc. 2009, p. 15). Appendix D provides an example cross-sectional illustration of post-reclamation contouring at Soledad Mountain.

Representatives from the GQM developed a conservation plan for the Mohave shoulderband snail at Soledad Mountain. Biological objectives were developed and the plan will be implemented in a way that is consistent with the long-term conservation of the Mohave shoulderband snail (GQM 2017). Conservation efforts focus on protecting habitat through management of suitable habitat within four conservation areas where the Mohave shoulderband snail occurs in order to ensure the long-term persistence of the Mohave shoulderband snail.

GQM identified four “Snail Conservation Areas” in the conservation plan (see Appendix F). GQM is proposing a total of 393 ac (159 ha) for conservation of the Mohave shoulderband snail, which contains 97 ac (39.25 ha) of rock features. Approximately 57 ac (23 ha) of the total (393 ac (159 ha) are located on private lands and 336 ac (136 ha) are located on BLM-administered lands (GQM 2017, p. 19).

Overall, mining activities across the range of the Mohave shoulderband snail, including the active mining underway at Soledad Mountain, represent a negative impact to the species. The best available information indicates that the only mining activity that could result in loss or modification of habitat is the GQM Project, which is expected to result in the permanent loss of 19.4 percent (40.8 ac (16.5 ha)) of the rangewide potentially suitable habitat identified for the Mohave shoulderband snail. The remaining 169.2 ac (68.5 ha) of the 210 ac (85 ha) of potentially suitable habitat identified for the Mohave shoulderband snail is not likely to be disturbed by mining activities.

Wildland Fire

Wildland fire in desert ecosystems, while relatively uncommon due to lack of fuels, can impact desert plant communities. Wildland fires that burn through nonnative grass communities can burn at higher temperatures and are of particular concern for desert ecosystems (Waters 2011, p. 27). Post-fire impacts observed in southern Nevada shrubland communities (6 fires over 1–17 years) included lower soil water content, higher soil temperatures, higher soil pH, and reduced organic matter (Lei 1999, pp. 111–112). In addition, wildland fire has been shown, at least in forested landscapes (central Arizona) to increase the susceptibility of boulders to post-fire weathering and erosion processes (Dorn 2003, p. 155). This can result in less shading of soils and create soils with reduced interstitial space (Waters 2011, p. 27). Individually and collectively, these factors may negatively impact the ecological needs of the Mohave shoulderband snail. However, Blackwelder (1927, entire) found a large difference in the capacity of various rocks to resist temperature changes; that is, most susceptible rocks, such as volcanic glass, tolerated sudden temperature changes of more than 200 °C (392 °F), and most igneous rocks can tolerate repeated sudden heating or cooling within a range of more than 200 °C (392 °F), and can endure slow heating and slow cooling through a range of 400 to 600 °C (752 to 1112 °F); more resistant rocks, such as acidic granite and quartzite, can tolerate slow temperature changes of 800 °C (1472 °F) (Blackwelder 1927, p. 138). The rock outcrops and talus slopes occupied by the Mohave shoulderband snail are primarily composed of rhyolite, a type of igneous rock formation, and quartz, and are therefore relatively resistant to the effects of high temperatures caused by wildland fire.

Historically, fires occurred infrequently in the Mojave Desert region (Brooks and Matchett 2006, p. 148). A biological and soil resource assessment in 1995 (Bamberg 1995, pp. 3, 19) noted that past fires had affected plant communities at Soledad Mountain. We reviewed the available fire history for California from 1878–2015 within our defined rangewide potentially suitable habitat for the Mohave shoulderband snail. There were four reported fires from 2003 to 2012 within this rangewide area, with three of those at the Soledad Mountain location (see Appendix G). Two fires were related to human activities (target shooting), one was caused by a lightning strike, and one had an unknown ignition source. The areas burned ranged from 43 ac (17.4 ha) to a lightning caused fire of 443 ac (179.3 ha) (Backus Fire in 2003 on BLM land), for a total of 631 ac (255.4 ha). The areas burned by fires reported in 2008 and 2013 (both ignited by recreational shooting) were located, in part, on Mohave shoulderband snail potentially suitable habitat; however, Mohave shoulderband snails were subsequently observed within these two fire perimeters in January 2017 (Cerasale 2017, pers. comm.). BLM managers have identified a small area on BLM land just to the south of Soledad Mountain where recreational shooting has been documented (Symons 2017, pers. comm.). However, that area is not located within potentially suitable habitat for the Mohave shoulderband snail. Remediation of the site is currently being planned by BLM (Symons 2017, pers. comm.).

As part of GQM's Surface Mining and Reclamation Plan, the mining operation at Soledad Mountain incorporates an overall fire protection system including a firewater loop, with hydrants at key locations, and three firewater storage tanks with capacities of 20,000 gallons (75,725 liters) each, which store water exclusively for fire protection and supply the firewater loop in the crushing/screening plant area (GQM 2009, p. 17.b.-1).

The BLM's Desert District Fire Plan for the Antelope Valley (2012) contains several fire management and objective strategies, including wildland fire suppression (Woods 2017, pers. comm.). Suppression of all fires in areas outside of the urban interface will occur at 10 acres, at a 90 percent success rate. In addition, fire response strategies are tailored to potential constraints such as critical habitat for wildlife, and threatened and endangered species, including the protection of sensitive sites from damage caused by heavy equipment (Woods 2017, pers. comm.). In addition, the 2016 Desert Renewable Energy Conservation Plan (DRECP) Land Use Plan Amendment to the California Desert Conservation Area Plan outlines several conservation and management goals and objectives that promote the ecological processes in this region that sustain vegetation (BLM 2016, p. 71). This includes maintaining or reestablishing a fire regime that supports native vegetation types (BLM 2016, p. 72).

Based on our analysis of fire history incidence over the past 100-plus years, rangewide impacts to the Mohave shoulderband snail are not likely. This is due, in part, to the reduced potential of human-ignition wildland fires because of the difficulty in accessing the talus slopes and rock outcrop habitat occupied by the Mohave shoulderband snail (e.g., fencing at Soledad Mountain, isolated and rugged terrain), the sparseness of vegetation and resistance of igneous rocks to fire, and the life history of the species (e.g., dormancy in soils or under rocks during much of the year), as well as ongoing fire suppression and vegetation management strategies in the Mojave Desert region.

Vegetation Type Conversion

The presence of invasive, nonnative plant species, particularly in combination with one or more activities or conditions, such as mining, livestock activity, wildland fire, drought, and anthropogenic atmospheric pollutants (particularly nitrogen compounds) can cause a shift from native plants towards a nonnative plant community and result in vegetation type conversion. For example, vehicular traffic associated with mining operations, both on and off mining sites, can disperse nonnative plant species into active mining areas (NRC 1999, p. 163). Colonization of nonnative species in desert regions, particularly fire tolerant grasses, can result in a reduction of available moisture to native vegetation in an already arid environment and may affect soil moisture needed for aestivation and reproductive needs of desert snails (Waters 2011, p. 27).

Additionally, a nonnative annual plant–wildland fire feedback loop, due to suppression of regrowth of native vegetation by rapidly colonizing fire tolerant grasses (Waters 2011, p. 27), can sustain the type conversion of vegetation found between areas considered potentially suitable habitat (i.e., rock outcrops and talus slopes) for the Mohave shoulderband snail. However, as discussed above in the Wildland Fire section, impacts to the species are not likely to be severe because of their occupancy below the surface within rock outcrops and talus slopes that are relatively resistant to the effects of high temperatures caused by fire.

Climate changes (discussed below under the Status–Future Conditions section), such as drought, may also play a role in vegetation type conversion process. Tagestad *et al*. (2016, entire) developed a classification of precipitation regimes for the Mojave Desert, finding that the area occupied by the Mojave shoulderband snail is within a high winter/low summer precipitation regime, which has been the consistent regime since at least 1905 (Tagestad *et al*. 2016, p. 393). Invasive, nonnative annual grasses, such as red brome (*Bromus madritensis* ssp. *rubens*), established under this precipitation pattern (i.e., abundant winter rainfall) can also increase the fire frequency in the western Mojave Desert in California (Lambert *et al*. 2010, p. 30). However, as discussed above in the Wildland Fire section, because the Mohave shoulderband snail aestivates for most of the year within a rocky habitat during the warmer and drier time of year, we would not expect fire to have a substantial impact to the species.

At Soledad Mountain, implementation of the Surface Mining and Reclamation Plan and an updated Revegetation Plan (Bamberg 2007, entire) for the Revised Project (see Hard Rock Mining section above) is expected to alleviate the effects of vegetation type conversion from habitat disturbance. For example, the tops as well as the sides of the waste rock dumps will be reclaimed, and the crests of the waste rock dumps will be reworked so that these areas will blend with the natural topography (Bamberg 2007, p. 16). Revegetation will proceed using locally adapted seed that is broadcast by hand or applied using aerial seeders, and adjusting the seed mix base on altitudinal zones (Bamberg 2007, pp. 9–14).

