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TECHNICAL WHITE PAPER 1: FOCAL SPECIES STATUS UPDATE FOR THE CITY OF SAN DIEGO VERNAL POOL HABITAT CONSERVATION PLAN

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INTRODUCTION

1.1 PROJECT OVERVIEW

The San Diego Association of Governments (SANDAG) will prepare a Vernal Pool Habitat Conservation Plan (HCP) for the City of San Diego (City) largely based on information contained in a series of Technical White Papers (TWPs). The TWPs focus on seven target vernal pool species including:

- Otay Mesa mint (*Pogogyne nudiuscula*)
- San Diego Mesa mint (*Pogogyne abramsii*)
- Spreading navarretia (*Navarretia fossalis*)
- San Diego button-celery (*Eryngium aristulatum* var. *parishii*)
- California Orcutt grass (*Orcuttia californica*)
- Riverside fairy shrimp (*Streptocephalus wootoni*)
- San Diego fairy shrimp (*Branchinecta sandiegonensis*)

The eight TWP topics are as follows:

- TWP 1: Focal Species Status Update in the City of San Diego
- TWP 2: Assessment of Conservation of Seven Target Species
- TWP 3: Development of Adaptive Management Strategy
- TWP 4: Development of Monitoring Strategy
- TWP 5: Property Analysis Record
- TWP 6: Recommendations for Conditions of Coverage
- TWP 7: Conservation Analysis
- TWP 8: Preserve Management Funding Mechanisms

This is TWP 1. It provides a status update on the seven focal species consisting of an analysis of the number and distribution of these species within the City, and habitat conditions, consisting of threats and risks to each species.

The Planning Area for the HCP is the geographical extent of land that will be included in the HCP and for which the protections provided under the HCP are afforded to the seven focal species. For the City's HCP, these lands include the entire jurisdictional boundaries of the City and three areas owned by the City's Public Utilities Department in the unincorporated portion of San Diego County. The Planning Area's extent is, by design, the area covered by the City's Multiple Species Conservation Program (MSCP); however, the HCP is a separate but compatible conservation plan for vernal pools and seven endangered focal species not covered under the City's MSCP.

Many lands included in the Planning Area are not under the local land use jurisdiction of the City. These lands could include special districts such as school districts, military lands, federal properties, and state lands. These lands not under the land use jurisdiction of the City are included in the HCP for the purpose of conservation analysis. However, the regulatory requirements of the HCP will not be applicable. If land ownership is transferred and comes under the City's jurisdiction, or if the owner voluntarily requests inclusion, the HCP regulatory requirements will be applied after undergoing the appropriate amendment process, as outlined within the HCP.

The Planning Area includes 7,975 known vernal pools. Of that total, 4,807 known vernal pools occur on Marine Corps Air Station (MCAS) Miramar. Data for MCAS Miramar vernal pools is confidential and, therefore, not included in this analysis. As such, the study area for TWP 1 is a subset of the Planning Area and includes 3,168 known vernal pools.

TWP 1 is based on review of historical and current vernal pool data within the study area. Baseline data consisted of Beauchamp and Cass (1979), Bauder (1986), City of San Diego (2004), EDAW (2007), 5-year review of species status reports from the U.S. Fish and Wildlife Service (USFWS; various dates), designated critical habitat and the vernal pool recovery plan (USFWS 1998), review of geodatabase and key ancillary data on species that would contribute to knowledge of its status, and additional data from USFWS and the City since 2004. TWP 1 also includes data and information provided by renowned local vernal pool and native plant experts Scott McMillan and Tom Oberbauer of AECOM. Scott McMillan and Tom Oberbauer each have more than 20 years of experience with vernal pools in San Diego County, and are recognized as leading vernal pool and rare plant experts by the local resource agencies.

TWP 1 includes a summary overview of key data (refer to Section 1.5 and Attachment A), as well as a detailed chapter for each focal species.

Attachment A includes a table summarizing the vernal pool and focal species information contained in the City's vernal pool database for the Planning Area. For each complex, data provided includes the geographic planning area (North, Central, or South), total number of pools, size (total surface area) of vernal pools, number of pools with any one of the seven focal species, soils, location within or outside of preserved lands, and proximity to other complexes within the study area). As noted above, confidential data for the 4,807 known vernal pools on MCAS Miramar is not available and, therefore, not included in this analysis.

Key data is summarized for the seven focal species in Section 1.5 and discussed in more detail in each of the respective species chapters.

Attachment B includes two conceptual models. One illustrates pressures on the endemic vernal pool plant focal species and one illustrates pressures on focal fairy shrimp species. Direct, indirect, and long-term cumulative pressures are identified, as well as the inter-relationship of these various pressures. The pressures identified in these conceptual models are discussed in further detail relative to each species in the following chapters. The conceptual models will be used in subsequent TWPs as part of the process of identifying management and monitoring strategies to address specific threats to the focal species.

1.2 OVERVIEW OF VERNAL POOLS

Vernal pools are ephemeral wetlands that occur from southern Oregon through California into northern Baja California, Mexico (USFWS 1998). They require a unique combination of climatic, topographic, geologic, and evolutionary factors for their formation and persistence. They form in regions with Mediterranean climates where shallow depressions fill with water during fall and winter rains, and then dry up when the water evaporates in the spring (Collie and Lathrop 1976; Holland 1976, 1988; Thorne 1984).

An impervious subsurface layer consisting of claypan, hardpan, or volcanic stratum prevents downward percolation of water within the pools (Holland 1976, 1988). Figure 1-1 shows a schematic cross-section of a vernal pool. Seasonal inundation makes vernal pools too wet for adjacent upland plant species adapted to drier soil conditions, while rapid drying during late spring makes pool basins unsuitable for typical marsh or aquatic species that require a more persistent source of water. Groups of vernal pools are sometimes referred to as vernal pool complexes, which may include two to several hundred individual vernal pools (Keeler-Wolf et al. 1998). These vernal pool complexes were given identification numbers by Bauder (1986). The numbers were updated by the City of San Diego's Vernal Pool Inventory (2004), and again updated by SANDAG (2011). Local upland vegetation communities associated with vernal pools include needlegrass grassland, annual grassland, coastal sage scrub, maritime succulent scrub, and chaparral (USFWS 1998).

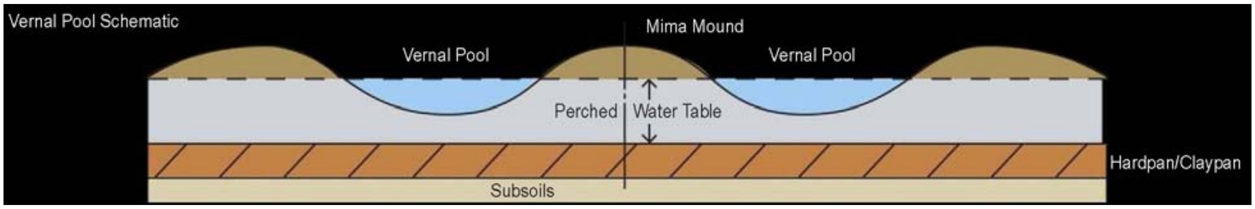

Figure 1-1. Schematic Cross-Section of a Vernal Pool

Historically, San Diego vernal pool habitat probably covered as much as 6% of the county, approximately 520 square kilometers (200 square miles). Current estimates indicate a loss of vernal pool habitat in San Diego County around 95 to 97% because of intensive cultivation and urbanization (Bauder and McMillan 1998).

Vernal pools are also known from northwestern Baja California, Mexico, from the border at Otay Mesa to the south as far as El Rosario (approximately 225 miles from the U.S./Mexican border). While there are more than 20 different locations for vernal pools in Baja California, most of these sites have either been destroyed in part, or at least impacted by cattle grazing, farming, and, more recently, development. AECOM senior restoration ecologist Scott McMillan estimates the loss of vernal habitat for Baja California is 75% or greater.

Vernal pools within a complex are generally hydrologically connected, such that water flows over the surface from one vernal pool to another and/or water flows and collects below ground such that the soil becomes saturated with water, thus filling the vernal pool through the perched water table that lies beneath (Figure 1-1). For overland flow to occur, the precipitation rate must exceed the infiltration rate or the soil column becomes completely saturated. Typically, significant watershed contributions only occur when the upland soils are fully recharged to the point where a perched groundwater table develops; this usually only occurs when seasonal precipitation is greater than average. Given rainfall patterns and amounts typical for Southern California, the direct precipitation into the pools is by far the most important source of water to the vernal pools (Hanes et al. 1990).

As shown in Attachment A, there are 63 vernal pool complexes identified within the study area, encompassing approximately 3,168 vernal pools and more than 59 acres of basin area. The majority of these complexes (42 complexes or 67%) are within the City’s existing Multi-Habitat Preserve Area boundary, which includes 2,745 (87%) of the City’s 3,168 vernal pools.

1.3 SUMMARY OF STATUS INFORMATION FOR FOCAL SPECIES

Table 1-1 summarizes key information and status data for each species. More detail is presented in the respective chapters. The chapters are intended to provide “stand alone” information for each species. Much of the data provided is similar for two or more species; therefore, some inherent redundancy exists in the presentation of the species information from chapter to chapter.

Threats and pressure to the focal vernal pool endemic plant and animal species are illustrated in the conceptual models included in Attachment B. To summarize, threats and pressures generally include:

- Direct pressures, such as construction, grazing, dumping, fire, off-road vehicle traffic
- Indirect pressures, such as altered hydrology, draining, exposure to pesticides, runoff from adjacent operations, competition by introduced species, loss of pollinators, habitat fragmentation
- Long-term, cumulative pressures, such as effects of isolation on genetic diversity and local genotypes, air and water pollution, and changes in nutrient availability
- Potential future climate change

Table 1-1
Summary of Focal Species Information

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
Otay Mesa mint	FE	No designated critical habitat	• Annual herb • Six flowers per node • Plant emit a strong, turpentine mint odor	Known from clay-pan-type vernal pools on Otay Mesa	• Dependent on inundation and drying cycles of vernal pools • Blooms from May or June through early July • Primarily bee pollinated • Gene dispersal occurs via pollen or seed	• Found only in southern San Diego County vernal pools on Otay Mesa • Extirpated from Baja due to development	• Occurs in 457 (14.4%) vernal pools within nine vernal pool complexes • All but one of the pools have had some habitat restoration • Found on Stockpen, Olivenhain, Linne, and Huerhuero soils
San Diego Mesa mint	FE	No designated critical habitat	• Annual herb • Two flowers per node • Plant emit a strong, sweet mint odor	Known from hard-pan-type vernal pools in San Diego County	• Dependent on inundation and drying cycles of vernal pools • Blooms from May or June through early July • Primarily bee pollinated • Gene dispersal occurs via pollen or seed	• Mesas of western San Diego County including Del Mar mesa, Mira Mesa, Marine Corps Air Station Miramar, Kearny Mesa, and western Tierrasanta • Historically, thought to have occurred around Linda Vista, the vicinity of Balboa Park, Normal Heights, and the area surrounding San Diego State University	• Occurs in 368 vernal pools (11.6%) within 16 vernal pool complexes • Estimated approximately 10% or less of pools have had habitat restoration • Found on Redding soils, with Olivenhain or Linne on several complexes • Hard-pan spoils acidic in pH

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
Spreading navarretia	FT	6,720 acres	• Annual herb • Flat-topped, compact, leafy head flowers with white to lavender-white petals • Seed is covered by a layer that becomes sticky and viscous when the capsule is moistened	Known from hardpan, claypan, alkali playas, and alluvial terrace pool complexes	• Pollination and dispersal mechanisms not well known • Ability to self-pollinate, but is not an obligate self-pollinator • Blooms in May and June through summer months • Minimal information on seed dispersal	• Found in widely disjointed and restricted vernal pool complexes extending from the Santa Clarita region of Los Angeles County, to the western lowlands of Riverside County, through coastal and foothill San Diego County, and south to San Quintin, Baja	• Occurs in 110 vernal pools (3.5%) within 12 complexes • Estimated that at least 80% of these pools have had some habitat restoration • Redding, Huerhuero, Stockpen, Olivenhain, and Linne • Primarily claypan-type soils associated with marine sediments and typically have basic pH subsurface layers
San Diego button-celery	FE	No designated critical habitat	• Biennial perennial gray-green herb that has a storage tap-root • stems and lanceolate leaves give the plant a prickly appearance	• Found in almost every type of Southern California vernal pool, including claypan-, hardpan-, and alluvial-terrace-type pools • Does not appear to be restricted to any particular type of soil type	• Vernal pool obligate and relies on ephemerally wet conditions to reproduce, blooming from April through June • Seems more tolerant of a wider range of vernal pool habitat than most obligate vernal pool species • Can tolerate disturbance factors better than most endemic species	• San Diego County at Otay Mesa, Kearny Mesa, Del Mar Mesa, MCAS Miramar, and Marine Corps Base (MCB) Camp Pendleton, and in northern Baja California, Mexico • Historically, habitat included a coastal swath from Mesa de Colonet and San Quintin in	• Occurs in 901 vernal pools (28.4%) within 28 vernal pool complexes • Estimated that at least 45% of these pools have had some habitat restoration • Occurs across various types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, and Linne

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
					• Presumably insect-pollinated	Baja north to Los Angeles County	
California Orcutt grass	FE	No designated critical habitat	• Annual grass • Bright gray-green in color and secretes sticky droplets • Inflorescences consist of seven spikelets arranged in two ranks, with the upper spikelets overlapping on a somewhat twisted axis	Restricted to vernal pools in Southern California	• Flowers from April through July and then sets seed • Adapted to conditions in the wettest, longest lasting portion of vernal pools • Typically require at least 30 days of inundation before germination begins • Believed to be wind pollinated	• Ventura, Los Angeles, Riverside, and San Diego counties • Several historical occurrences reported from northern Baja	• Occurs in 58 vernal pools (1.8%) with California Orcutt grass within six vernal pool complexes • Estimated that at least 90% of pools have had some habitat restoration • Occurs on Huerhuero, Olivenhain, Stockpen, and Linne soils • Claypan-type soils associated with marine sediments with subsurface layers that are basic in pH
Riverside fairy shrimp	FE	306 acres currently designated, with an additional 481 acres proposed, for a total of 847 acres	• Small aquatic crustacean • Feed on algae, bacteria, protozoa, rotifers, and bits of detritus	Restricted to vernal pools and other non-vegetated ephemeral pools greater than 30.5 centimeters (12 inches) in depth in Riverside, Orange, and San Diego Counties	• Usually observed January through March, although the hatching period may be extended in years with early or late rainfall • Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool,	• Riverside, San Diego, and Orange counties • Historical occurrences reported from Ventura County, Los Angeles County, and northwestern Baja	• Identified in198 vernal pools (6.3%) within 11 vernal pool complexes • Estimated that at least 95% of these pools have had some habitat restoration • Occurs on Huerhuero, Stockpen,