Conservation and management actions are also identified in the BLM's DRECP Land Use Plan Amendment to the California Desert Conservation Area Plan (BLM 2016, entire), which encompasses lands identified as potentially suitable habitat for Mohave shoulderband snail on Soledad Mountain and surrounding areas that are managed by BLM. These include: (1) Minimizing or preventing new infestations of invasive plants, and, where feasible in target areas, decreasing from existing conditions those invasive plant species that negatively affect vegetation types; and (2) maintaining or reestablishing a fire regime that supports native vegetation types (BLM 2016, p. 72), as noted above. Outside of this area, vegetation type conversion of potentially suitable habitat is expected to continue on private lands. While vegetation type conversion may be a potential stressor, it is not likely to have a significant impact to the Mohave shoulderband snail within the rock outcrops and talus slopes identified as potentially suitable habitat.

Off-Highway Vehicle Activity

Off-highway vehicle (OHV) activity can degrade desert habitat due to destruction of plants and disturbance and compaction of desert soils. The best available information indicates that OHV activity is currently limited within the areas where the Mohave shoulderband snail is known to occur. At Soledad Mountain, private lands managed by the GQM are restricted from these activities (e.g., fencing, security patrols). A survey in 2009 for presence of the federally-threatened desert tortoise (*Gopherus agassizii*) in the area surrounding Soledad Mountain found little evidence of OHV traffic (Sunrise Consulting 2009, p. 8). Although some OHV activity may be occurring on private lands at the Middle Butte and Standard Hill locations, these activities are generally found on the desert floor and are not occurring at the species' preferred microhabitat (e.g., rock outcrops and talus slopes); that is, these terrain features are not suitable for OHV activity. Based on the best available scientific and commercial information, OHV activity is not considered a stressor to the Mohave shoulderband snail or its habitat.

Disease or Predation

No diseases resulting from pathogenic agents are described for the Mohave shoulderband snail. However, a number of potential pathogens (bacteria, viruses, fungi, parasites) are known to negatively affect terrestrial snails and slugs (Wilson 2012, entire). Nematodes are the most studied group of parasites relative to terrestrial mollusks; however, with the exception of *Phasmarhabditis* spp., most parasitic nematodes do not result in significant harm to host snails or slugs, though it is speculated that their presence may serve as a check on population growth (Wilson 2012, p. 434). Gastropods are able to produce distinct immunological responses to various pathogens, but, as a group, studies of their immunology are limited (Loker 2010, entire). At this time, based on the best available scientific and commercial information, disease is not a stressor to the species.

As noted above (*Individual Needs* section), several potential predators have been observed in the Soledad Mountain location of the Mohave shoulderband snail; however, no observed predation has been observed for the Mohave shoulderband snail. Given the species life history (i.e., occupying rocks and crevices, burying in soils, and limited seasonal activity), predation is not considered a stressor to the Mohave shoulderband snail at this time, other than the potential to impact a few individuals. There are no conservation measures in place to reduce potential impacts associated with disease or predation.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Scientific Collecting Permits (SCPs) are required by the State of California for the take, collection, capture, mark, or salvage for scientific, educational, and non-commercial propagation purposes any plant or animal life in the state (California Fish & Game Code § 1002(a), 14 CCR 650). Currently, only one person is authorized through the SCP process to conduct research on the Mohave shoulderband snail throughout its range (e.g., protocol surveys, marking, captivity, sacrifice); no additional applications have been submitted to California Fish and Wildlife (CDFW) with a specific request to work on Mohave shoulderband snail (Miner 2016, pers. comm.). However, many researchers have SCPs with broad authorizations and conditions to capture, handle and release, and sacrifice limited voucher specimens per location for the purpose of identification, for all non-listed terrestrial and vernal pool invertebrates throughout California (Miner 2016, pers. comm.). A review of most Report of Specimens Captured or Salvaged forms by CDFW has not indicated an interest in collecting or otherwise taking this species by these permittees (Miner 2016, pers. comm.). In summary, and given the relatively remote locations of the Mohave shoulderband snail, restricted access (e.g., Soledad Mountain) to areas where it has been observed, the difficulty in locating live animals and its limited activity, overutilization for commercial, recreational, scientific, or educational purposes is not considered a stressor to the species.

Summary of Current Conditions

Although there is limited rangewide survey information, based on the best available information, the Mohave shoulderband snail has occurred historically and currently at three locations within one geographic area in the western Mojave Desert—Soledad Mountain, Middle Butte, and Standard Hill, with a total, as of January 2017, of 91 observations. Rangewide, potentially suitable habitat, as determined by the physical and ecological features and the species' ecological needs, is estimated at 210 ac (85 ha). Overall, the primary current impact to the Mohave shoulderband snail is hard rock mining, which affects a portion of its habitat within one of the three locations where the species has been observed. Based on our rangewide geospatial analysis (see discussion in *Population Abundance and Distribution* section), we determined that habitat loss or habitat modification from gold and silver mining activities is expected to result in the loss of 40.8 ac (16.5 ha) or 19.4 percent of the rangewide 210 ac (85 ha) estimated Mohave shoulderband snail potentially suitable habitat. [Note: Using a refined model specifically for Soledad Mountain that incorporates talus features, the expected loss is 48 ac (19.5 ha).]

Other potential impacts that may result in modification, degradation, or loss of habitat or loss of individuals include OHV activity, wildland fire, and vegetation type conversion. We determined that in all locations where the species has been observed, OHV activity is not likely to impact rock outcrops that support the Mohave shoulderband snail. Due to the Mohave shoulderband snail's life history characteristics and its rocky habitat and the wildland fire suppression and nonnative plant control measures being implemented on private lands under the control of the GQM, and on lands managed by the BLM in the Mojave Desert, wildland fire and vegetation type conversion are not likely to substantially impact the Mohave shoulderband snail. This species has been observed in areas on Soledad Mountain previously burned by wildland fires. The best available information indicates that disease, predation, and overutilization for commercial, recreational, scientific, or educational purposes are not considered stressors to the species. Of all the stressors evaluated, mining activity is likely to have the greatest impact on the Mohave shoulderband snail, resulting in loss or modification of up to 19.4 percent (40.8 ac (16.5 ha)) of the species' rangewide, potentially suitable (modeled) habitat. The remaining 169.2 ac (68.5 ha) of the 210 ac (85 ha) of potentially suitable habitat for the Mohave shoulderband snail is not likely to be disturbed by mining activities.

Status – Future Conditions

The future timeframe evaluated in our analysis is approximately 40 to 50 years, which captures the range of time periods for proposed projects within the species' range, as well as our best professional judgment of the projected future conditions related to climate change, wildland fire conditions, or other potential cumulative impacts.

After considering the current conditions for Mohave shoulderband snail and its habitat, we describe here three circumstances that could potentially result in the most likely future conditions scenario:

- Mining impacts for the GQM Project will continue for about 12 years on a portion (40.8 ac (16.5 ha) or 19.4 percent) of the rangewide modeled suitable habitat on Soledad Mountain,
- Wildfire and vegetation type conversion may continue to modify suitable habitat, and
- Climate change effects (i.e., significantly elevated temperatures, significantly decreased precipitation, extended drought conditions beyond the historical norm) may modify suitable habitat, which could also change the scope of the wildfire and vegetation type conversion stressors.

Based on our review of the best available information, we determined that there were no other scenarios that were likely to occur for this species.

Mining, Wildfire, and Vegetation Type Conversion

In the previous section, we identified mining activities, wildfire, and vegetation type conversion as stressors may be currently impacting the Mohave shoulderband snail or its habitat. The best available information suggests that these stressors may also occur into the future, resulting in a similar scope of impacts to individual snails as currently occurring, including the potential for loss of habitat and reduced food sources. These impacts are projected to affect individuals at the Soledad Mountain location, but are not likely to have an impact at the population or rangewide scale. Additional information is provided below regarding potential wildland fire impacts in the future.

Wildland Fire

As stated in the wildland fire discussion under Status–Current Condition above, wildland fires that burn at high temperatures can result in impacts to physical and chemical properties of desert soils, including loss of interstitial spaces important for soil moisture and movement of the Mohave shoulderband snail. Wildland fire can also increase nonnative grasses and result in loss of moisture to native vegetation, creating a shift in nonnative vegetation. It is reasonable to assume that these types of impacts could occur in the future given the likelihood of wildfire across the landscape, such as from lightning strikes.

Van Linn *et al*. (2013, entire) developed fire risk predictions for a region of the northeastern portion of the Mojave Desert. Their modeling of wildland fire risk was based on estimated fuel loadings (using vegetation index, elevation, and climate variables) in combination with spatial modeling of fuels (to represent factors such as fuel moisture or vegetation) (Van Linn *et al*. 2013,

p. 771). The resulting fire risk model was relatively accurate in predicting fire occurrences for this area, which predicated that those areas with low to moderate fuel loads and moderate fuel moisture had the highest fire risk (Van Linn *et al*. 2013, p. 775). The authors note, however, that the fuel load model described only about 29 percent of the variability (thus, unexplained variation is relatively high), and that this type of spatial modeling would need to be adapted before being used as a management tool to identify areas of potential high fire risk in other regions of the Mojave Desert, particularly where invasive and nonnative grasses species occur (Van Linn *et al*. 2013, p. 776). Thus, this future wildland fire risk projection may not be applicable to the locations where the Mohave shoulderband snail has been observed.

Alternatively, using a county-level analysis, Baltar *et al*. (2014, entire) evaluated how changes in temperature and population influenced the burn area and number of wildland fires. Using regression modeling methods, they found that, for all months and all California counties, increases in temperature were associated with total area burned and number of observed wildland fires, particularly for inland regions (Baltar *et al*. 2014, pp. 401, 404). However, these authors noted that the model fit for the data to estimate the response for the number of fires across all county-years only explained 40 percent of the observed variance, and the variance for the total area burned model was even less (0.3 percent) (Baltar *et al*. 2014, p. 404). The authors caution that this study evaluated a relatively short time period (17 years) with incomplete data sets and conclude that additional studies, including within the western Mojave Desert region where the Mohave shoulderband snail is found, are needed to confirm the generalizability of their results (Baltar *et al*. 2014, p. 404).

Pursuant to BLM regulations (43 CFR 1610.5-5), the 2016 DRECP Land Use Plan Amendment (LUPA) to the California Desert Conservation Area Plan approved as part of the DRECP does not expire and will remain in place until amended through future land use planning efforts (BLM 2016, p. 10). The DRECP LUPA identifies conservation and management measures to support ecological processes, including maintaining (or reestablishing) a fire regime that supports and sustain vegetation types (BLM 2016, p. 72). Mandatory land reclamation activities at the Soledad Mountain location due to impacts from the GQM (see *Reclamation and Other Conservation Measures at Soledad Mountain* section above) will also help reestablish native vegetation and mitigate fire risk by reducing fuel loads caused by nonnative grasses.

In conclusion, future projections for the risk of wildland fire in the western Mojave Desert do not currently present a clear trend in either the extent or number of wildland fires. Wildland fires within potentially suitable habitat for the Mohave shoulderband snail over the past 100-plus years have been infrequent and the future risk is expected to be relatively low due to limited fuels and inaccessibility, and ongoing conservation and management measures.

Climate Change Effects

In this section, we consider climate changes that may affect environmental conditions that the Mohave shoulderband snail relies on. As defined by the Intergovernmental Panel on Climate Change (IPCC), the term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a, p. 1450). The term “climate change" thus refers to a change in the mean or the variability of relevant properties, which persists for an extended period, typically decades or longer, due to natural conditions (e.g., solar cycles) or human-caused changes in the composition of atmosphere or in land use (IPCC 2013a, p. 1,450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring. In particular, warming of the climate system is unequivocal and many of the observed changes in the last 60 years are unprecedented over decades to millennia (IPCC 2013b, p. 4). The current rate of climate change may be as fast as any extended warming period over the past 65 million years and is projected to accelerate in the next 30 to 80 years (NRC 2013, p. 5). Thus, rapid climate change is adding to other sources of extinction pressures, such as land use and invasive species, which will likely place extinction rates in this era among just a handful of the severe biodiversity events observed in Earth's geological record (American Association for the Advancement of Sciences (AAAS) 2014, p. 17).

Examples of various other observed and projected changes in climate and associated effects and risks, and the bases for them, are provided for global and regional scales in recent reports issued by the IPCC (2013c, 2014), and similar types of information for the United States and regions within it can be found in the National Climate Assessment (Melillo *et al*. 2014, entire).

Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "extremely likely" (defined by the IPCC as 95 to 100 percent likelihood) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from fossil fuel use (IPCC 2013b, p. 17 and related citations).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the Century depending on the assumptions about population levels, emissions of GHGs, and other factors that influence climate change. Thus, absent extremely rapid stabilization of GHGs at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding GHG emissions (IPCC 2013b, 2014; entire).

Global climate projections are informative, and, in some cases, the only or the best scientific information available. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (e.g., IPCC 2013c, 2014; entire) and within the United States (Melillo *et al*. 2014, entire). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling).

Various changes in climate may have direct or indirect effects on species. These may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables such as habitat fragmentation (for examples, see Franco *et al.* 2006; Forister *et al*. 2010; Galbraith *et al*. 2010; Chen *et al*. 2011; Bertelsmeier *et al*. 2013, entire). In addition to considering individual species, scientists are evaluating potential climate change-related impacts to, and responses of, ecological systems, habitat conditions, and groups of species (e.g., Deutsch *et al*. 2008; Euskirchen *et al.* 2009; Berg *et al*. 2010; McKechnie and Wolf 2010; Sinervo *et al*. 2010; Beaumont *et al*. 2011; McKelvey *et al*. 2011; Rogers and Schindler 2011; Bellard *et al*. 2012).

Regional temperature observations for assessing climate change are often used as an indicator of how climate is changing. The Western Regional Climate Center (WRCC) has defined 11 climate regions for evaluating various climate trends in California (Abatzoglou *et al*. 2009, p. 1,535).

Two indicators of temperature, the increase in mean temperature and the increase in maximum temperature, are important for evaluating trends in climate change in California. For the climate region that encompasses the western Mojave Desert (Mojave, California), the 100-year linear trends provided by the WRCC indicate an increase in mean temperatures (Jan–Dec) of approximately 1.16 °C/100 yr (2.09 °F ± 0.52 °F/100 yr) since 1895, and 2.19 °C/100 yr (3.94 °F ± 1.22 °F/100 yr) since 1949 (WRCC 2016b). Similarly, the maximum temperature 100-year linear trend for the Desert Region shows an increase of about 1.04 °C/100 yr (1.87 °F ± 0.61 °F/100 yr) since 1895, and 1.84 °C/100 yr (3.31 °F ± 1.53 °F/100 yr) since 1949 (WRCC 2016b). We assume the rate of temperature increase for this region is higher for the second time period (since 1949) than for the first time period (since 1895) due to the increased use of fossil fuels in the 20th century.

Although these observed trends provide information as to how climate has changed in the past, climate models can be used to simulate and develop future climate projections. Pierce *et al*. (2013, entire) presented both state-wide and regional probabilistic estimates of temperature and precipitation changes for California (by the 2060s) using downscaled data from 16 global circulation models and 3 nested regional climate models. The study looked at a historical (1985–1994) and a future (2060–2069) time period using the IPCC Special Report on Emission Scenarios A2 (Pierce *et al*. 2013, p. 841), which is an IPCC-defined scenario used for the IPCCs Third and Fourth Assessment reports, and is based on a global population growth scenario and economic conditions that result in a relatively high level of atmospheric GHGs by 2100 (IPCC 2000, pp. 4–5; see Stocker *et al*. 2013, pp. 60–68, and Walsh *et al*. 2014, pp. 25–28, for discussions and comparisons of the prior and current IPCC approaches and outcomes). Importantly, the projections by Pierce *et al*. (2013, pp. 852–853) include daily distributions and natural internal climate variability.

Simulations using these downscaling methods project an increase in yearly temperature for the area that encompasses the Mojave Desert ranging from 2.5 °C (4.5 °F) to 3.0 °C (5.4 °F) by the 2060s time period (Pierce *et al*. 2013, p. 844), compared to 1985–1994. The simulations indicated a yearly upper temperature increase of 2.7 °C (4.86 °F) from 1985–1994 to 2060–2069 (averaged across models) for this area (Pierce *et al*. 2013, p. 842).

Although three-year droughts are not unusual when evaluated over the past 1000 years in California (Griffin and Anchukaitis 2014, p. 9020), beginning in 2012 and continuing into 2016, California experienced a severe drought throughout most of the state. Griffin and Anchukaitis (2014, entire) evaluated how unusual this drought event was in the context of the last millennium using blue oak (*Quercus douglasii*) tree ring data from four sampling sites (with additional tree sampling following the 2014 growth season). Their paleoclimate drought and precipitation reconstructions for Central and Southern California show that, although the precipitation during this drought was anomalously low (based on tree ring chronologies), it was not outside the range of variability (Griffin and Anchukaitis 2014, p. 9,017). However, when evaluated on a an annual basis, the 2014 drought was the worst single drought year of at least the last 1,200 years in California. The severity of this drought condition was demonstrated in the 2014 summer Palmer Drought Severity Index (PDSI), which was calculated to be the lowest on record (1901–2014) (Williams *et al*. 2015, p. 6,823). In addition, the 2012–2014 drought event was the most severe of three consecutive drought years, based on three events found in the record for the last 1,200 years (Griffin and Anchukaitis 2014, pp. 9,020–9,021). The study concluded that low precipitation combined with high temperatures was responsible for creating this worst short-term drought episode (Griffin and Anchukaitis 2014, pp. 9,021–9,022).