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
					depending on water temperature • Cysts are capable of withstanding temperature extremes and prolonged drying		Olivenhain, Diablo, and Linne soils • Claypan-type soils associated with marine sediments with subsurface layers that are basic in pH
San Diego fairy shrimp	FE	3,082 acres	• Small aquatic crustacean • Feed on algae, diatoms, and particulate organic matter	• Occur in vernal pools and other non-vegetated ephemeral pools from 2 to 12 inches in depth in coastal areas of San Diego County, Orange County, and northwestern Baja • Restricted to dilute vernal pools, having relatively low sodium concentrations, low alkalinity, and neutral pH	• Usually observed January through March, although the hatching period may be extended in years with early or late rainfall • Individuals hatch, mature, and reproduce within 7 to 14 days of rainfall filling a pool, depending on water temperature	• Coastal areas of San Diego County, Orange County, and northwestern Baja • Historic occurrence in Santa Barbara County	• Occurs in 611 vernal pools (19.4%) within 36 vernal pool complexes • Estimated that at least 60% of these pools have had some habitat restoration • Occurs across all types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, Linne, and Chesterton. • Occur on both claypan- and hardpan-type soils

FE = federally endangered
FT = federally threatened

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CHAPTER 2
OTAY MESA MINT

2.1 LISTING STATUS

Otay Mesa mint was federally listed as endangered on August 3, 1993. The USFWS 5-year review was completed on September 1, 2010 (USFWS 2010a). No critical habitat has been designated for Otay Mesa mint, but the Recovery Plan for Vernal Pools of Southern California (Recovery Plan) calls for all populations of Otay Mesa mint to be conserved and protected (USFWS 1998). An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

2.2 SPECIES DESCRIPTION

Otay Mesa mint is an annual herb in the mint family (*Lamiaceae*). Howell (1931) considered Otay Mesa mint to be diagnosable from San Diego Mesa mint (*Pogogyne abramsii*) by having a glabrous (smooth) calyx and bract with a different morphology. This distinction is supported by Jokerst (1993). Otay Mesa mint is also diagnosable by usually having at least six flowers (occasionally more) per node on the stem, a glabrous to minutely pubescent (hairy) calyx, while San Diego Mesa mint typically only has two flowers per node. Otay Mesa mint bracts and leaves are wider than San Diego Mesa mint.

Otay Mesa mint can reach 30 centimeters (1 foot) or more. The plant is typically minimally branched, and the vegetative and floral portions of the plant emit a strong, turpentine mint odor. Otay Mesa mint displays internodal elongation, adventitious roots, reduced branching when grown under water (but are branched), and shorter when never inundated (Bauder 1987, 1992). In contrast to San Diego Mesa mint, the vegetative portions of the plant do not develop a reddish tinge until the plant is past the flowering period. The flowers are purple with a white throat.

2.3 HABITAT

Otay Mesa mint is restricted to vernal pools on Otay Mesa in the City and County of San Diego. Vernal pools that support Otay Mesa mint are found on Huerhuero or Stockpen soils and the one complex on the San Diego National Wildlife Refuge that has Olivenhain and Diablo clay soils (Bauder and McMillan 1998; Beauchamp and Cass 1979). All Otay Mesa mint populations are known from clay-pan-type vernal pools.

2.4 LIFE CYCLE

The life cycle of the Otay Mesa mint is dependent on inundation and drying cycles of vernal pools. The link between the onset of germination, temporal conditions associated with vernal pool inundation, temperature, and moisture are critical to the germination, maturation, flowering, and fruiting of Otay Mesa mint. The interaction of these factors provides the plants favorable conditions in the spring rather than in the summer, autumn, or winter. Natural differences in the precipitation and the inundation/drying time of vernal pools from year to year may influence the distribution and abundance of Otay Mesa mint. These environmental factors make it difficult to obtain an accurate measure of the population. Additionally, a portion of the population is represented by seeds remaining in the seed bank, which is not accounted for each year.

Flowering commences in May and continues through June or July; by early to mid-summer, the pools become dry. The family is primarily bee pollinated (Proctor and Yeo 1973). AECOM senior restoration ecologist Scott McMillan has observed potential pollinators such as hover flies (Syrphids), bee flies (Bombylids), sweet bees (Halictids), and the common honey bee (*Apis mellifera*) visiting Otay Mesa mint flowers.

Gene dispersal may occur via pollen or seed. Otay Mesa mint does not have seed morphology associated with animal or wind dispersal, although scattered occurrences of pool plants along well-worn trails that link individual pools over wide areas suggest that large animals may contribute to seed dispersal (Cole 1995). Waterfowl use pools, especially the larger ponds or vernal lakes, and they are presumed to carry seeds and invertebrate eggs from pool to pool (Proctor et al. 1967; Zedler 1987). While the seed does not have any apparent special adaptations for dispersal, it can be readily dispersed when it is retained in the heavy clay soils common to vernal pools. The seed can stick to the heavy clay and then be transferred, along with other inoculums, via wildlife movement or other means of dispersal.

Zedler and Black (1992) found that San Diego Mesa mint seeds germinated and grew from pellets of brush rabbits and Audubon's cottontail rabbits (*Sylvilagus bachmani* and *S. auduboni*), which were collected from vernal pools on Del Mar Mesa and Miramar Mesa. They postulated that rabbit movement might be a potential mechanism for dispersal and genetic mixing of vernal pool obligate species, such as Otay Mesa mint. Otay Mesa mint seeds can sometimes float, which may result in limited dispersal opportunities when pools interconnect or lakes fill their basins in years of greater than average precipitation (Scheidlinger 1981).

2.5 STATUS AND DISTRIBUTION

Otay Mesa mint is found only in southern San Diego County. This mint grows in vernal pools near the Otay Mesa region. Historically, Otay Mesa mint was believed to be found beyond Otay Mesa and occurred at 10 locations in southern San Diego County, including sites farther north near University Heights, Balboa Park, and Mission Valley (refer to USFWS 2010a, Appendix 1). However, upon review of these historical herbarium collections from the central part of San Diego County, it was determined that these historical occurrences were actually the San Diego Mesa mint (McMillan 2011).

Otay Mesa mint also historically grew in vernal pools near the Tijuana Airport in Baja California, Mexico, but has likely been extirpated there due to urban development. Most recently, the San Diego National Wildlife Refuge introduced it into the vernal pool complex ("S" series) located just south of the Sweetwater Reservoir. Seeds were distributed at the Shinohara vernal pool restoration site prior to the 2011 growing season. The seeds have sprouted, but it is too soon to tell whether this population will be successfully established.

No estimate of numbers of individual Otay Mesa mint plants at specific sites is currently available. This is likely due to the difficulty of measuring temporal abundance at each occurrence. Local site conditions, rainfall, and fresh water pooling likely influence numbers of standing plants and their local distribution (Schiller et al. 2000). Like most annual plants, the germination success of Otay Mesa mint differs annually depending, in part, on temperature, timing, and amount of rainfall. Yearly variability in rainfall will result in variability in water depth and duration of vernal pools, which can alter the proportion of each pool experiencing particular moisture conditions in a given year. This can have implications for species distribution within and among pools given the narrow habitat preferences and tolerances of many vernal pool plant species (Bauder 2005). The number of individuals may differ at any site for any year because numbers also depend, in part, on reproductive success of previous cohorts, the number of seeds deposited in the seed bank, and the survivorship of the annual seedling cohort in the year the survey was conducted. In 2003, the City conducted a survey of vernal pools within its jurisdiction. At that time, of the 1,142 vernal pools surveyed with sensitive plant species, Otay Mesa mint was found in 376 pools, with a mean percent cover per pool of 18% (City of San Diego 2004).

2.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model shown in Attachment B. Specific threats to Otay Mesa mint can be divided into three major categories:

1. direct destruction of Otay Mesa mint from construction, grazing, dumping, fire, off-road vehicle traffic (including Border Patrol activity), and other mechanical disturbances;

2. indirect threats that degrade or destroy Otay Mesa mint, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, habitat fragmentation; and,

3. potential long-term, cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support Otay Mesa mint could become filled with upland native and nonnative species that outcompete Otay Mesa mint in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could outcompete Otay Mesa mint in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact germination rates, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which Otay Mesa mint currently grows more vulnerable to the threats of subsequent erosion and nonnative/native plant invasion (Ackerly 2005; Graham 1997; Miller et al. 2003).

As with other vernal pool species, Otay Mesa mint is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators. Due to its restricted range and small population size, conservation of Otay Mesa mint is dependent on preservation of extant populations and re-establishment of populations of Otay Mesa mint within other pools on Otay Mesa.

2.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring Otay Mesa mint populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successful restoration efforts were achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvement to protect the watershed and attract pollinators. Effective weed control in vernal pools with Otay Mesa mint was achieved through the use of hand weeding and herbicide applications; seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for Otay Mesa mint was collected from genetically and geographically local populations. These methods have resulted in the addition of Otay Mesa mint to more than 300 vernal pools.

2.8 STATUS IN STUDY AREA

Figure 2-1 shows the distribution of Otay Mesa mint within the study area. The locations of Otay Mesa mint within the various vernal pool complexes in the study area are included in Attachment A. As shown, Otay Mesa mint occurs in 457 (14.4%) vernal pools located within nine vernal pool complexes, all of which are located on Otay Mesa. All but one of the 458 vernal pools are pools that have had some habitat restoration: the single pool at J29-30 complex.

It has been documented that soil type may play an important role in the distribution of vernal pool species in Southern California. Certain species may only occur on the hardpan-type vernal pool, while other species are only found in claypan pools. In addition to these major differences in substrate, other factors such as soil texture, depth, pH, and soil origin may influence the distribution of these species (Bauder and McMillan 1998). The soil types that underlie the 10

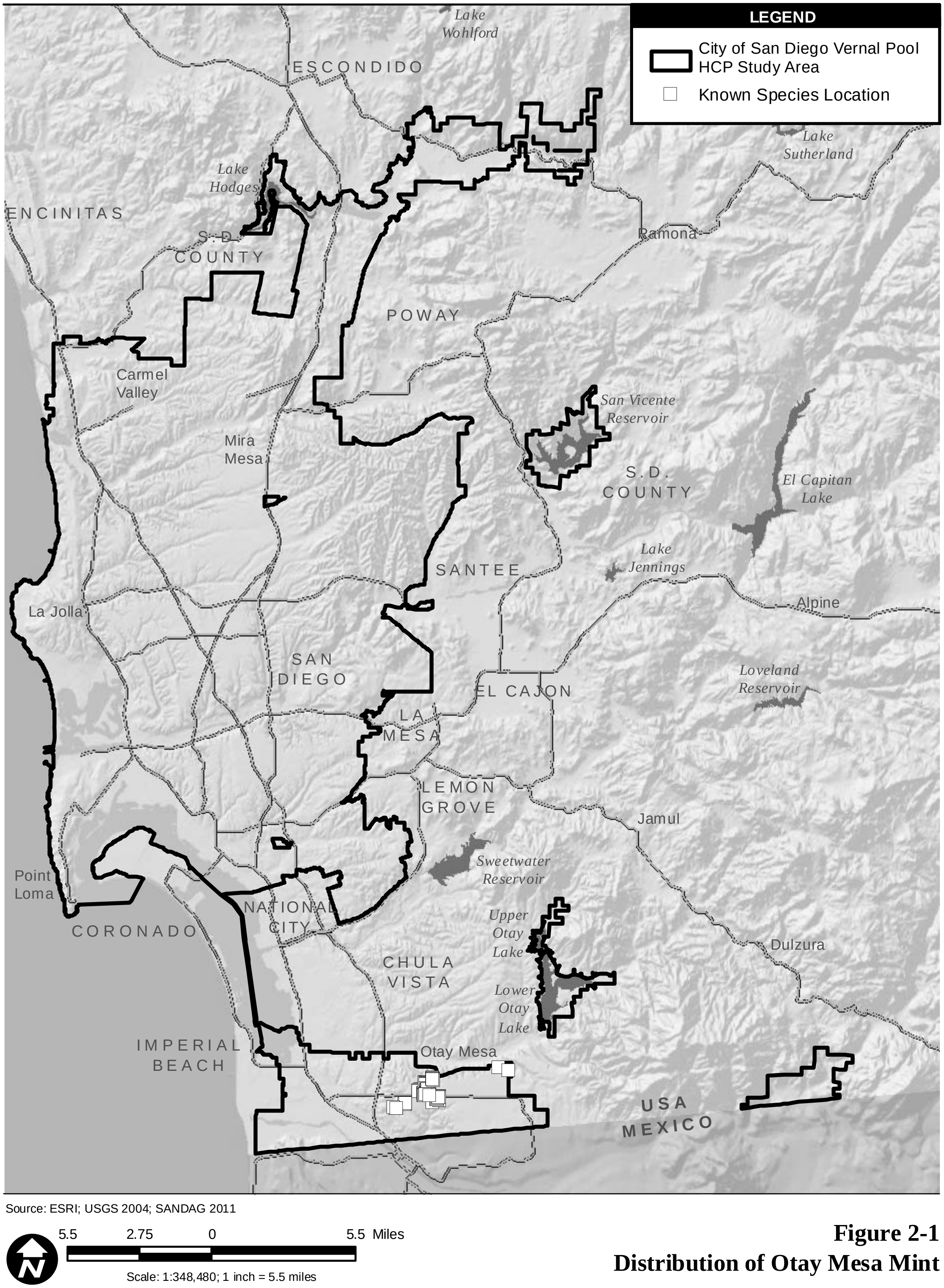

Figure 2-1
Distribution of Otay Mesa Mint

Otay Mesa mint complexes within the study area are Stockpen, Olivenhain, Linne, and Huerhuero. These are all claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH. AECOM senior restoration ecologist Scott McMillan believes that these factors could be important to the distribution of Otay Mesa mint.

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CHAPTER 3
SAN DIEGO MESA MINT

3.1 LISTING STATUS

San Diego Mesa mint was federally listed as endangered in September 1978. The USFWS 5-year review was completed on September 1, 2010. No critical habitat has been designated for San Diego Mesa mint, but the Recovery Plan calls for essentially all populations of San Diego Mesa mint to be conserved and protected. Much of the range and distribution for the species is found on MCAS Miramar with remaining populations outside the MCAS Miramar found on City of San Diego MSCP lands. The MCAS Miramar is an active military installation and cannot be designated as critical habitat, for preservation, or for non-military habitat mitigation. While the MCAS Miramar has an approved management plan for vernal pools and San Diego Mesa mint, it is not required to maintain all existing populations of San Diego Mesa mint within the MCAS Miramar boundary (U.S. Marine Corps 2006). Because of this less-than-certain protection for San Diego Mesa mint on the MCAS Miramar, the Recovery Plan considers all populations within the Vernal Pool HCP Planning Area to be critical to the stability and conservation of the species (USFWS 1998). An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

3.2 SPECIES DESCRIPTION

San Diego Mesa mint is an annual herb in the mint family (Lamiaceae). Howell (1931) considered San Diego Mesa mint to be diagnosable from Otay Mesa mint (*Pogogyne nudiuscula*) by having a hairy calyx and bract with a different morphology. This distinction is supported by Jokerst (1993). San Diego Mesa mint is also diagnosable by usually having only two flowers per node on the stem, whereas Otay Mesa mint has at least six flowers per node.

San Diego Mesa mint can reach 30 centimeters (1 foot) or more in height and typically blooms from May or June through early July. The plants usually give off a strong, sweet mint odor. San Diego Mesa mint usually has two flowers per node, which are arranged in whorls. The vegetative portions of the plant develop a reddish tinge during maturation. The plant has a hairy calyx, rather than the smooth calyx of the Otay Mesa mint, and bracts and leaves that are narrower than Otay Mesa mint.

3.3 HABITAT

San Diego Mesa mint is found in vernal pool habitat in San Diego County. Vernal pools that support San Diego Mesa mint are typically found on Redding soils, historically the second most common of the five pool-supporting soils in San Diego County, and currently the most common (Beauchamp and Cass 1979:26; Bauder and McMillan 1998:61–62). All San Diego Mesa mint populations are known from hard-pan-type vernal pools.

3.4 LIFE CYCLE

The life cycle of San Diego Mesa mint is dependent on inundation and drying cycles of vernal pools. The link between the onset of germination, temporal conditions associated with vernal pool inundation, temperature, and moisture are critical to the germination, maturation, flowering, and fruiting of San Diego Mesa mint. The interaction of these factors provides the plants favorable conditions in the spring rather than in the summer, autumn, or winter. Natural differences in the precipitation and the inundation/drying time of vernal pools from year to year may influence the distribution and abundance of San Diego Mesa mint. These environmental factors make it difficult to obtain an accurate measure of the population. Additionally, a portion of the population is represented by seeds remaining in the seed bank that are not accounted for each year.

San Diego Mesa mint usually blooms in May and June when water is absent from the vernal pool (Munz 1974:531). The plants produce fruit, dry out, and senesce in the hot, dry summer months.

Pollination of San Diego Mesa mint was described by Schiller et al. (2000:392) by monitoring insect visitors to individual plants on Del Mar Mesa. They found the Eurasian honey bee (*Apis mellifera*), two anthophorid bees (*Exomalopsis nitens* and *E. torticornis*), and bee flies (*Bombylids*) to be the most common and likely pollinators of San Diego Mesa mint at the Del Mar Mesa locality. Most of the insect visitors (76%) in this study were Bombylids; anthophorid bees were the next most common (17%). AECOM senior restoration ecologist Scott McMillan has observed other potential pollinators on San Diego Mesa mint, including hover flies (Syrphids). Schiller et al. documented that San Diego Mesa mint is self-fertile, but has significantly greater seed set when cross-pollinated (2000:393).

Gene dispersal may occur via pollen or seed. San Diego Mesa mint does not have seed morphology associated with animal or wind dispersal, although scattered occurrences of pool plants along well-worn trails that link individual pools over wide areas suggest that large animals may contribute to seed dispersal (Cole 1995). Waterfowl use pools, especially the larger ponds or vernal lakes, and they are presumed to carry seeds and invertebrate eggs from pool to pool (Proctor et al. 1967; Zedler 1987). While the seed does not have any apparent special adaptations for dispersal, it can be readily dispersed when it is retained in the heavy clay soils common to vernal pools. The seed can stick to the heavy clay and then be transferred, along with other inoculums, via wildlife movement or other means of dispersal.

Zedler and Black (1992:4) found that San Diego Mesa mint seeds germinated and grow from pellets of brush rabbits and Audubon's cottontail rabbits, which were collected from vernal pools on Del Mar Mesa and Miramar Mesa. They postulated that rabbit movement might be a potential mechanism for dispersal and genetic mixing of vernal pool obligate species. In addition, San Diego Mesa mint seeds can sometimes float, which may result in limited dispersal opportunities when pools interconnect or lakes fill their basins in years of greater than average precipitation (Scheidlinger 1981:54).

3.5 STATUS AND DISTRIBUTION

San Diego Mesa mint is found in vernal pools on mesas of western San Diego County; however, specific occurrence and range information was not included in the official listing (USFWS 1978, p. 44810). The Recovery Plan (USFWS 1998) identifies the northern distribution for San Diego Mesa mint as Del Mar mesa. It occurs south on Mira Mesa, MCAS Miramar, and Kearny Mesa, with a few scattered populations in western Tierrasanta. Examination of occurrence data from the time of listing (Bauder 1986; CDFG 2010) suggests that the distribution of San Diego Mesa mint has decreased since its listing in 1978. San Diego Mesa mint was extirpated from pool complexes in the most southern and northern extremities of its range (Element Occurrences 49, 56); San Diego Mesa mint was extirpated from at least one pool complex in 12 of the 13 geographic areas where it was known to occur since listing (refer to Appendix 1 of the USFWS 5-year review). No new extant occurrences have been detected since the time of listing; however, San Diego Mesa mint has been restored at multiple mitigation sites (refer to Appendix 1 of the USFWS 5-year review).

Historically, outside of San Diego Mesa mint's current range, the species is thought to have occurred around Linda Vista, the vicinity of Balboa Park, Normal Heights, and the area surrounding San Diego State University (USFWS 1998; Zedler et al. 1979). Some confusion has existed regarding San Diego Mesa mint's historical range due to misidentified herbarium specimens (identified as *Pogogyne nudiuscula*) and vague references regarding collection sites. Upon review of these historical herbarium collections from the central part of San Diego County, it was determined that these historical occurrences were, in fact, San Diego Mesa mint (Bauder and McMillan 1998; Howell 1931).

No estimate of numbers of San Diego Mesa mint plants at specific sites is currently available. This is likely due to the difficulty of measuring temporal abundance at each occurrence. Local site conditions, rainfall, and fresh water pooling likely influence numbers of standing plants and their local distribution (Schiller et al. 2000). Like most annual plants, the germination success of San Diego Mesa mint differs annually depending, in part, on temperature, timing, and amount of rainfall. Yearly variability in rainfall will result in variability in water depth and duration of vernal pools, which can alter the proportion of each pool experiencing particular moisture conditions in a given year. This can have implications for species distribution within and among pools, given the narrow habitat preferences and tolerances of many vernal pool plant species (Bauder 2005). The number of individuals may differ at any site for any year because numbers also depend, in part, on reproductive success of previous cohorts, the number of seeds deposited in the seed bank, and the survivorship of the annual seedling cohort in the year the survey was conducted. In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed with sensitive plant species, San Diego Mesa mint was found in 373 pools, with a mean percent cover per pool of 6% (City of San Diego 2004).

3.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model found in Attachment B. Specific threats to San Diego Mesa mint can be divided into three major categories:

1. direct destruction of San Diego Mesa mint from construction, grazing, dumping, fire, military development and training, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego Mesa mint, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, and habitat fragmentation; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

At the time of listing in 1978, the major threats to San Diego Mesa mint and its habitat were road-widening projects (such as Miramar Road, State Route 163, and State Route 52), housing development, off-highway vehicle (OHV) use, and illegal dumping. Impacts from development include more than building of homes, and are discussed here under the broader term “urban development.” Military activities, altered hydrology, and nonnative plants are new threats identified since its listing, which all continue to pressure San Diego Mesa mint habitat.

While impacts from urban development and altered hydrology have decreased, indirect impacts from these continue to threaten San Diego Mesa mint. Military activities remain a threat to most occurrences on MCAS Miramar due to training and development. In general, urbanization is not expected to expand, but in the limited areas where this is still a possibility, destruction, modification, and curtailment of San Diego Mesa mint habitat may continue.

Impact from invasive species is the prominent range-wide threat to San Diego Mesa mint populations, and is exacerbated by disturbance associated with other threats (e.g., urban development, OHV use). The Cedar Fire in 2003 burned large expanses of MCAS Miramar, including many vernal pools that support San Diego Mesa mint and other listed vernal pool species. For many of these areas, the fire facilitated a dramatic increase in the weed populations. Since the fire, AECOM senior restoration ecologist Scott McMillan has observed an increase in weed invasion, which is impacting populations of San Diego Mesa mint.

Another possible threat to this species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. The narrow range of San Diego Mesa mint makes it particularly vulnerable to all threats. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support San Diego Mesa mint could become filled with upland native and nonnative species that outcompete San Diego Mesa mint in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could out-compete San Diego Mesa mint in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact germination rates, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which San Diego Mesa mint currently grows more vulnerable to the threats of subsequent erosion and especially nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003). San Diego Mesa mint is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators.

3.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had success restoring San Diego Mesa mint populations and the habitat that supports them (EDAW 2002, 2009; RECON 2007). These successfully restoration efforts have been achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvements to provide watershed protection and to attract pollinators. Effective weed control in vernal pools with San Diego Mesa mint has been achieved through the use of hand weeding and herbicide applications, while seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for San Diego Mesa mint was collected from genetically and geographically local populations. These methods have resulted in the addition of San Diego Mesa mint to more than 50 pools.

3.8 STATUS IN STUDY AREA

Figure 3-1 shows the distribution of San Diego Mesa mint within the City. The locations of San Diego Mesa mint within the various vernal pool complexes in the City are included in Attachment A. As shown, there are 368 vernal pools (11.6%) with San Diego Mesa mint within 16 vernal pool complexes. While the exact number of restored vernal pool with San Diego Mesa mint is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that approximately 10% or less of these pools have had some habitat restoration or enhancement.

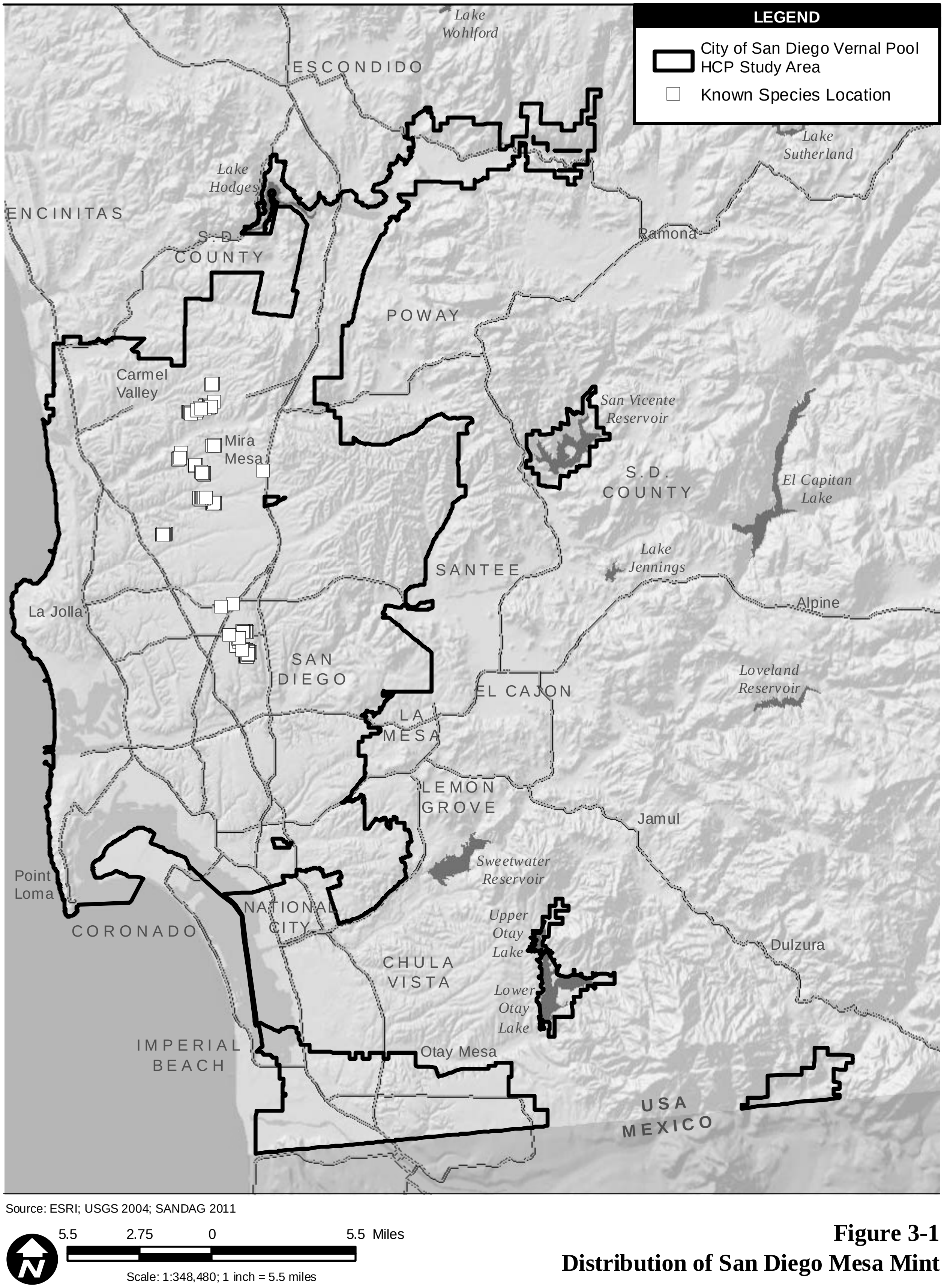


Figure 3-1
Distribution of San Diego Mesa Mint

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\SanDiegoMesaMint.mxd, 9/13/2011, augellop

While the primary soil type that underlies San Diego Mesa mint is Redding in most complexes, Olivenhain was also identified from several complexes. One location, the J30 complex (Lone Star), also had Linne soils underlying the complex. Redding is a hardpan-type soil that is associated with alluvial deposits and typically has subsurface layers that are acidic in pH may be important to the distribution of San Diego Mesa mint.