Williams *et al.* (2015, entire) recently estimated the anthropogenic contribution to California's drought during 2012–2014. They found that the intensifying effect of high potential evapotranspiration on this drought event (measured by summer PDSI) was almost entirely the result of high temperatures (18–27 percent in 2012–2014; 20–26 percent in 2014) (Williams *et al*. 2015, p. 6,825). Another study evaluating the influence of temperature on the drought in water year 2014 in California found that, although the low level of precipitation was the primary driver for the drought conditions, temperature was an important factor in exacerbating the drought, noting that the water year 2014 was the third year of the multiyear drought event and therefore conditions were drier than normal at the beginning of the water year (Shukla *et al*. 2015, p. 4,392).

In sum, these projections indicate that increased temperatures ranging from 2.5 °C (4.5 °F) to 3.0 °C (5.4 °F) are likely to occur in the western Mojave Desert by the 2060s due to the effects of climate change (Pierce *et al*. 2013, p. 844).

Precipitation patterns can also be used as an indicator of potential climate change. We obtained yearly precipitation data for the Mojave Station located in the western Mojave Desert from the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) (http://www.ncdc.noaa.gov/). We then conducted a nonparametric correlation test, the Mann-Kendall statistical test (Hipel and McLeod 1994, pp. 63–64, 856–858), which is commonly used for analyzing climatic time series (e.g., Ahmad *et al*. 2015, entire), to evaluate trends in precipitation over time. This analysis was conducted using the R and R Studio software programs (Version 3.1.2; R Development Core Team, 2014) with the "Kendall" package (Version 2.2) (McLeod 2011). Because of the incomplete or missing monthly data for the Mojave Station from 2004 to 2015, we used the precipitation data for the nearby Lancaster Station for those years. We found that precipitation showed no statistically significant trend (increasing or decreasing) from 1941–2015 (see times series chart and summary table in Appendix B).

State-wide and regional probabilistic estimates of precipitation changes for California were also evaluated by Pierce *et al*. (2013, entire). When averaged across all models and downscaling methods, small annual mean decreases in precipitation were found for the southern part of California, but there was significant disagreement across the models (Pierce *et al*. 2013, pp. 849, 854). Some simulations indicate an increase in summer rainfall within the Mojave Desert region, and dynamic downscaled simulations found larger increases in summer precipitation in the region of California affected by the North America monsoonal flow, including portions of the Mojave Desert region, than the statistical downscaling methods (Pierce *et al*. 2013, pp. 851, 855).

Tagestad *et al*. (2016, pp. 394, 396) also found a projected increase in precipitation for the Mojave Desert region using four global climate change models and two IPCC scenarios–A1 (high emissions) and B2 (low emissions). Relatedly, projections of differences between precipitation and evapotranspiration (water availability) in 2070-2099 as compared to 1975-2004 by Gao *et al*. (2014, pp. 1,746–1,747) found a decrease in the availability of water in southern California during spring months, but an increase or no change for winter and summer months. These studies suggest that increased precipitation projections for southern California may be offset by warmer temperatures as well as the potential for shifts in the seasonality of precipitation, which may produce an increase in annual invasive grasses, and therefore increase in wildland fire frequency (see cumulative effects discussion below).

As described above (see *Individual Needs* section), terrestrial snails can adapt to warm and dry conditions, including projected climate changes, with behavioral responses, but physiological adaptations at the cellular and biochemical level are also important (Marko *et al*. 2015, p. 124). Troschinski *et al*. (2014a, entire; 2014b, entire) studied physiological heat stress responses in several populations of a Mediterranean land snail (*Xeropicta derbentina*) exposed to elevated temperatures and found that Hsp70, a primary component of the cellular heat stress response system, acts to protect the cell against the proteotoxic action of elevated temperature and other stressors. Thus, given the similar environmental conditions of *X. derbentina* to the Mohave shoulderband snail as well as the annual temperature extremes that the Mojave Desert has historically exhibited, it is reasonable to assume that the Mohave shoulderband snail's cellular heat stress response system offers protection against elevated temperature and other climate-related stressors that could otherwise result in death of individuals.

In 2006, the State of California passed Assembly Bill 32, the Global Warming Solutions Act, as a commitment to develop State and local climate change policy. The law requires the Air Resources Board to adopt regulations to achieve the maximum technologically feasible and cost-effective GHG emission reductions to lower GHG emissions by 2020 to 1990 levels. In 2014, total GHG emissions were 441.5 million metric tons of CO2 equivalent ($MMTCO_2e$), a decrease of 2.8 $MMTCO_2e$ compared to 2013, which represents an overall decrease of 9.4 percent since peak levels in 2004 (California Environmental Protection Agency (CEPA) 2016, p. 1), in part, due to the implementation of the California Global Warming Solutions Act of 2006.

Climate Change and Potential for Cumulative Effects

Threats can work in concert with one another to cumulatively create conditions that may impact the Mohave shoulderband snail or its habitat beyond the scope of each individual threat. Given an expected increase in temperature in the region, it is possible for vegetation changes to occur in concert with changes in land use and other environmental factors before the end of the century. At this time, the best available information indicates that, if there are any cumulative impacts in the future, the most likely could be vegetation changes from the combination of wildland fire and increased drought conditions.

Bachelet *et al*. 2016 (entire) prepared a climate analysis for portions of the Mojave and Sonoran deserts in order to evaluate likely responses of major vegetation types. Their model predicted large increases in herbaceous vegetation (i.e., grasses, sedges, forbs) in the Mojave Desert for two future time periods (2036–2065 and 2071–2100) using three future climate projections and IPCC's Representative Concentration Pathway (RCP) 8.5 scenario representing changes in atmospheric carbon dioxide, and incorporating the downscaling method from Abatzoglou (2013) (Bachelet *et al*. 2016, pp. 21–25). Bachelet *et al*. (2016, p. 25) also note that other model simulations indicated increased annual precipitation in California's desert regions, which could exacerbate the invasion and establishment of nonnative grasses.

Keeley and Syphard (2016, entire) analyzed fire-climate relationships to predict future fire regimes in California. Their review concluded that: (1) Climate is not a major determinant of fire activity across all landscapes; (2) hotter and drier conditions for areas at lower elevations and lower latitude were found to have little or no increase in fire activity as vegetation types in these regions are ignition limited; (3) increasing annual temperatures by themselves are not good predictors of increased fire activity; seasonality, especially spring and summer temperatures, are more important; and (4) fire-climate models need to be scaled to vegetation types; broad-scale models may produce over-predictions of the total increase in future fire regimes (Keeley and Syphard 2016, p. 1, 10). Additionally, drought is a key factor in defining fire regimes and annual precipitation is the primary driver of drought variability (Williams *et al*. 2015, p. 6,819), but, at the present time, it is difficult to separate current droughts in California from natural cycles of drought (Keeley and Syphard 2016, p. 6). This study also suggests that any projected increases in precipitation could result in a higher prevalence of fires in the Mojave Desert; however, the authors note that projected increases in temperature may mitigate the increase in fire due to a reduction in available moisture (Tagestad *et al*. 2016, p. 394).

Increases in atmospheric carbon dioxide may also affect desert microbiotic soil crusts, a potential (although not confirmed) food source for the Mohave shoulderband snail. Lane *et al*. (2013, entire) found that biological soil crusts were able to sequester carbon under different moisture regimes. Also, Stark *et al*. (2011, pp. 459–461) determined that patches of a biological crust moss exposed to moderate and severe drought-type conditions had reduced underground biomass, indicating excess carbon consumption during recovery. These studies highlight the potential interacting effects of projected (future) climate change on desert biological soil crust communities; however, there is no information as to how these interactions may affect potential food availability for the Mohave shoulderband snail. Additionally, we note that it is unlikely that microbiotic soil crusts comprise a significant portion of the snail's diet.

Summary of Future Conditions

Models represent tools to describe basic physical and biological behaviors using the best available science, and, by presenting a range of reasonable future outcomes, they can help generate hypotheses while also identifying knowledge gaps where greater accuracy is needed (Batchelet *et al*. 2016, p. 23). Climate change model projections indicate an increase in temperature for the western Mojave Desert region ranging from 2.5 °C (4.5 °F) to 3.0 °C (5.4 °F) by the 2060s as compared to 1985-1994. Although droughts in this region are not unusual, drought periods have the potential to be exacerbated by projected temperature increases. Precipitation patterns into the future are less clear as the climate models show significant disagreement in their projections.

We also considered temperature and precipitation projections from climate change models in conjunction with wildland fire risk and, relatedly, vegetation type conversion. Projected increases in precipitation could result in a higher prevalence of fires in the Mojave Desert, but projected increases in temperature may mitigate the increase in fire due to a reduction in available moisture. Biological soil crust communities may be affected by increased levels of carbon dioxide, interacting with increased temperature and changes in precipitation patterns.