CHAPTER 4
SPREADING NAVARRETIA

4.1 LISTING STATUS

Spreading navarretia was federally listed as threatened on October 13, 1998. The USFWS 5-year review was completed on August 10, 2009. Approximately 6,720 acres of habitat in Los Angeles, Riverside, and San Diego Counties, California, fall within the boundaries of the critical habitat designation for spreading navarretia (USFWS 2010b). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

4.2 SPECIES DESCRIPTION

Spreading navarretia is an annual herb in the phlox family (*Polemoniaceae*). It is a low, mostly spreading or ascending plant, 10 to 15 centimeters (4 to 6 inches) tall. The leaves are 1 to 5 centimeters (0.4 to 2 inches) long and finely divided into slender spine-tipped lobes. The lower portions of stems are mostly hairless (glabrous). The flowers are arranged in flat-topped, compact, leafy heads. The white to lavender-white petals (corolla) are joined at their bases to form a tube, although the tips (lobes) are free. The fruit is an ovoid, two-chambered capsule. Each seed is covered by a layer that becomes sticky and viscous when the capsule is moistened. The range of spreading navarretia overlaps with two other species in the genus *Navarretia*:

needle-leaved navarretia (*N. intertexta*) and prostrate navarretia (*N. prostrata*). Spreading navarretia is distinguished from the other two species by its linear corolla lobes, spreading or ascending habit, flat-topped inflorescences, calyx size and shape (sepals collectively), and the position of the corolla relative to the calyx (Day 1993).

4.3 HABITAT

Spreading navarretia occurs on a number of vernal pool soil types, including Huerhuero, Stockpen, Redding, and Chesterton, and is known from hardpan, claypan, alkali playas, and alluvial terrace pool complexes.

The hydrologic regime in the western Riverside County populations of spreading navarretia is unique. These populations are usually associated with the alkali soils series, which facilitate habitat that has sporadic flooding in combination with slow drainage of the alkaline soils. This habitat floods locally on a seasonal basin, while large-scale flooding occurs less frequently (possibly every 20 to 50 years). During the normal seasonal flooding regime, the alkali scrub vegetation expands in distribution and out-competes other native and nonnative species. When large-scale flooding occurs, standing and slow draining water is present for weeks or months and results in the death of submerged alkali scrub. These conditions during large-scale flooding allow adapted annual species, like spreading navarretia, to regain and locally expand their range (Bramlet 1993, 2004; Roberts 2004).

4.4 LIFE CYCLE

The life cycle of spreading navarretia is dependent on the function of the vernal pool ecosystem. This annual species germinates from seeds left in the seed bank. For many vernal pool plant species, temperature and moisture affect the timing of plant germination (Myers 1975). Although not proven, it is likely that spreading navarretia uses these same cues for germination. Most navarretia species have indehiscent fruit, or fruit with fibers that absorb water and expand to break open the fruit after a substantial rain (Spenser and Rieseberg 1998). The timing of germination is important so that the plant germinates under favorable conditions in the spring rather than the summer, autumn, or winter.

Spreading navarretia abundance also varies from year to year depending on precipitation and the inundation/drying time of the vernal pool. This annual variation makes it impossible to obtain an accurate count of the number of individuals in the population because the proportion of standing plants to remaining seeds in the seed bank that makes up the population cannot be measured.

Additionally, the occurrences can vary spatially in alkali playa habitat where pools are not in the same place from year to year.

Pollination and dispersal mechanisms are not well known for spreading navarretia. The plant has the ability to self-pollinate, but is not an obligate self-pollinator. Outcrossing, rather than self-pollination, could be advantageous for many vernal pool specialists because it provides a way to better adapt and evolve to the changing conditions of vernal pool habitat through the recombination of beneficial genes. Outcrossing requires annual plants to flower for longer periods of time to attract pollinators (Spenser and Rieseberg 1998). Information on the pollinators of spreading navarretia is not available. Hypothetically, insects would be the main pollinators of the flowers. For example, the Hymenopteran insect *Perdita navarretiae* (a type of mining bee in the Andrenidae family) has been documented to make repeated visits to spreading navarretia, possibly for pollination (Krombein 1979). Many vernal pool plants are pollinated by insects that collect pollen in the vernal pool and nest upland of the pool (Thorp and Leong 1998). This relationship between plant and pollinator connects the upland areas to the vernal pools and shows how important the upland areas are for sustainability of vernal pools.

After germination, the plant usually flowers in May and June when the vernal pool is devoid of water (Glenn Lukos 2005). The plant then produces fruit, dries out, and senesces in the hot, dry summer months.

Minimal information exists on the dispersal of spreading navarretia seeds. Individual seeds can often be glued in clusters of five to 20 seeds, and the glued layer becomes viscous and sticky when wet. The seed could stick to an animal or bird passing through the vernal pool, providing a method of dispersal. On the other hand, theories also suggest that the layer helps secure the seed during seed establishment (Sorenson 1986). More research is needed to discover the actual methods of pollination and dispersal for spreading navarretia.

4.5 STATUS AND DISTRIBUTION

Spreading navarretia is found in widely disjointed and restricted vernal pool complexes extending from the Santa Clarita region of Los Angeles County, east to the western lowlands of Riverside County, south through coastal and foothill San Diego County, and south to San Quintin, Baja California, Mexico. Nearly 60% of populations in the official listing (USFWS 1998) and in the Recovery Plan (USFWS 1998) were concentrated at three locations: Otay Mesa in southern San Diego County, alongside the San Jacinto River in western Riverside County, and near Hemet in western Riverside County (Bauder 1986; Bramlet 1993). At the time of listing, spreading navarretia occupied less than 300 acres (120 hectares) of habitat in the United States (USFWS 1998).

Range-wide, comprehensive surveys for spreading navarretia have not occurred since listing. The distribution of spreading navarretia presented in the USFWS 5-year review is based on a variety of sources. Surveys are disjointed across space and time, and lack uniform variables that quantify the extent and precise location of occurrences, thus making it difficult to comprehensively evaluate the status and trend of the species. There were 34 extant, documented occurrences of spreading navarretia at the time of listing. Seventeen additional occurrences have been identified since listing. Three of these recently detected occurrences have since been extirpated by urban development. Currently, there are 48 extant occurrences of spreading navarretia in Riverside and San Diego Counties. It is probable that these 17 new occurrences existed at the time of listing, but had not been detected and, therefore, were not analyzed in the final listing rule. Surveys have failed to locate spreading navarretia at 12 occurrences known at listing; however, spreading navarretia does not express itself every year. This natural phenomenon, where not all of the seeds in the soil germinate in a given year even when conditions are suitable, is a form of reserve termed a “seed bank.” Because suitable habitat is still considered present at these 12 occurrences, they are considered extant. It is possible that spreading navarretia was present only in the seed bank and, therefore, not observed as standing plants when surveys were conducted. During drier years, the species is not as abundant and is more difficult to find, especially during casual surveys. Also presumed extant are seven occurrences known at listing that have not been resurveyed since then.

4.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model provided in Attachment B. Specific threats to spreading navarretia can be divided into three major categories:

1. direct destruction of spreading navarretia from construction, grazing, dumping, fire, military development and training, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy spreading navarretia, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, and habitat fragmentation; and

3. potential long-term, cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat is the primary threat to spreading navarretia, especially where urbanization exists. Urbanization of surrounding lands results in fragmentation of spreading navarretia habitat, including protected areas. Lands that are not preserved in perpetuity are subject to significant habitat modification. Acquisition of land and conservation easements have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss and degradation continues. Restoration activities and associated conservation measures for spreading navarretia habitat have been implemented and improved over time, although many areas are still subject to impacts such as nonnative plant invasion, OHV use, trespassing, manure dumping, and alteration of hydrology, which all contribute to lowering the quality of habitat for spreading navarretia.

Impacts associated with competition from invasive nonnative plants, trash dumping, trampling, and climate change (drier conditions and drought) were identified at the time of listing and continue to threaten spreading navarretia. Since listing, human access and disturbance effects associated with adjacent development have been documented to occur at 71% of the spreading navarretia occurrences. Impact from invasive species is the prominent range-wide threat to spreading navarretia populations and is exacerbated by disturbances associated with other threats (e.g., urban development, OHV use). Certain invasive nonnative plants (i.e., *Lolium perenne*) may replace spreading navarretia if conditions are appropriate (USFWS 2009).

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support spreading navarretia could become filled with upland native and nonnative species that outcompete spreading navarretia in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could outcompete spreading navarretia in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact germination rates, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which spreading navarretia currently grows more vulnerable to the threats of subsequent erosion and especially nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003). Spreading navarretia is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators.

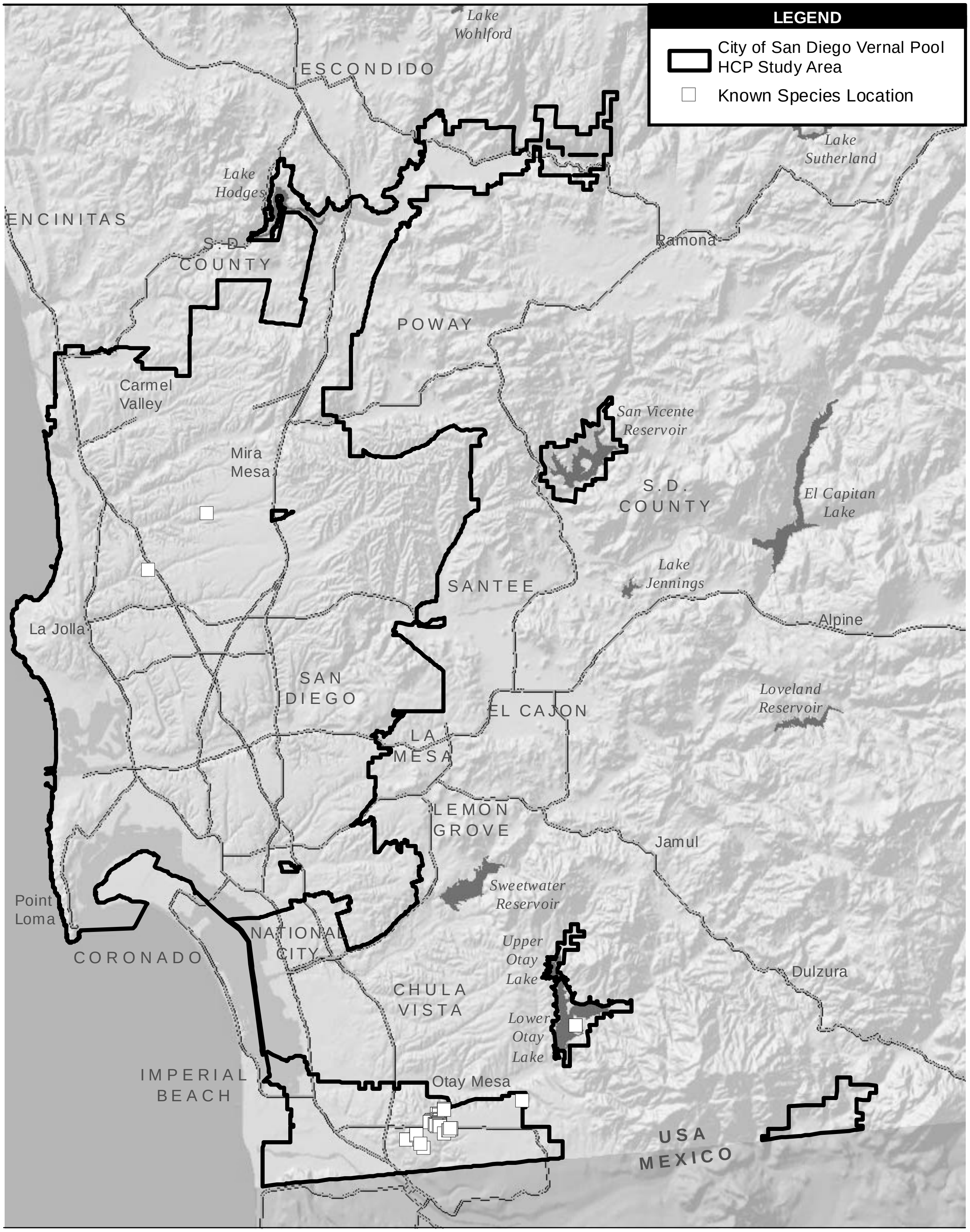
4.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring spreading navarretia populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successful restoration efforts were achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvements to protect the watershed and attract pollinators. Effective weed control in vernal pools that have spreading navarretia has been achieved through hand weeding and herbicide applications, while seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for spreading navarretia was collected from genetically and geographically local populations. These methods resulted in the addition of spreading navarretia to more than 25 pools.

4.8 STATUS IN STUDY AREA

Figure 4-1 shows the distribution of spreading navarretia within the study area. The locations of spreading navarretia within the various vernal pool complexes in the study area are included in Attachment A. As shown, spreading navarretia occurs in 110 vernal pools (3.5%) within 12 complexes. While the exact number of restored vernal pools with spreading navarretia is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 80% of these pools have had some habitat restoration or enhancement.

The soil types that underlie the 13 complexes with spreading navarretia are Redding, Huerhuero, Stockpen, Olivenhain, and Linne. With the exception of one complex (D5-8, also known as Carroll Canyon), all of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH; these specific types of soils may be important to the distribution of spreading navarretia.



Source: ESRI; USGS 2004; SANDAG 2011

5.5 2.75 0 5.5 Miles

Scale: 1:348,480; 1 inch = 5.5 miles

Figure 4-1
Distribution of Spreading Navarretia

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CHAPTER 5
SAN DIEGO BUTTON-CELERY

5.1 LISTING STATUS

San Diego button-celery was federally listed as endangered on August 3, 1993 (USFWS 1993). The USFWS 5-year review was completed on September 1, 2010. No critical habitat has been designated for San Diego button-celery, but the Recovery Plan calls for essentially all populations of San Diego button-celery within the Vernal Pool HCP Planning Area to be conserved. An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

5.2 SPECIES DESCRIPTION

San Diego button-celery is a biennial or longer lived perennial gray-green herb that has a storage tap-root. It has a spreading shape and reaches a height of 40 centimeters (16 inches) (Constance 1993). The stems and lanceolate leaves give the plant a prickly appearance. San Diego button-celery (var. *parishii*) is one of three varieties of *Eryngium aristulatum* (Constance 1993). San Diego button-celery is separated from common button-celery (var. *aristulatum*) by having styles in fruit that are about the same length as the calyx (outerwhorl of protective structures around the flower) and is separated from Hoover's button-celery (var. *hooveri*) by having bractlets (modified leaves) without callused margins (Constance 1993).

5.3 HABITAT

San Diego button-celery is found in almost every type of Southern California vernal pool, including claypan-, hardpan-, and alluvial-terrace-type pools. San Diego button-celery is known to occur on numerous vernal pool soil types.

5.4 LIFE CYCLE

San Diego button-celery is a vernal pool obligate and relies on ephemerally wet conditions to reproduce, blooming from April through June. San Diego button-celery seems more tolerant of a wider range of vernal pool habitat than most obligate vernal pool species, and can tolerate disturbance factors better than most vernal pool endemics. It is specifically adapted to surviving in vernally wet conditions due to the presence of air channels in the roots that facilitate necessary gas exchange in submerged plants (Keeley 1998).

San Diego button-celery is presumably insect-pollinated (Zedler 1987), potentially by bee flies (*Bombyliids*) (Schiller et al. 2000) and solitary bees (*Apoidea*), as are many vernal pool species (Thorpe 2007). Currently, the level of relationships between pollinators and San Diego button-celery is unknown. If a close ecological relationship exists with San Diego button-celery and its pollinators, conservation of the pollinators at all life stages in habitat near vernal pools may be needed to preserve the efficiency of the pollination service (Thorp 2007). Local and widespread insect extirpations and extinctions have not been well monitored, and are only rarely documented (Dunn 2005). Specialist bee pollinators of vernal pool flowering plants have been well documented in California vernal pools (Thorp 1989, 1998, 2007, 2009; Thorp and Leong 1995). Diversity of insects and insect pollinator presence and diversity in and near California vernal pools within the range of San Diego button-celery is relatively unknown.

Important differences between San Diego button-celery and the other sensitive vernal pool plant species in Southern California is that San Diego button-celery is a perennial species and has been known to occur in the inter-mound areas, outside of vernal pool basins. San Diego Mesa mint, Otay Mesa mint, California Orcutt grass, and spreading navarretia are all annual species and are highly dependent on the health and quality of the existing seed bank for current and future ecological stability. While a healthy seed bank is important for San Diego button-celery as well, the fact that the plants are perennial means that the seed bank can be almost non-existent and the San Diego button-celery will continue to persist for a number of years. In addition, it is safer to use button-celery seed in restoration and enhancement projects because there is less concern with impacting existing seed banks when collecting seed.

5.5 STATUS AND DISTRIBUTION

San Diego button-celery is found in vernal pools in San Diego County at Otay Mesa, Kearny Mesa, Del Mar Mesa, MCAS Miramar, and Marine Corps Base (MCB) Camp Pendleton, and in northern Baja California, Mexico (USFWS 1993). Historically, habitat included a coastal swath from Mesa de Colonet and San Quintin in Baja California, Mexico, north to Los Angeles County. Two specimens were collected in Los Angeles County prior to 1902, including one from Redondo Beach; these were mentioned in a regional flora inventory of the time (Davidson and Moxley 1923) and were verified as San Diego button-celery by Sheikh (1978). Another theory indicates that the plant may have ranged into Ventura County or possibly San Luis Obispo County (Munz 1935); however, specimens representing the latter occurrence are now considered likely a different variety (i.e., *E. a.* var. *hooveri*). Likewise, the specimen that likely served as the basis for the Ventura County report was a misidentified herbarium specimen of *E. vaseyi* (coyote thistle) (Wallace 2009). The current extent of the range of San Diego button-celery is, therefore, less than that known from historical records. The northernmost range of the variety on the Pacific coast is at MCB Camp Pendleton (Wire Mountain). San Diego button-celery can be locally abundant in remnant vernal pools; however, the distribution of this variety has been dramatically reduced due to loss of most (95 to 97%) of vernal pool habitat in San Diego County (USFWS 1998).

5.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model provided in Attachment B. Specific threats to San Diego button-celery can be divided into three major categories:

1. direct destruction of San Diego button-celery from construction, grazing, dumping, fire, military development and training, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego button-celery, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, and habitat fragmentation; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

Loss and modification of vernal pool habitat continues to impact San Diego button-celery. Acquisition of land and conservation easements have preserved vernal pool habitat, but some loss of vernal pool habitat has continued. Threats associated with OHVs continue throughout the range of the variety, including on preserve lands (e.g., Santa Rosa Plateau) and conserved lands (e.g., some sites within the jurisdiction of the San Diego MSCP). Threats associated with mowing and trampling associated with humans and cattle have been reduced. Road construction in urbanized Southern California will likely continue to pose some level of threat to vernal pool habitat. Watershed alterations near vernal pool habitat have caused changes in the hydrological structure and function of some vernal pool habitat. While still a threat throughout the range of the variety, impacts of hydrological alterations have decreased in some areas due to development standards that control run-off and water use. Although military activities continue to impact habitat occupied by San Diego button-celery, some vernal pool habitat has been restored through cooperation with MCAS Miramar and MCB Camp Pendleton via provisions in the Integrated Natural Resource Management Plans.

Threats identified at listing and new threats continue to impact San Diego button-celery (USFWS 1993, pp. 41384–41392). Small population size and effects caused by fragmentation have potential to affect genetic continuity and maintenance of remnant populations. Nonnative species have the potential to and are known to be displacing available habitat, causing competition that San Diego button-celery has not evolved with and increasing the risk for wildfire events that may impact San Diego button-celery (USFWS 2010b). Fire and fire suppression activities are some of the most hazardous stochastic risks to the species, with increasing wildfire size and intensity that can impact vernal pool ecosystems. Extended drought and climate change are potentially range-wide threats to all vernal pool taxa; threats may decrease the long-term viability of small to medium-sized vernal pools through loss of rainfall over several to many years.

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support San Diego button-celery could become filled with upland native and nonnative species that outcompete San Diego button-celery in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could out-compete San Diego button-celery in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact germination rates, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which San Diego button-celery currently grow more vulnerable to the threats of subsequent erosion and especially nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003). San Diego button-celery is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators.

5.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring San Diego button-celery populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successfully restoration efforts were achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvement to protect the watershed and attract pollinators. Effective weed control in vernal pools with San Diego button-celery has been achieved through the use of hand weeding and herbicide applications, while seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for Otay Mesa mint was collected from genetically and geographically local populations. These methods resulted the addition of San Diego button-celery to more than 300.

5.8 STATUS IN STUDY AREA

Figure 5-1 shows the distribution of San Diego button-celery within the study area. The locations of San Diego button-celery within the various vernal pool complexes in the study area provided in Attachment A. San Diego button-celery occurs in 901 vernal pools (28.4%) within 28 vernal pool complexes. While the exact number of restored vernal pools with San Diego button-celery is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 45% of these pools have had some habitat restoration or enhancement.

Within the study area, San Diego button-celery occurs across various types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, and Linne. Unlike some of the other sensitive plant species known to occur in Southern California vernal pools, San Diego button-celery does not appear to be restricted to any particular type of soil type. San Diego button-celery can be found on hardpan and claypan pools throughout Southern California, and is found on almost every soil type known to support vernal pools.

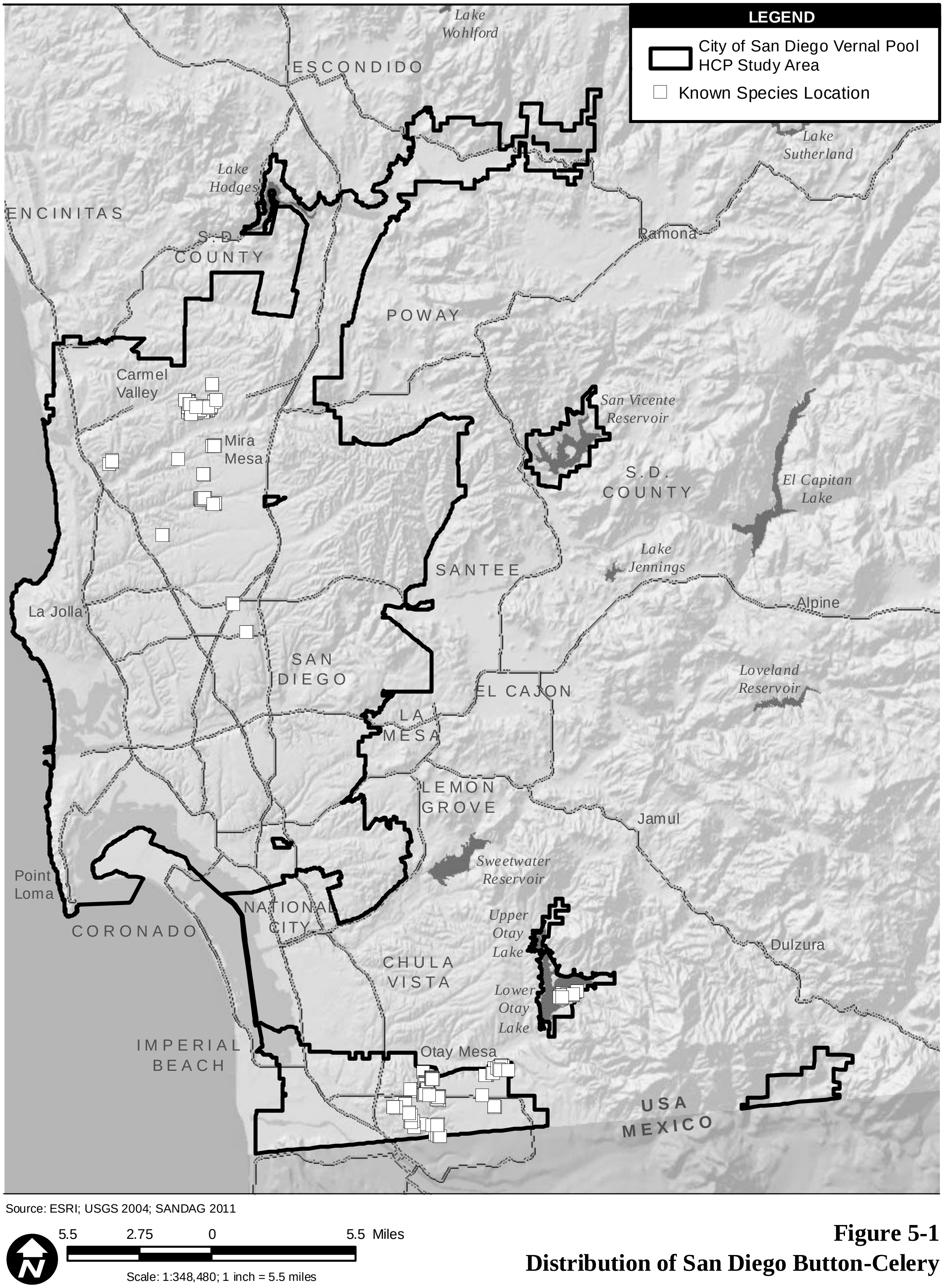

Figure 5-1
Distribution of San Diego Button-Celery

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\SanDiegoButtonCelery.mxd, 9/13/2011, augellop

CHAPTER 6
CALIFORNIA ORCUTT GRASS

6.1 LISTING STATUS

California Orcutt grass was federally listed as endangered on August 3, 1993. The species was listed as endangered by the State of California in September 1979. The USFWS 5-year review was completed on March 11, 2011 (USFWS 2011a). No critical habitat has been designated for California Orcutt grass, but the Recovery Plan calls for all populations of Orcutt grass to be conserved and protected (USFWS 1998). An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

6.2 SPECIES DESCRIPTION

California Orcutt grass is an annual grass in the grass family (*Poaceae*). This species is inconspicuous and prostrate at first, although it develops more erect glandular pubescent stems that grow to be between 5 and 20 centimeters (2 to 8 inches) tall. The plant is bright gray-green in color and secretes sticky droplets. Inflorescences consist of seven spikelets arranged in two ranks, with the upper spikelets overlapping on a somewhat twisted axis. These spikelets are well separated on the lower part of the axis and crowded toward the tip. California Orcutt grass is sparsely hairy with a prostrate stem (USFWS 1998).

6.3 HABITAT

California Orcutt grass is restricted to vernal pools in Southern California, with several historical occurrences reported from northern Baja California, Mexico.