The Desert Renewable Energy Conservation Plan (DRECP) (see discussion in Appendix F) has identified goals and objectives for soil resources that include assessing and applying “proactive and responsive management and mitigation actions to address unavoidable indirect impacts for project-related disturbances to soils, which may be exacerbated by climate change (e.g., wildfire, flash floods)” (BLM 2016, p. 26).

Given their evolutionary history in the southwestern United States, desert snails, such as the Mohave shoulderband snail, have demonstrated behavioral and physiological abilities to withstand warmer and drier conditions. Therefore, it is reasonable to predict that effects associated with projected environmental conditions due to the effects of climate change will not significantly affect the Mohave shoulderband snail or its habitat.

Risk Assessment

Introduction

In order to characterize a species’ viability and demographic risks, we consider the concepts of resilience, representation, and redundancy. We also consider known and potential stressors that may negatively impact the physical and biological features that the species needs for survival and reproduction. Stressors are expressed as risks to its demographic features such as abundance (redundancy), population or spatial structure (resiliency), and genetic or ecological diversity (representation). We consider the level of impact a stressor may have on a species along with the consideration of demographic factors (e.g., whether a species has stable, increasing, or decreasing trends in abundance, population growth rates, diversity of populations, and loss or degradation of habitat). The following discussion provides a representation of the demographic risks for the Mohave shoulderband snail.

Abundance

Accurate historical and current estimates of abundance are not available for the Mohave shoulderband snail at the present time. As noted above, 91 observations (live animal or shell) over three distinct geographical locations have been recorded from 2013–2017. This information is based on limited survey efforts. At this time, the best available information does not indicate that the species' abundance is significantly impacted by factors that are human-caused. The best available information also does not indicate either increasing or declining numbers of snails for this species.

For small populations, demographic stochasticity (the variability of annual population change that results from random birth and death events at the individual level) can impact the population. Based on our evaluation of the best available information, there is little information on population sizes for the Mohave shoulderband snail across its range. Regardless, surveys conducted in 2015–2017 (though incomplete) continue to document its presence at the Soledad location (e.g., 80 percent of sites surveyed in January 2017). Preliminary results from additional surveys conducted February 22-25, 2017, indicate that snail shells were also found on the northeast side of the mountain near Middle Butte (including Cactus Gold Mine), but not at Standard Hill (WestLand Resources Inc. 2017, pp. 13–14). Further, the likelihood for this species to persist with an appropriate population size and growth rate at these locations is supported by our current finding of the potential for only low-level to negligible impacts from the stressors described in this SSA Report. Therefore, the total abundance across the Mohave shoulderband snail's range is not likely to decrease to a level that would result in a negative effect to the population.

Population or Spatial Structure Resiliency

As indicated above, population size, growth rate, and current population trends are unknown for the Mohave shoulderband snail due to the lack of abundance information. The range of the Mohave shoulderband snail occurs within an approximate 10-mi (16.09-km) radius from the center of Soledad Mountain (i.e., the estimated location of its type locality (Willett 1931, p. 125)) based on geological features that support its known habitat (i.e., rock outcrops and talus slopes). Within this range, we identified approximately 210 ac (85 ha) of potentially suitable habitat for the species. Mining activities at Soledad Mountain over the next 12 years will likely result in the rangewide loss of approximately 19.4 percent (40.8 ac (16.5 ha)) of potentially suitable habitat identified for the Mohave shoulderband snail. This area is the largest of the three locations from which individuals have been observed. Based on this assessment, it is unlikely that this loss would result in a significant loss of resiliency to the species.

Diversity

As discussed above (Status–Future Conditions), climate change effects (e.g., higher temperatures) and wildland fire may affect the resilience of the Mohave shoulderband snail by creating an environment that is less favorable to its physiological and ecological needs.

However, this desert land snail has adapted to successfully occupy habitats with arid conditions from at least the Miocene age.

Currently, we are unaware of any documented specific risks for the Mohave shoulderband snail related to a substantial change or loss of diversity in life history traits, population demographics, morphology, behavior, or genetic characteristics. Rates of dispersal or gene flow are not known to have changed. Additionally, there is no currently available information to indicate that the current abundance of the Mohave shoulderband snail is at level that is causing inbreeding depression or loss of genetic variation. Finally, the best available information also indicates that the species has historically demonstrated its ability to withstand a broad range of environmental conditions, indicating that it will likely be able to withstand predicted conditions in the future.

Overall Assessment

The Mohave shoulderband snail is found within rockslides and talus slopes within volcanic features (plugs) in the Mojave Desert, Kern County, California. It is currently known from three general locations in the western Mojave Desert, which is also the presumed historical range. The region's physical and biological features related to precipitation patterns, substrate, and availability of food largely determine the distribution of the Mohave shoulderband snail. Since its first discovery in 1931 (Willett 1931), limited surveys have recorded its presence in 2013, 2015, 2016, and 2017. The current distribution of the Mohave shoulderband snail is representative of relict snail populations that are now restricted to disjunct and fragmented locations subsequent to changed environmental conditions after the Pleistocene. Rangewide, potentially suitable habitat, as determined by the physical and ecological features and the ecological needs of the Mohave shoulderband snail, is estimated at 210 ac (85 ha).

There is limited information regarding the life history requirements of the Mohave shoulderband snail. Based on our review of available relevant literature for similar species, we identified the physical and ecological needs of the species as follows: rock outcrops/rock slides or talus slopes; food sources, such as mosses, lichens, fungi, algae, or other plant materials growing on rock surfaces or within microbiotic crusts; and water availability, particularly following precipitation events.

Hard rock mining, which has been active in the western Mojave Desert since the late 1800s, represents the primary stressor to the Mohave shoulderband snail. The GQM operation at Soledad Mountain is estimated to result in the loss of 19.4 percent (40.8 acres (ac) (16.5 hectares (ha)) of modeled suitable habitat across the species' range. We identified several other potential stressors that may be affecting the species' habitat currently or in the future, including wildland fire, vegetation type conversion, and impacts associated with climate changes effects. However, these are not likely to significantly impact the Mohave shoulderband snail or its habitat at the population or rangewide scale.

While some information is lacking for this species, including population estimates and abundance trends, the best available information does not indicate that loss, degradation, or modification of habitat, nor any other stressor, is resulting in a decline in the species. Ongoing conservation management measures, including control of invasive plants, reclamation and revegetation of mined areas, fire suppression, and restricted access to Mohave shoulderband snail habitat, currently and in the future, alleviate effects related to wildland fire, vegetation type conversion, and OHV activity, but will not remove all the potential effects of habitat-related impacts.

A conservation plan for the Mohave shoulderband snail, associated with anticipated impacts from hard rock mining activities at Soledad Mountain has been completed by GQM (GQM 2017, entire). The plan identifies objectives to protect habitat where the Mohave shoulderband snail occurs to ensure its long-term persistence.

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Watts, S. 2016a. Electronic mail message from Stephen E. Watts, Chief, Environmental Resources and Planning, Edwards Air Force Base, with GIS results of potential Mohave shoulderband snail habitat, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. December 12, 2016.

Watts, S. 2016b. Electronic mail message from Stephen E. Watts, Chief, Environmental Resources and Planning, Edwards Air Force Base, with results of potential Mohave shoulderband snail habitat modeling, to Tony McKinney, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. February 5, 2016.

Woods, C. 2017. Electronic mail message from Caroline Woods, Wildlife Biologist, Bureau of Land Management, Ridgecrest, California, regarding fire management, Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. January 3, 2017.

Appendices

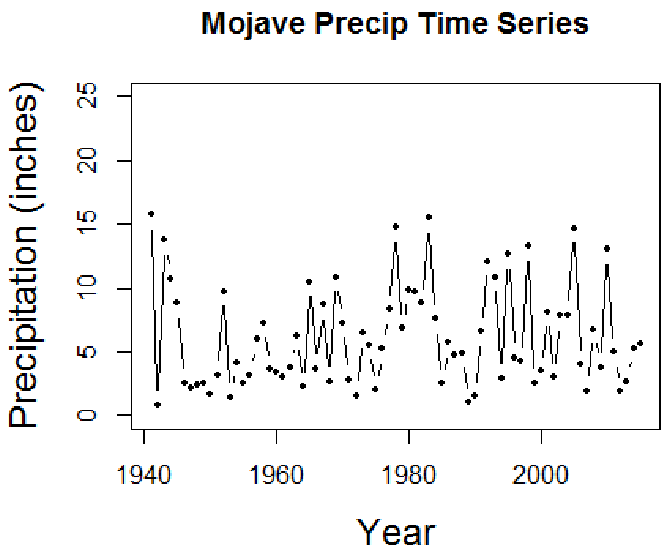
Appendix A – Climate Summary for Mojave, California

MOJAVE, CALIFORNIA: Period of Record Monthly Climate Summary; Period of Record 01/01/1904 to 06/08/2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Max. Temperature (F)	57.8	61.2	64.7	71.3	79.9	89.9	97.6	96.4	89.0	78.5	65.7	57.2	75.8
Avg. Min. Temperature (F)	34.2	37.1	41.0	46.3	55.1	63.8	69.7	68.0	60.3	50.3	40.2	32.9	49.9
Avg. Total Precipitation (in.)	1.20	1.27	0.93	0.30	0.09	0.03	0.11	0.15	0.21	0.24	0.53	0.87	5.93
Avg. Total Snow Fall (in.)	0.8	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	1.7
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Western Regional Climate Center (2016). Available at *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5756*, accessed July 19, 2016.