6.4 LIFE CYCLE

The life cycle of California Orcutt grass is dependent on the function of the vernal pool ecosystem. California Orcutt grass typically flowers from April through July and then sets seed. This species is adapted to conditions in the wettest, longest lasting portion of vernal pools. It is less abundant at the shallow periphery of vernal pools that are subject to more rapid changes in moisture (Munz 1974; Reeder 1993). The first significant fall and winter rains begin the process of vernal pool inundation; with no rain, no significant germination of this species will occur. California Orcutt grass seeds germinate while pools are inundated, and the plant appears prostrate during this period. Orcutt grass typically requires at least 15 to 30 days of inundation before germination will occur, so in low rainfall years, there may not be enough ponding to promote adequate germination and the species may remain dormant in the seed bank until an adequate rainfall season (Griggs 1976, 1981). As the season progresses, temperature increases and rainfall declines result in increased evaporation. This stimulates the plants' stems to become more erect, at which time the plant begins to flower. Flowering generally occurs April through June, and by early to mid-summer, the pools become dry. California Orcutt grass relies on fungi to play a role in stimulating germination (Griggs 1976, 1981; Keeley 1988), but it is unclear if this fungal association is present in all populations.

Like the entire grass family, California Orcutt grass is believed to be wind pollinated, although no studies of wind pollination or vector-assisted pollination in this species are currently known (USFWS 2011a).

6.5 STATUS AND DISTRIBUTION

California Orcutt grass is currently considered to be extant at 28 occurrences in four counties of Southern California: three occurrences in Ventura County, three occurrences in Los Angeles County, nine occurrences in Riverside County, and 13 occurrences in San Diego County. Within San Diego County, this species is currently extant at eight pool complexes in Otay Mesa, three pools in MCAS Miramar, one pool in the City of Carlsbad, and one pool in Warner Valley. Of these 13 occurrences, only the eight pool complexes located in Otay Mesa fall within the jurisdiction of the City of San Diego. Two additional populations of this species known from

Otay Mesa are presumed to have been extirpated, and the status of a population at a created pool at the Penasquitos Substation is unknown (USFWS 2011a).

Historically, this species was also found on Mesa de Colonet and in pools at San Quintin in northern Baja California, Mexico. There is no current knowledge confirming the contemporary existence of the species in Baja California, Mexico, but the vernal pool habitat that supported these occurrences still persists (McMillan 2011; USFWS 2011a).

No estimate of numbers of California Orcutt grass specimens at specific sites is currently available. This is likely due to the difficulty of measuring temporal abundance at each occurrence. Local site conditions, rainfall, and fresh water pooling likely influence numbers of standing plants and their local distribution (Schiller et al. 2000). Like most annual plants, the germination success of California Orcutt grass differs annually depending, in part, on temperature, timing, and amount of rainfall. Yearly variability in rainfall will result in variability in water depth and duration of vernal pools, which can alter the proportion of each pool experiencing particular moisture conditions in a given year. This can have implications for species distribution within and among pools given the narrow habitat preferences and tolerances of many vernal pool plant species (Bauder 2005).

The number of individuals may differ at any site for any year because numbers also depend, in part, on reproductive success of previous cohorts, the number of seeds deposited in the seed bank, and the survivorship of the annual seedling cohort in the year the survey was conducted.

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, California Orcutt grass was found in 58 pools, with a mean percent cover per pool of 3.8%. This relatively low percent cover is due, in part, to plant physiognomy, as California Orcutt grass is a slender, diminutive species that will yield low cover estimates even in areas of relatively high population density (City of San Diego 2004).

6.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model provided in Attachment B. Specific threats to California Orcutt grass can be divided into three major categories:

1. direct destruction of California Orcutt grass from construction, grazing, dumping, fire, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy California Orcutt grass habitat, including altered hydrology, draining, competition by introduced species, habitat fragmentation, and alteration of natural fire regimes; and

3. potential long-term cumulative impacts, such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

Loss of habitat due to urban and agricultural development has historically been the predominant threat to California Orcutt grass, and is considered a primary threat to vernal pools in Southern California (Bauder 1986, 1987). Populations of California Orcutt grass that are not directly threatened by development are still subject to indirect impacts caused by habitat fragmentation and urbanization of surrounding lands, including OHV use, other human access and disturbance, changed hydrological conditions, invasion by nonnative plants, dumping, pollution, and altered fire regimes. Additionally, even areas of protected habitat may still be affected by direct and indirect impacts that make the habitat less suitable for California Orcutt grass, including OHV use, unauthorized access, and introduction of nonnative species (USFWS 2011a). Furthermore, California Orcutt grass's small population size makes it more vulnerable to demographic, genetic, and environmental stochastic events and natural catastrophes (Asquith 2001; Caughley 1994).

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support Orcutt grass could become filled with upland native and nonnative species that outcompete Orcutt grass in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could outcompete Orcutt grass in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

In addition to changes in rainfall patterns, climate change could also result in temperature changes that may impact germination rates, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which Orcutt grass currently grows more vulnerable to the threats of subsequent erosion and nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003).

California Orcutt grass is restricted to 13 vernal pool complexes in San Diego County, eight of which occur within the jurisdiction of the City and are located in Otay Mesa. As with other vernal pool species, California Orcutt grass is dependent on a maintained hydrology and surrounding watershed.

6.7 PROPAGATION AND RESTORATION POTENTIAL

There has been some success in restoring California Orcutt grass populations and the habitat that supports them. These successful restoration efforts have been achieved by applying aggressive programs for weed control, reestablishing the seed bank, and improving upland habitat for watershed protection and pollinators. Effective weed control in vernal pools with California Orcutt grass has been achieved through hand weeding and herbicide applications; seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for California Orcutt grass was collected from genetically and geographically local populations. These methods resulted in the addition of California Orcutt grass to more than 25 pools with.

6.8 STATUS IN STUDY AREA

Figure 6-1 shows the distribution of California Orcutt grass within the study area. The locations of California Orcutt grass within the various vernal pool complexes in the study area provided in Attachment A. There are 58 vernal pools (1.8%) with California Orcutt grass within six vernal pool complexes. While the exact number of restored vernal pools with California Orcutt grass is not evaluated here, it is estimated that at least 90% of these pools have had some habitat restoration or enhancement (McMillan 2011).

Within the study area, all of the complexes and pools with California Orcutt grass are on Otay Mesa. The soil types that underlie the seven complexes with California Orcutt grass are Huerhuero, Olivenhain, Stockpen, and Linne. All of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH; these specific types of soils may be important to the distribution of Orcutt grass.

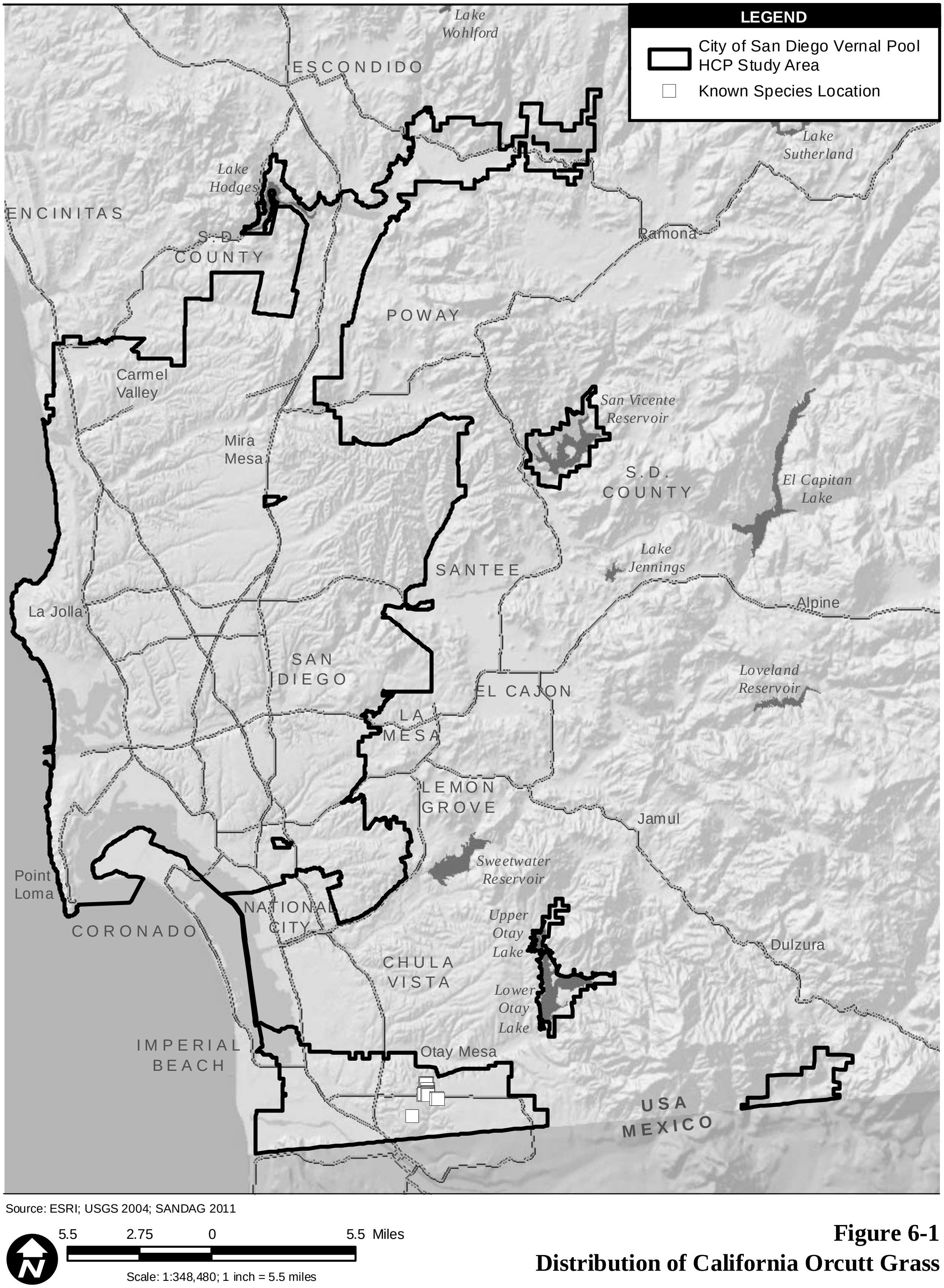

Figure 6-1
Distribution of California Orcutt Grass

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\CaliforniaOrcuttGrass.mxd, 9/13/2011, augellop

CHAPTER 7
RIVERSIDE FAIRY SHRIMP

Photograph: C. Brown, USGS

7.1 LISTING STATUS

Riverside fairy shrimp was federally listed as endangered on August 3, 1993. The USFWS 5-year review was completed on September 29, 2008 (USFWS 2008a). A final designation of critical habitat for this species was made on April 12, 2005. The current critical habitat consists of 306 acres of land in four units in Ventura, Orange, and San Diego Counties. USFWS drafted a proposed rule, dated June 1, 2011, to revise the critical habitat for Riverside fairy shrimp. This revision would designate approximately 2,984 acres of land in five units in Ventura, Orange, Riverside, and San Diego Counties, which, if finalized as proposed, would result in an increase of approximately 2,678 acres of critical habitat for this species (USFWS 2011b). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

7.2 SPECIES DESCRIPTION

Riverside fairy shrimp is a small aquatic crustacean in the order Anostraca. Mature males are between 13 and 25 millimeters (0.5 to 1.0 inch) long. The frontal appendage is cylindrical, bibbed at the tip, and extends only part way to the distal end of the basal segment of the antenna. The spur of the thumb is a simple blade-like structure. The finger has two teeth; the proximal tooth is shorter than the distal tooth. The distal tooth has a lateral shoulder that is equal to about half the tooth’s total length measured along the proximal edge. The cercopods, which enhance

the rudder-like function of the abdomen, are separate, with plumose setae (feathery bristles) along the medial and lateral borders. Mature females are between about 13 and 22 millimeters (0.5 to 0.87 inch) in length. The brood pouch extends to abdominal segments seven, eight, or nine. The cercopods of females and males are the same (USFWS 1998).

Riverside fairy shrimp feed on algae, bacteria, protozoa, rotifers, and bits of detritus. Male Riverside fairy shrimp are distinguished from other fairy shrimp species primarily by the second pair of antennae. The females carry their cysts in an oval or elongate ventral brood sac (Eng et al. 1990; Eriksen and Belk 1999).

7.3 HABITAT

This species is restricted to vernal pools and other non-vegetated ephemeral pools greater than 30.5 centimeters (12 inches) in depth in Riverside, Orange, and San Diego Counties.

7.4 LIFE CYCLE

The life cycle of Riverside fairy shrimp is dependent on the function of the vernal pool ecosystem. As mentioned above, this species is known from pools that are greater than 30.5 centimeters (12 inches) in depth. The species cannot persist in perennial water bodies because the re-wetting of the dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999). Riverside fairy shrimp are usually observed January through March, although the hatching period may be extended in years with early or late rainfall. Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool, depending on water temperature (Simovich and Hathaway 1997).

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in the same or subsequent rainy seasons. Therefore, cyst “banks” develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the Riverside fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce. If all cysts hatched during an insufficient filling, the species could be extirpated from a pool (Philippi et al. 2001; Simovich 2005; Simovich and Hathaway 1997). The ability of Riverside fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of the species (Ripley et al. 2004; Simovich 2005).

7.5 STATUS AND DISTRIBUTION

Riverside fairy shrimp is currently considered to be extant at 45 known occupied vernal pool complexes (approximately 200 occupied pools), covering an area of approximately 59 acres. Twenty-six of the extant known occupied complexes are in San Diego County, 11 are in Riverside County, and eight are in Orange County. Of the 26 extant occurrences in San Diego County, two are located in MCAS Miramar, one is located in Ramona, one is located in the City of Carlsbad, eight are located in MCB Camp Pendleton, and the remaining 14 are located in Otay Mesa. Eleven of the 14 pool complexes located on Otay Mesa fall within the jurisdiction of the City of San Diego (USFWS 2008a).

Historical occurrences are also reported from the Tierra Rejada Preserve complex in Ventura County, the Los Angeles Airport and Madrona Marsh complexes in Los Angeles County, and from Valle de las Palmas and at Bajamar (north of Ensenada) in Baja California, Mexico. The population formerly present at the Los Angeles Airport complex is known to be extirpated, and there is no current knowledge confirming the contemporary existence of the species in the other locations described above (USFWS 2008a).

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, Riverside fairy shrimp was found in 11.7% (134) of pools (City of San Diego 2004). Due to the small size and life history traits of Riverside fairy shrimp, surveying occurrences for changes in numbers of individuals and demographic trends over time is not feasible. Therefore, population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time (USFWS 2008a).