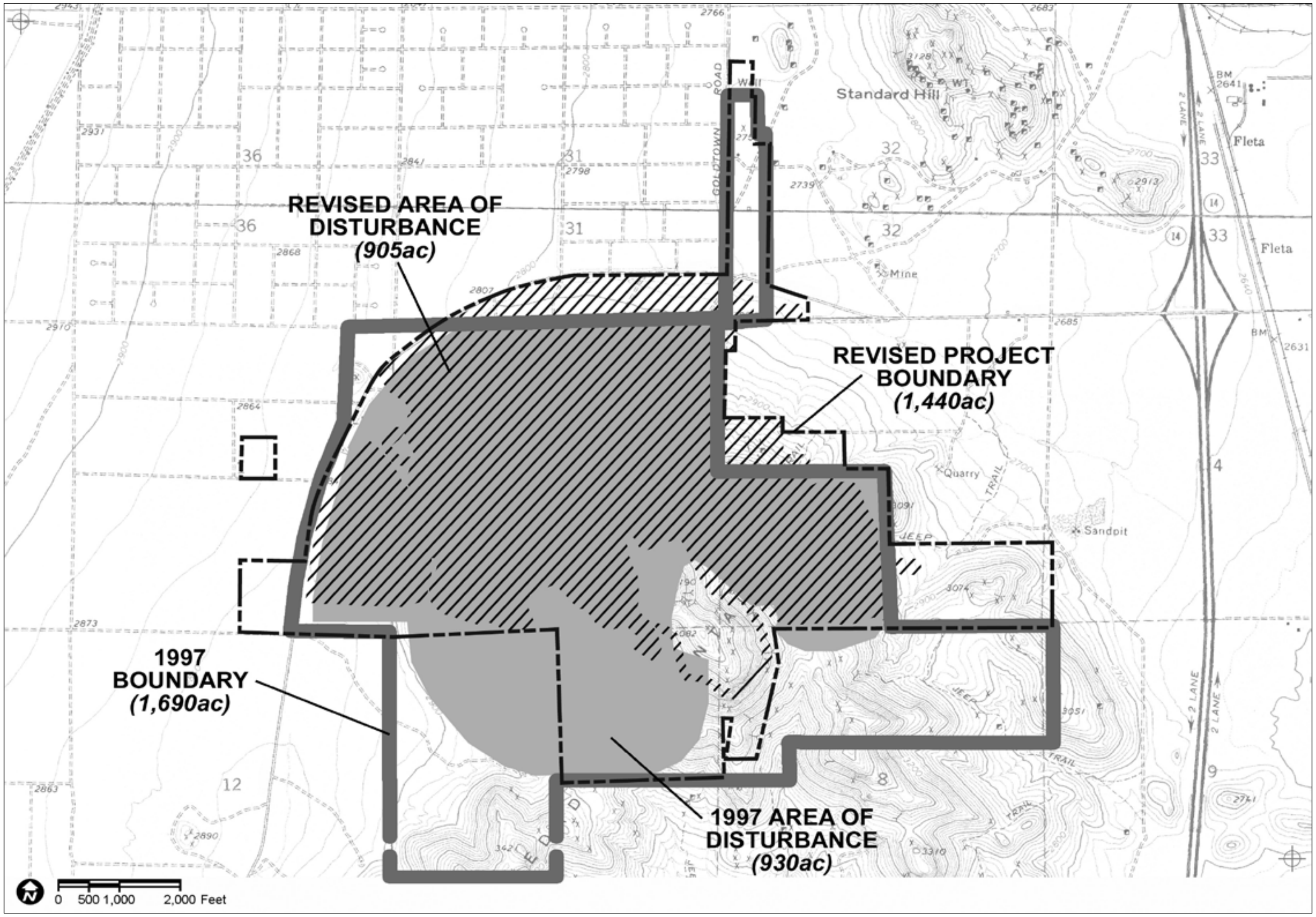
Appendix B – Precipitation Time Series (using R Program)



Mann-Kendall Test Results (using R) for Precipitation Time Series						
Location	Mann-Kendall Statistic (S)	Kendall's tau (τ)	Var (S)	p-value (two-tailed test)	α	Test Interpretation
Mojave 1941-2003; Lancaster 2004-2015	223	0.08	47785	0.30984	0.05	**Accept H_0**

Test Hypothesis and Interpretation: H_0 – there is no trend in precipitation over time; alternate hypothesis (H_1) is that there has been a trend (increasing or decreasing) over time. If the p value is less than the significance level (alpha (α) = 0.05), then H_0 is rejected. If it is greater than 0.05, then H_0 cannot be rejected. Rejecting H_0 means that there is a trend in the time series, while not rejecting H_0 indicates that no trend was detected. A trend is "strong" if the absolute value of τ is near one.

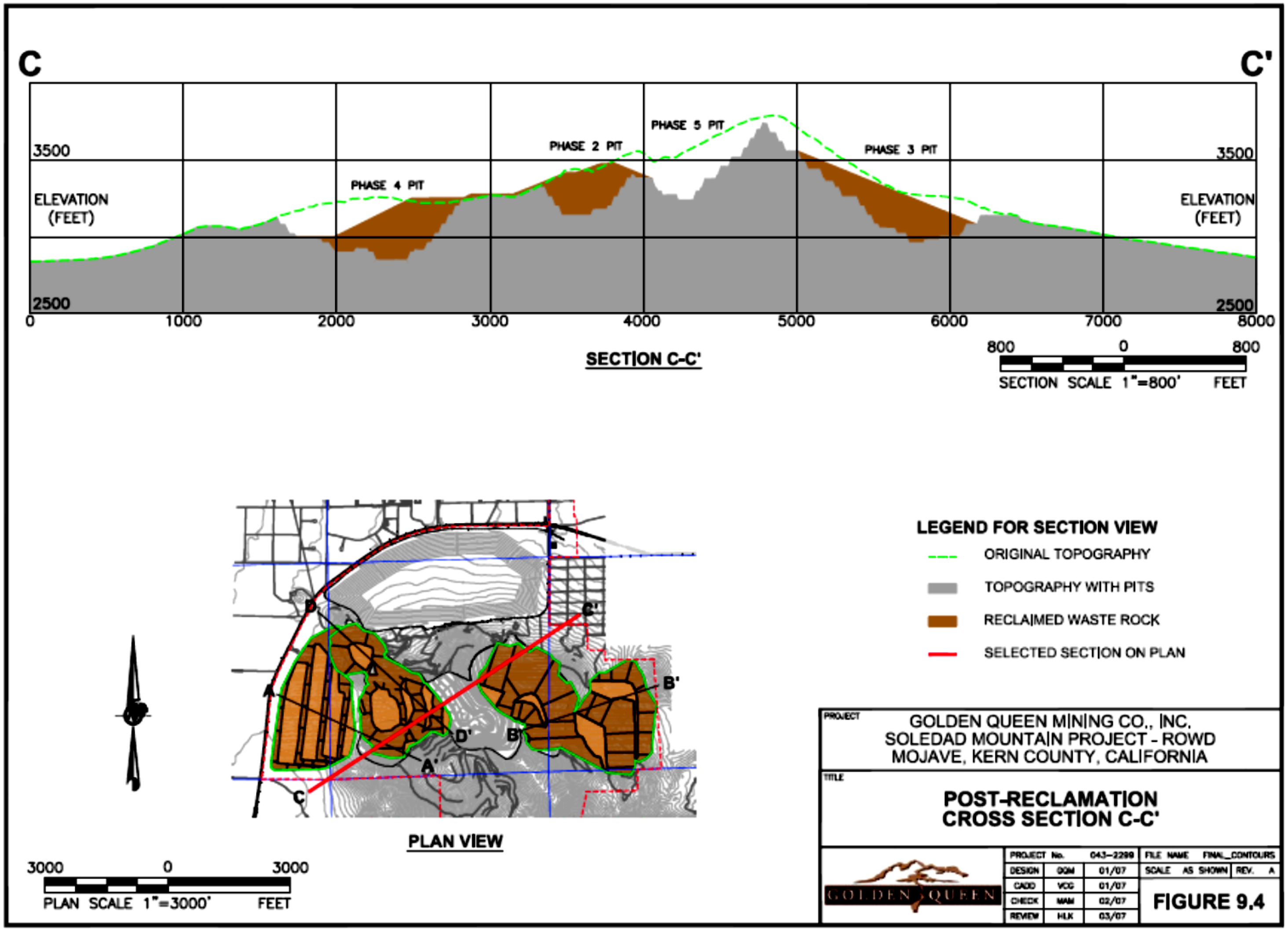
Appendix C – Comparison of 1997 and Revised Projects