7.6 THREATS AND PRESSURES

Threats to endangered fairy shrimp species are illustrated in a conceptual model provided in Attachment B. Specific threats to Riverside fairy shrimp can be divided into three major categories:

1. direct destruction of Riverside fairy shrimp from construction, grazing, dumping, trampling, plowing, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy Riverside fairy shrimp habitat, including altered hydrology, exposure to pesticides, invasion by nonnative plant species, habitat fragmentation, and military training activities; and

3. potential long-term cumulative impacts, such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat continues to be a significant threat to the Riverside fairy shrimp, especially in areas where urbanization is expected to expand. Since its listing in 1993, at least nine complexes known to be occupied by Riverside fairy shrimp have been lost to urban development, another 10 complexes have been partially lost to urban development, and eight contain pools that have been damaged, but not lost. Most of these losses and impacts are the result of urban development, international border security, and military-related development and training. Conservation of land and restoration programs have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private lands. Additionally, even preserved lands are often subject to impacts, such as invasion by nonnative plants, OHV use, trespassing, and other conditions and effects that degrade the quality of habitat (USFWS 2008a).

Riverside fairy shrimp habitat is also threatened by indirect impacts resulting from the proximity of its habitat to urban development, including OHV use and other human access and disturbance impacts, runoff and altered hydrology, dumping, and water and air pollution. OHV use for recreation, law enforcement (including Border Patrol), and military activities threatens this species throughout much of its range. Nonnative plants also threaten Riverside fairy shrimp habitat throughout its range by causing nonnative thatch accumulation in pools, which can often result in a reduction in ponding depth and duration, and decrease in water quality (McMillan 2011). Riverside fairy shrimp habitat is naturally fragmented, and development projects and other disturbance factors continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species (USFWS 2008a).

Riverside fairy shrimp may also be affected by factors associated with climate change, which has the potential to adversely affect this species through changes in vernal pool inundation patterns and consistency. It is possible that climate warming will cause shifts in the distribution and abundance of species, and the ability of Riverside fairy shrimp to survive will likely depend, in part, on the species’ ability to disperse to pools where conditions are suitable (Bohonak and Jenkins 2003; Bonte et al. 2004). However, loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shifts induced by climate change may be more difficult for the species to successfully accommodate. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality, and even modest changes in climate could alter the seasonality and duration of vernal pool hydration (Cayan et al. 2001; Field et al. 1999). These changes could adversely affect

Riverside fairy shrimp, as this species is adapted to complete its life cycle within a limited temperature range and requires a minimum length of inundation to reach maturity and reproduce. Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual occurrences, even where occurrences are already known to fluctuate widely (McLaughlin et al. 2002).

Riverside fairy shrimp is restricted to 26 vernal pool complexes in San Diego County, 11 of which occur within the jurisdiction of the City and are located on Otay Mesa. As with other vernal pool species, Riverside fairy shrimp is dependent on a maintained hydrology and surrounding watershed.

7.7 INNOCULATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring Riverside fairy shrimp populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successful restoration efforts have been achieved by a combination of conducting topographic reconstruction, applying aggressive programs for weed and thatch control, reestablishing cyst banks through inoculation, and improving upland habitat for watershed protection and water quality improvements. Topographic reconstruction has been achieved through a combination of hand and mechanical grading; effective weed and thatch control in vernal pools with San Diego fairy shrimp has been achieved through the use of hand weeding and herbicide applications. Cyst banks have been rebuilt using a program of soil collection and redistribution—cyst soil was collected from genetically and geographically appropriate local populations. These methods resulted in the addition of Riverside fairy shrimp to more than 50 pools.

7.8 STATUS IN STUDY AREA

Figure 7-1 shows the distribution of Riverside fairy shrimp within the study area. The locations of Riverside fairy shrimp within the various vernal pool complexes in the study area are included in Attachment A. Riverside fairy shrimp has been identified in 198 vernal pools (6.3%) within 11 vernal pool complexes. While the exact number of restored vernal pool with Riverside fairy shrimp is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 95% of these pools have had some habitat restoration or enhancement (McMillan 2011).

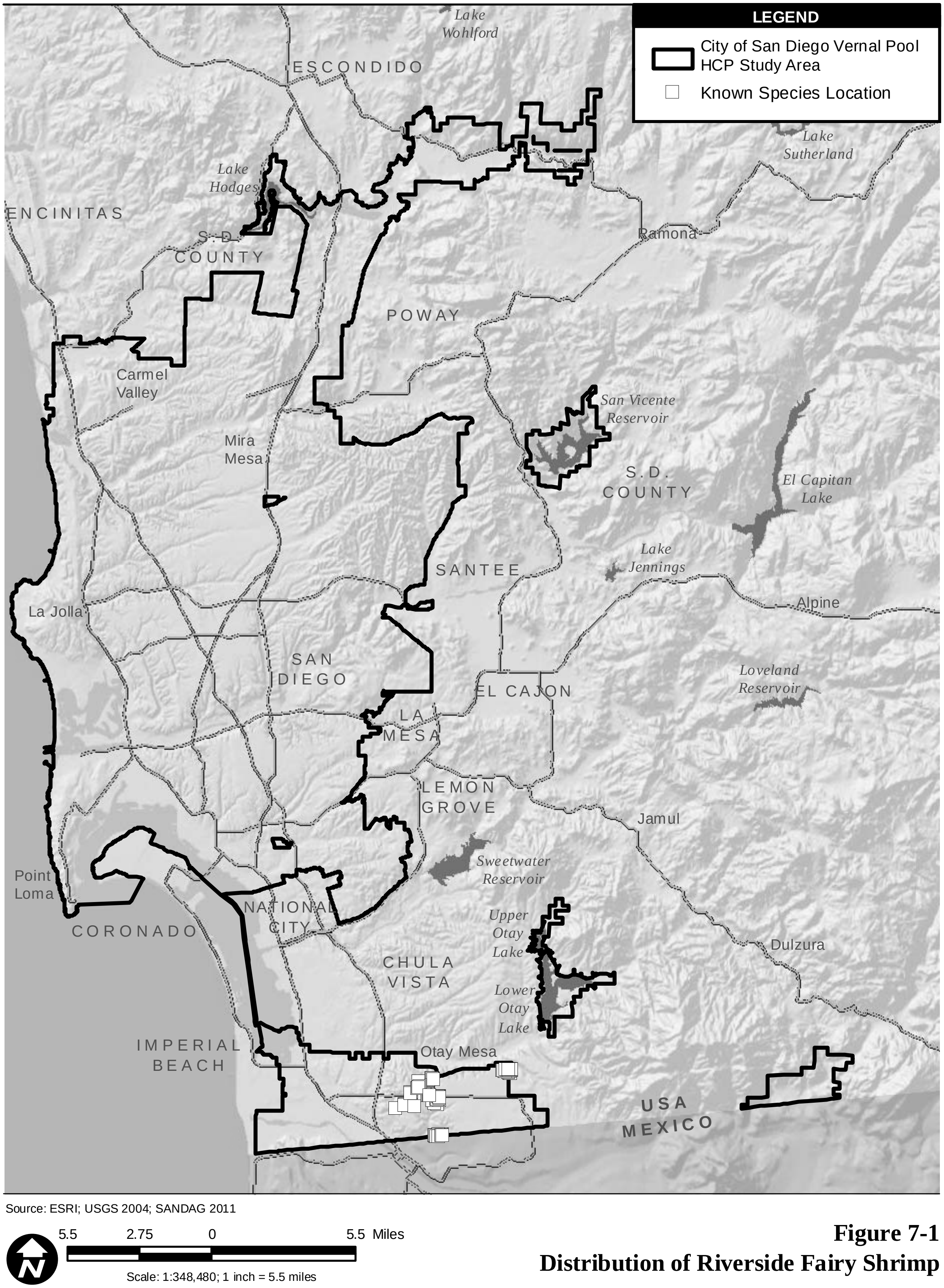

Figure 7-1
Distribution of Riverside Fairy Shrimp

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\RiversideFairyShrimp.mxd, 9/13/2011, augellop

Within the study area, all of the complexes and pools with Riverside fairy shrimp occur on Otay Mesa. The soil types that underlie the 11 complexes with Riverside fairy shrimp are Huerhuero, Stockpen, Olivenhain, Diablo, and Linne**.** All of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH, which may be important to the distribution of Riverside fairy shrimp.

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CHAPTER 8
SAN DIEGO FAIRY SHRIMP

Source: Diolinda Parsick

8.1 LISTING STATUS

San Diego fairy shrimp was federally listed as endangered on February 3, 1997. The USFWS 5-year review was completed on September 30, 2008 (USFWS 2008b). Critical habitat for the San Diego fairy shrimp was designated on October 23, 2000. Critical habitat was remanded but not vacated by the Central District Court of California on June 12, 2002. Critical habitat was re-proposed on April 22, 2003. Revised critical habitat for the San Diego fairy shrimp was designated on December 12, 2007. This final rule designated five critical habitat units (with 29 subunits) for San Diego fairy shrimp on 3,082 acres of land in Orange and San Diego Counties (USFWS 2007). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

8.2 SPECIES DESCRIPTION

San Diego fairy shrimp is a small aquatic crustacean in the order Anostraca. San Diego fairy shrimp have large stalked compound eyes, no carapace, and 11 pairs of swimming legs. Mature males attain 16 millimeters (0.6 inch) in length, and females attain 14 millimeters (0.5 inch) in length (USFWS 1998). San Diego fairy shrimp feed on algae, diatoms, and particulate organic matter (Parsick 2002). Male San Diego fairy shrimp are distinguished from other *Branchinecta*

species males by differences in the distal tip of the second antennae. The females carry their cysts in an oval or elongate ventral brood sac (Eriksen and Belk 1999). Females are distinguishable from other *Branchinecta* species females by the shape and length of the brood sac, length of the ovary, and presence of paired dorsolateral spines on five of the abdominal segments. The San Diego fairy shrimp is often misidentified with the versatile fairy shrimp (*Branchinecta lindahli*) (Fugate 1993), which is native to and commonly found throughout western North America (Eng et al. 1990; Simovich 1998).

8.3 HABITAT

This species is restricted to vernal pools and other non-vegetated ephemeral pools from 2 to 12 inches in depth in coastal areas of San Diego County, Orange County, and northwestern Baja California, Mexico. San Diego fairy shrimp are restricted to dilute vernal pools, having relatively low sodium concentrations, low alkalinity, and neutral pH (Gonzales et al. 1996).

8.4 LIFE CYCLE

The life cycle of San Diego fairy shrimp is dependent on the function of the vernal pool ecosystem. The species cannot persist in perennial water bodies because the re-wetting of the dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999). San Diego fairy shrimp are usually observed January through March when seasonal rainfall fills vernal pools and initiates cyst hatching. Individuals hatch and mature within 7 to 14 days of rainfall filling a pool, depending on water temperature (Simovich and Hathaway 1997). This hatching period may be extended in years with early or late rainfall.

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in the same or subsequent rainy seasons. Therefore, cyst “banks” develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the San Diego fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce. If all cysts hatched during an insufficient filling, the species could be extirpated from a pool (Philippi et al. 2001; Simovich 2005; Simovich and Hathaway 1997). The ability of San Diego fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of the species (Ripley et al. 2004; Simovich 2005).

8.5 STATUS AND DISTRIBUTION

San Diego fairy shrimp is currently considered to be extant at 137 known occupied vernal pool complexes in the United States. One hundred thirty-two of the extant known occupied complexes in the U.S. are in San Diego County and five are in Orange County. Of the 132 occupied pool complexes in San Diego County, 57 fall within the jurisdiction of the City. These pool complexes are located in Del Mar Mesa, Kearny Mesa, Mira Mesa, Chollas Heights, Mission Trails Regional Park, Marron Valley, and Otay Mesa. Additional occupied vernal pool complexes located in San Diego County, but not in the City, are found on MCAS Miramar, MCB Camp Pendleton, Poway, Carlsbad, San Marcos, Santee, Ramona, Santa Fe Valley, Naval Base Coronado, Otay Mesa, Sweetwater Reservoir, and Tijuana Slough (USFWS 2008b).

In Baja California, San Diego fairy shrimp have been recorded at two localities: Valle de Palmas, south of Tecate, and Baja Mar, north of Ensenada. The status of these populations is currently unknown. A single isolated female was previously reported from vernal pools in Isla Vista, Santa Barbara County, California; however, directed surveys have not located any additional individuals (USFWS 1998).

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, San Diego fairy shrimp was found in 35.7% (408) of pools. *Branchinecta* spp. was identified in an additional 220 pools (City of San Diego 2004). Due to the small size and life history traits of San Diego fairy shrimp, surveying occurrences for changes in numbers of individuals and demographic trends over time is not feasible. Therefore, population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time. In 2008, a project was been funded by an Endangered Species Act Section 6 grant to develop a protocol to estimate San Diego fairy shrimp population sizes and conduct population viability analyses in real time to detect a decline preceding the likely extinction of a population (USFWS 2008b).

8.6 THREATS AND PRESSURES

Threats to endangered fairy shrimp species are illustrated in a conceptual model found in Attachment B. Specific threats to San Diego fairy shrimp can be divided into three major categories:

1. direct destruction of San Diego fairy shrimp from construction, grazing, dumping, trampling, plowing, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego fairy shrimp habitat, including altered hydrology, exposure to pesticides, invasion by nonnative plant species, habitat fragmentation, and military activities; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, competition/hybridization with other species, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat continues to be a significant threat to San Diego fairy shrimp, especially in areas where urbanization is expected to expand. As of 2008, 28 (14 of which are in the City of San Diego HCP Planning Area) of the 137 vernal pool complexes occupied by the species had been partially lost to urban development, and about five additional complexes contained pools that had been damaged, but not lost. Most of these losses and impacts are the result of urban development, followed by industrial/commercial development, international border security, and military facilities and training. Acquisition of land and conservation easements have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private land. Additionally, even preserved lands are often subject to impacts, such as invasion by nonnative plants, OHV use, trespassing, and other conditions and effects that degrade the quality of habitat (USFWS 2008b).