Comparison of 1997 and Revised Projects

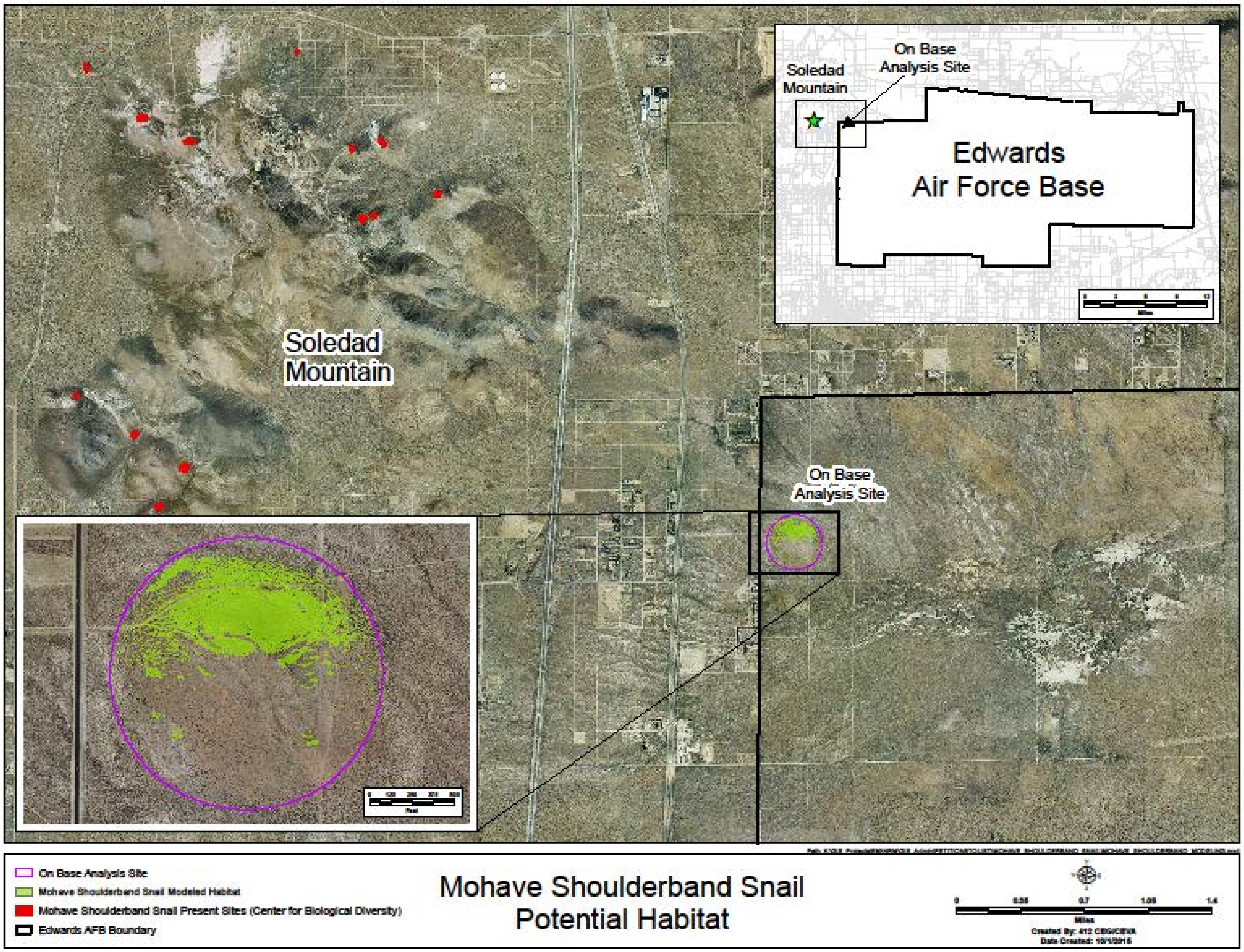
Source: Kern County Planning Department 2010 [citing 1997 FEIR/EIS, Exhibit 1.0-2 (Property Boundaries and Federal Lands) 1997 FEIR/EIS, Exhibit 2.2-2 (Conceptual Plot Plan)].

Appendix D – Example of Golden Queen Mine post-reclamation cross-section at Soledad Mountain



Source: Kern County Planning Department, 2010 (Draft SEIR Appendix B)

Appendix E – Modeled Potential Mohave Shoulderband Snail Habitat, Edwards Air Force Base.
Source: Watts 2016.



Appendix F – Existing Regulatory Mechanisms and Voluntary Conservation Measures

Federal Mechanisms

Federal Land Policy and Management Act (FLPMA) of 1976

FLMPA (43 U.S.C. 1711-1712) represents BLM's "organic act" for public lands management under the principles of multiple use and sustained yield. Its implementing regulations give BLM regulatory authority over activities for protection of the environment, including mining claims. Under FLPMA and BLM policy, public lands must be managed so as to protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values (BLM 2005, p. 1).

Land Use and Resource Management Plans

BLM land use planning requirements are established by Sections 201 and 202 of FLMPA and regulations at 43 CFR 1600 (BLM 2005, p. 1). A *Land Use Planning Handbook* (BLM 2005, entire) provides guidance for implementing land use planning requirements established under FLMPA and implementing regulations. Land use plans prepared by BLM include resource management plans (RMPs) and management framework plans (BLM 2005, p. 1). The RMPs establish the basis for actions and approved uses on the public lands and are prepared for areas of public lands, called planning areas (BLM 2005, pp. 1, 14). These plans are periodically evaluated and revised in response to changed conditions and resource demands (BLM 2005, pp. 33–34).

A Land Use Plan Amendment (LUPA) to an RMP represents a "set of decisions that establishes management direction for BLM-administered land within an administrative area through amendment to existing land use plans" (BLM 2016, p. xvii). The Desert Renewable Energy Conservation Plan (DRECP), completed in September 2016, is a LUPA that amends several BLM RMPs, relevant to the western Mojave Desert habitat that supports the Mohave shoulderband snail, including the California Desert Conservation Area Plan, and its amendments, including the West Mojave Plan (BLM 2016, p. xvii). As an example, the DRECP has identified goals and objectives for soil resources that include assessing and applying "proactive and responsive management and mitigation actions to address unavoidable indirect impacts for project-related disturbances to soils, which may be exacerbated by climate change (e.g., wildfire, flash floods)" (BLM 2016, p. 26).

BLM Manuals

BLM Manual 6840, Special Status Species Management, provides direction and policy with regards to (1) listed species or those proposed to be listed under the Act and (2) species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the Act (BLM 2008, p. 3). Under Manual 6840 direction, BLM managers are to ensure that land use and implementation plans fully address appropriate conservation of BLM special status species (BLM 2008, p. 6). As any project within the range of a narrow endemic species such as the Mohave shoulderband snail, is being analyzed, the potential for listing under the Act must be included in the effects analysis and the approving authority should only approve a project if the approval would not lead the species to need to be listed (Symons 2017, pers. comm.).

General Mining Law of 1872

The General Mining Law of 1872 (30 U.S.C. 21 et seq.), as amended, regulates the discovery of hard rock minerals. Environmental controls set forth in this law are established in Section 22, which states that claimants are subject to “regulations prescribed by law.” Surface mining regulations established under the General Mining Law of 1872 (43 CFR 3809) require the preparation of a Plan of Operations, which are reviewed and approved by BLM to determine whether the mining activity would unduly harm or degrade public land. In September 1997, Kern County certified the *"Soledad Mountain Project Final Environmental Impact Report/Environmental Impact Statement, State Clearinghouse [SCH] No. 1996061052"* (Kern County and BLM, 1997), which contained the CEQA and NEPA environmental clearances for BLM’s issuance of its Record of Decision (issued November 3, 1997), which approved the Plan of Operations (Kern County and BLM, 1997, pp. 1-1, 1-9).

National Environmental Policy Act (NEPA)

All Federal agencies are required to adhere to the NEPA of 1970 (42 U.S.C. 4321 et seq.) for projects they fund, authorize, or carry out. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. The Council on Environmental Quality’s regulations for implementing NEPA state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502). The public notice provisions of NEPA provide an opportunity for the Service and other interested parties to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely prohibits an uninformed agency action. However, if an Environmental Impact Statement is prepared for an agency action, the agency must take a “hard look” at the consequences of this action and must consider all potentially significant environmental impacts. Federal agencies may include mitigation measures in the final Environmental Impact Statement as a result of the NEPA process that may help to conserve the Mohave shoulderband snail and its habitat.

Although NEPA requires full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats, it does not by itself regulate activities that might affect the Mohave shoulderband snail; that is, effects to the species and its habitat would receive the same scrutiny as other plant and wildlife resources during the NEPA process and associated analyses of a project’s potential impacts to the human environment. We receive notification letters for Draft and Final Environmental Impact Reports prepared by BLM pursuant to NEPA such as those prepared for the GQM in 1997 and for LUPAs for RMPs, as discussed in this report.

State Mechanisms

California Department of Fish and Wildlife Status

The California Endangered Species Act does not protect invertebrates. Therefore, the Mohave shoulderband snail is not identified as a Species of Special Concern by CDFW, nor could it be listed as endangered or threatened under the California Endangered Species Act (CDFW 2016a, entire). It is also not included on the agency's Special Animals List (CDFW 2016b, entire).

California Environmental Quality Act (CEQA)

CEQA (California Public Resources Code 21000–21177) is the principal statute mandating environmental assessment of projects in California. The purpose of CEQA is to evaluate whether a proposed project may have an adverse effect on the environment and, if so, to determine whether that effect can be reduced or eliminated by pursuing an alternative course of action, or through mitigation. CEQA applies to certain activities of State and local public agencies; a public agency must comply with CEQA when it undertakes an activity defined under CEQA as a "project." A project is defined as an activity undertaken by a public agency or a private activity that requires some discretionary approval (i.e., the agency has the authority to deny or approve the requested permit) from a government agency, and which may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment. Most proposals for physical development in California are subject to the provisions of CEQA, as are many governmental decisions such as adoption of a general or community plan. Development projects that require a discretionary governmental approval require some level of environmental review under CEQA, unless an exemption applies (California Environmental Resources Evaluation System (CERES) 2014). If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (Public Resources Code 21000; CEQA Guidelines at California Code of Regulations, Title 14, Division 6, Chapter 3, sections 15000–15387).

As with NEPA, CEQA does not provide a direct regulatory role for the CDFW relative to activities that may affect the Mohave shoulderband snail. However, CEQA requires a complete assessment of the potential for a proposed project to have a significant adverse effect on the environment. Among the conditions outlined in the CEQA Guidelines that may lead to mandatory findings of significance are where the project "has the potential to … substantially reduce the habitat of a fish or wildlife species; cause a fish or wildlife population to drop below self-sustaining levels; threaten to eliminate a plant or animal community; substantially reduce the number or restrict the range of an endangered, rare or threatened species" (14 CCR § 15065(a)(1)). The CEQA Guidelines further state that a species "not included in any listing [as threatened or endangered] shall nevertheless be considered to be endangered, rare, or threatened, if the species can be shown to meet the criteria" for such listing (14 CCR § 15380(d)). In other words, CEQA would require any project that may impact the Mohave shoulderband snail population to assess and disclose such potential impacts during the environmental review process (Osborn 2015, pers. comm.). Further, if project implementation in combination with other threats may result in the species becoming endangered under State law throughout all or a significant portion of its range in the future, then, even absent formal designation as such, the species may be treated as listed for purposes of environmental review (Osborn 2015, pers. comm.).

As described in the Hard Rock Mining section above, Draft and Final Environmental Impact Reports were prepared in 1997 pursuant to NEPA and CEQA by the Kern County Planning and Community Development Department and BLM for mining activities in the western Mojave Desert through a Memorandum of Understanding between the two agencies (Kern County and BLM 1997, pp. 6–7). Open pit mining operations that use cyanide heap leaching process to produce precious metal (e.g., gold or silver) require the preparation of an EIR (Kern County and BLM 1997, p. 7). A Draft and Final Supplemental EIR prepared by Kern County in 2010 for the GQM Revised Project addressed the effects of these processes and other impacts.

Surface Mining and Reclamation Act (SMARA) of 1975; State Mining and Geology Board Regulations

SMARA (California Public Resources Code, Sections 2710 et seq.) includes a comprehensive surface mining and reclamation policy. It provides regulation of surface mining operations such that adverse environmental impacts are minimized and mined lands are reclaimed to a usable condition while encouraging the production, conservation, and protection of the state's mineral resources (California Department of Conservation (CDC 2016, entire). SMARA (Chapter 9, Division 2 of the California Public Resources Code) also requires the State Mining and Geology Board to adopt State policy for the reclamation of mined lands and the conservation of mineral resources (CDC 2016, entire). These policies are codified in California Code of Regulations, Title 14, Division 2, Chapter 8, Subchapter 1.

The GQM Revised Project at Soledad Mountain and other proposed surface mining activities in California are required to meet the requirements of SMARA as well as State Mining and Geology Board regulations that address reclamation of mining activities on lands within the State of California. The Hard Rock Mining section in this report provides details of required reclamation activities for the GQM at Soledad Mountain.

California Global Warming Solutions Act of 2006

In 2006, the State of California passed Assembly Bill 32, the Global Warming Solutions Act, as a commitment to develop State and local climate change policy. The law requires the Air Resources Board (Board) to adopt regulations to achieve the maximum technologically feasible and cost-effective GHG emission reductions to lower GHG emissions by 2020 to 1990 levels (CEPA 2016, entire). The Global Warming Solutions Act covers the following GHGs: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. The Board approved the initial Climate Change Scoping Plan in 2008, which included a number of measures to sharply cut GHG emissions, and, in May 2014, the Board approved the first update to the plan (Update), which includes new strategies and recommendations as well as highlights of the progress made in California in meeting the near-term 2020 GHG emission reduction goals (CEPA 2014, entire). A Cap-and-Trade program began in January 2013, with a GHG emissions cap that declines over time and, in September 2013, the Board issued its first carbon offset credits as part of this program (CEPA 2016, entire).

The Board prepares, maintains, and updates California's statewide GHG emission inventory, which is used to track the State's emission trends and progress toward California's GHG emission reduction goals (CEPA 2014, p. 89). Updated versions of the GHG emission inventory is published by the Board on its GHG Emission Inventory website (www.arb.ca.gov/cc/inventory/inventory.htm) and this inventory (measured as million tonnes of carbon dioxide equivalents or $MMTCO_2e$) provides estimates of the amount of GHGs emitted to the atmosphere by human activities within California (CEPA 2014, p. 89).

Local Mechanisms

A Kern County Conditional Use Permit is required to address mining impacts, such as those projected for the GQM Revised Project at Soledad Mountain. The permit conditions, unless specifically addressed under SMARA or other federal, state, or Kern County regulations, represent mitigation measures for the project or are specific conditions of approval for compliance with SMARA or Kern County Zoning Ordinance for Surface Mining Operations (Chapter 19.100) (Kern County and BLM 1997, p. 8). The Kern County Planning Commission unanimously approved the Project during its regularly scheduled meeting in Bakersfield on April 8, 2010.

In addition, air quality protection and monitoring for the GQM Revised Project at Soledad Mountain is required by Kern County Air Pollution Control District and the Kern County General Plan (Kern County 2010, pp. 4.2-31–4.2-33). Regulatory requirements and mitigation measures or conditions of approval identified in the 1997 FEIR/EIS carried over to the Revised Project and include 1) best available control technology for permitted sources of emissions; 2) maintaining roads on a routine basis, including dust suppression techniques to minimize fugitive emissions; 3) controlling sources of emissions in compliance with California Health and Safety Code; 4) installation of monitoring stations for PM_{10} upwind and downwind from processing facilities; 5) removal of existing tailings piles to reduce long-tern fugitive emissions from site; and 6) adoption of reclamation plan that includes reclamation of previously disturbed areas (Kern County 2010, p. 4.2-51).

Voluntary Conservation Measures

Representatives from the GQM prepared a conservation plan for the Mohave shoulderband snail at Soledad Mountain. The conservation plan identifies five major objectives:

> (1) Elimination a source of arsenic pollution to the Mohave shoulderband snail and its habitat by remediation of existing tailings on Soledad Mountain that contain arsenic.
> (2) Identification of areas targeted for conservation on Soledad Mountain.
> (3) Acquisition of private land and mineral rights on public lands within these targeted conservation areas.
> (4) Dedication of negative easements or other protective measures assuring that habitat on private land will be protected.

(5) Execution of a binding agreement between GQM and BLM to preclude surface disturbance in snail habitat occurring on BLM-administered land for which GQM maintains mineral rights (GQM 2017).

GQM also proposes to survey for the presence of the Mohave shoulderband snail in protected areas and implement adaptive management measures should data indicate a decreasing trend in occupancy within the conservation areas (GQM 2017).

GQM conducted remediation of the tailings on site, which contained arsenic from past mining operations. They have identified four conservation areas for the Mohave shoulderband snail (393 ac (159 ha) with 97 ac (39.25 ha) of rock features) and have acquired the mineral rights for habitat at these areas (GQM 2017).

Four conservation areas were identified (GQM 2017, p. 20):

(1) East Conservation Area – 176 ac (71.22 ha)
(2) West Conservation Area – 211 ac (85.4 ha)
(3) Western Isolated Rock Outcrop Conservation Area – 4.5 ac (1.8 ha)
(4) Eastern Isolated Rock Outcrop Conservation Area – 1.9 ac (0.77 ha)

GQM has completed work on the first three objectives. They expect to fully implement the plan by January 2019 (GQM 2017).

Appendix G – Wildland Fire Perimeter Map, Soledad Mountain