Indirect impacts to San Diego fairy shrimp result from the proximity of the species' habitat to urban development. These include OHV use and other human access and disturbance impacts, runoff and altered hydrology, dumping, and water and air pollution. OHV use for recreation, law enforcement (including Border Patrol), and military activities threatens this species throughout much of its range. Nonnative plants also threaten San Diego fairy shrimp habitat throughout its range by causing nonnative thatch accumulation in pools, which can often result in a reduction in ponding depth and duration, as well as water quality (McMillan 2011). San Diego fairy shrimp habitat is naturally fragmented, but development projects and other disturbance factors continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species (USFWS 2008b).

San Diego fairy shrimp may also be affected by factors associated with climate change, which has the potential to adversely affect this species through changes in vernal pool inundation patterns and consistency. It is possible that climate warming will cause shifts in the distribution and abundance of species, and the ability of San Diego fairy shrimp to survive will likely depend, in part, on the species' ability to disperse to pools where conditions are suitable

(Bohonak and Jenkins 2003; Bonte et al. 2004). In addition, loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shifts induced by climate change may be more difficult for the species to successfully accommodate. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality, and even modest changes in climate could alter the seasonality and duration of vernal pool hydration (Cayan et al. 2005; Field et al. 1999). These changes could adversely affect San Diego fairy shrimp, as this species is adapted to complete its life cycle within a limited temperature range and requires a minimum length of inundation to reach maturity and reproduce. Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual occurrences, even where occurrences are already known to fluctuate widely (McLaughlin et al. 2002).

Other potential threats to San Diego fairy shrimp are hybridization and direct competition with the versatile fairy shrimp. The versatile fairy shrimp is common throughout western North America, is found in a wide variety of habitats, and tends to inhabit disturbed sites (Gonzalez et al. 1996). The versatile fairy shrimp has been documented within the range of the San Diego fairy shrimp in relatively disturbed pools at Otay Mesa, MCAS Miramar, Del Mar Mesa, and MCB Camp Pendleton. The two species are known to hybridize in the laboratory (Fugate 1998) and in the field (Simovitch et al. in press). The disturbance of vernal pool habitat by vehicles used in military training may increase the distribution of the versatile fairy shrimp on MCB Camp Pendleton. Although the known distribution of versatile fairy shrimp is still fairly limited within the range of the San Diego fairy shrimp, hybridization and competition could threaten the San Diego fairy shrimp in the future should the range of the versatile fairy shrimp expand (USFWS 2008b).

Another recent issue of concern for San Diego fairy shrimp reproduction and genetics is the cytoplasmic incompatibility induced by *Wolbachia* (or similar) bacteria. These bacteria reside in the intracellular space of reproductive tissue of many invertebrates and are maternally inherited from generation to generation. If males and females are infected with different strains of the bacteria, they are usually not reproductively compatible. Because of this, the bacteria can initiate lineage isolation and speciation (Werren et al. 2008). In addition to incompatibility, the bacteria can also lead to biased sex ratios, parthenogenesis (female asexual reproduction), feminization of males, and a high juvenile male mortality. There is substantial evidence that the versatile fairy shrimp harbors feminizing endoparasitic bacteria (Krumm 2006). While there is no evidence of the bacteria in San Diego fairy shrimp, the potential hybridization of the two species suggests that this could be a concern for the genetics and reproduction of the San Diego fairy shrimp.

8.7 INNOCULATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring San Diego fairy shrimp populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successful restoration efforts were achieved through a combination of conducting topographic reconstruction, applying aggressive programs for weed and thatch control, reestablishing cyst banks through inoculation, and improving upland habitat for watershed protection and water quality improvements. Topographic reconstruction has been achieved through a combination of hand and mechanical grading; effective weed and thatch control in vernal pools with San Diego fairy shrimp has been achieved through hand weeding and herbicide application. Cyst banks have been rebuilt using a program of soil collection and redistribution. Cyst soil was collected from genetically and geographically appropriate local populations. These methods have resulted in the addition of San Diego fairy shrimp to more than 300 pools.

8.8 STATUS IN STUDY AREA

Figure 8-1 shows the distribution of San Diego fairy shrimp within the study area. The locations of San Diego fairy shrimp within the various vernal pool complexes in the study area are included in Attachment A. San Diego fairy shrimp has been identified in 615 vernal pools (19.4%) within 36 vernal pool complexes. While the exact number of restored vernal pool with San Diego fairy shrimp is not evaluated here, it is estimated that at least 60% of these pools have had some habitat restoration or enhancement (McMillan 2011).

San Diego fairy shrimp occurs across all types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, Linne, and Chesterton. These complexes occur on both claypan- and hardpan-type soils, and include every soil type that has been identified to support vernal pools.

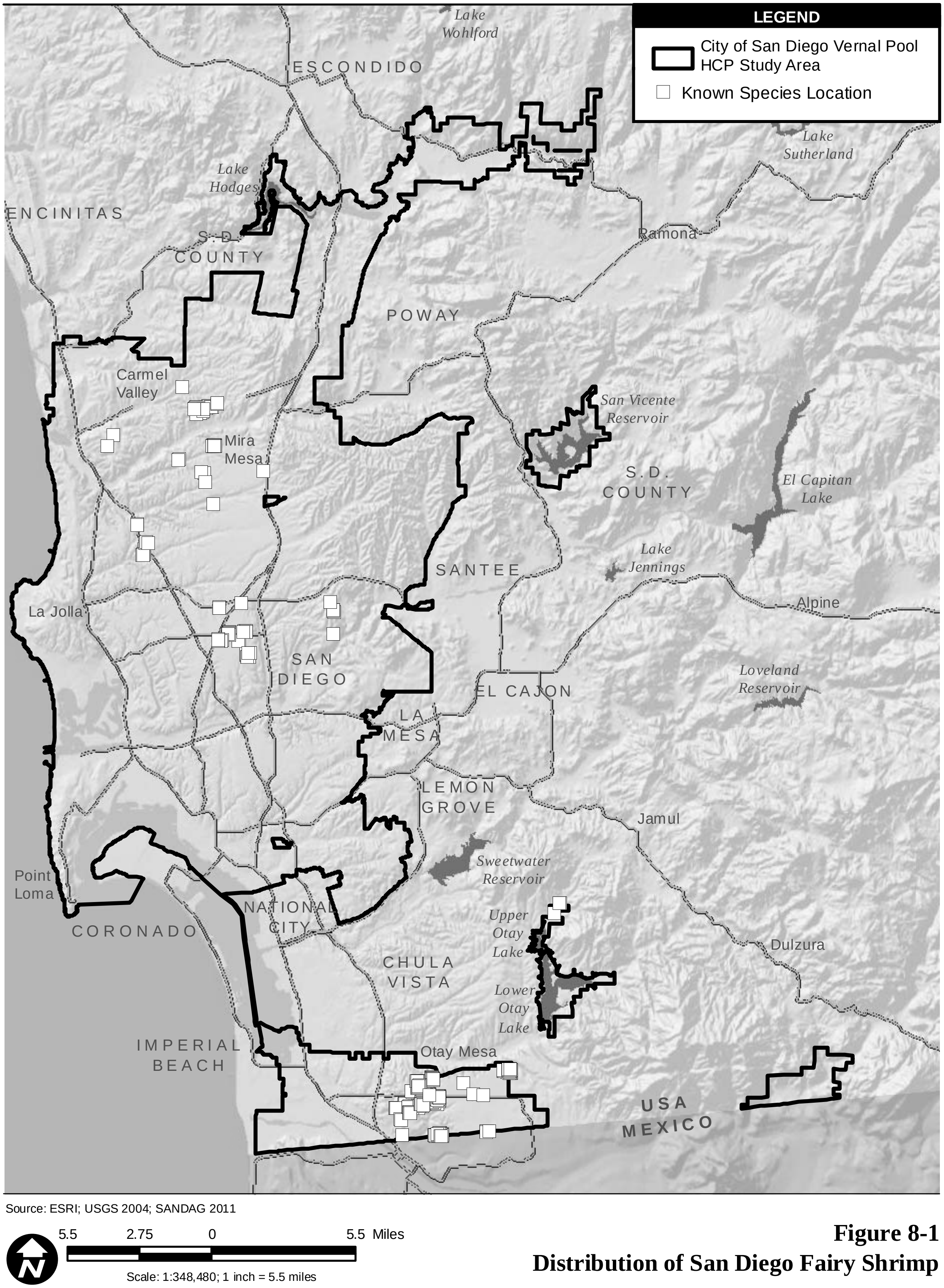

Figure 8-1
Distribution of San Diego Fairy Shrimp

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CHAPTER 9
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ATTACHMENT A
VERNAL POOL AND
FOCAL SPECIES DATA

Attachment A
Vernal Pool Complex Data in City of San Diego Vernal Pool Habitat Conservation Plan Planning Area

Vernal Pool Complex ID	Complex Name	Geographic Area	Number of Pools in Complex	Total Surface Area of Pools (acre)	Soil Type(s)	Inside or Outside MHPA[1]	Pools Outside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Not Subject to City Jurisdiction	Pools on Lands Not Included[2]	Proximity to Other Complexes in Study Area (mile)	Number of Pools with Focal Species						
												Otay Mesa Mint	San Diego Mesa Mint	Spreading Navarretia	California Orcutt Grass	San Diego Button Celery	Riverside Fairy Shrimp	San Diego Fairy Shrimp
B 11	Mesa Norte	North	44	0.60	RdC, TeF	Outside		44			0.9	0	12	0	0	10	0	24
B 5–6	Tierra Alta	North	1	0.01	RdC, TeF	Within		1			0.1	0	0	0	0	0	0	0
B 5–8	Crescent Heights, Lopez Ridge	North	18	0.64	RdC, TeF	Within		18			0.1	0	11	0	0	1	0	2
C 10–16	Winterwood	North	61	0.81	RdC, TeF	Within		61			0.2	0	27	0	0	7	0	2
C 17–18	Fieldstone	North	9	0.32	RdC	Within		9			0.2	0	8	0	0	0	0	0
C 27	Mira Mesa Market Center	North	1	0.06	RdC	Outside		1			2.0	0	1	0	0	0	0	1
C 28	Jonas Salk Elementary School	North	81	0.97	RdC	Within				81	0.2	0	0	0	0	0	0	1
D 5–8	Parkdale Carroll Canyon Carroll Canyon	North	123	1.21	RdC, ReE, TeF	Within		123			0.2	0	42	1	0	65	0	0
F 16–17	Menlo KM Parcel, Marine Corps Air Station (MCAS) Miramar	Central	48	0.92	RdC, ReE	Outside		14		34	0.1	0	0	0	0	0	0	1
H 1–15	Del Mar Mesa, Rhodes	North	516	6.52	OhF, RdC, RfF, TeF	Within	14	252	248	2	0.3	0	70	0	0	193	0	29
H 17	Shaw Texas	North	28	0.24	RdC, RfF, TeF	Within		28			0.9	0	0	0	0	0	0	0
H 33	SDG&E/East Ocean Air Drive	North	14	0.37	GaF, RdC	Outside		2		12	0.2	0	0	0	0	6	0	0
H 38	Carmel Mountain	North	64	0.61	CvC, LvF3, RdC	Within		64			0.2	0	0	0	0	0	0	2
H 39	Greystone Torrey Highlands	North	19	0.68	OhC, OhE	Outside		19			0.3	0	5	0	0	3	0	0
I 1	Arjons	North	34	0.73	RdC, TeF	Outside		34			0.2	0	22	0	0	15	0	1
I 12	Pueblo Lands North, Pueblo Lands South	North	7	0.08	RdC, TeF	Within	4	2		1	0.2	0	0	0	0	0	0	6
I 6 B	Bob Baker (Ford Leasing)	North	8	0.08	RdC, TeF	Outside		8			0.0	0	7	0	0	0	0	0
I 6 C	Bob Baker (Facilities Development)	North	15	0.24	OhE, OhF	Outside		15			0.0	0	11	0	0	2	0	0
J 11 E	Slump Block Pools	South	2	0.63	OhE	Within		2			0.2	0	0	0	0	0	0	0
J 11 W	J 11W	South	5	0.49	OhE, OhF	Within		5			0.4	0	0	0	0	0	0	1
J 12	J 12	South	5	0.28	OhE, OhF	Within		5			0.1	0	0	0	0	0	0	0
J 13 E	South Otay J-13E	South	8	0.06	HrC, OhF	Within	3	5			0.1	0	0	0	0	1	0	0
J 13 N	South Otay 1 acre, NDU 1 and 2	South	37	0.31	HrC	Outside	20	17			0.1	0	0	2	1	3	0	13
J 13 S	Otay South J-13S, NDU 1 and 2	South	45	0.79	HrC	Outside	17	28			Adjacent	0	0	0	0	7	0	2
J 14	Bachman, 905, Brown Field, Cal Terraces (South), Anderprises	South	138	2.12	GP, OhF, SuB	Within	2	135	1		Adjacent	64	0	7	5	55	29	38

Vernal Pool Complex ID	Complex Name	Geographic Area	Number of Pools in Complex	Total Surface Area of Pools (acre)	Soil Type(s)	Inside or Outside MHPA[1]	Pools Outside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Not Subject to City Jurisdiction	Pools on Lands Not Included[2]	Proximity to Other Complexes in Study Area (mile)	Number of Pools with Focal Species						
												Otay Mesa Mint	San Diego Mesa Mint	Spreading Navarretia	California Orcutt Grass	San Diego Button Celery	Riverside Fairy Shrimp	San Diego Fairy Shrimp
J 15	Arnie's point	South	57	2.46	DaF, OhF, SuA, SuB	Within			57		0.1	0	0	0	0	6	16	41
J 16–18	Goat Mesa/Wruck Canyon	South	25	0.51	DaF, LsF, OhF, SuA, SuB	Within		23	2		0.1	0	0	0	0	4	0	0
J 2 N	Cal Terraces (North)	South	63	0.45	OhF, SuB	Within		63			0.1	56	0	5	7	48	10	32
J 2 S	Cal Terraces (North), Otay Mesa Road Helix, Otay Mesa Road Recon	South	172	2.48	OhF, SuB	Within		172			Adjacent	164	0	55	36	163	80	128
J 2 W	Cal Terraces (North), Clayton Parcel, Otay Mesa Road Recon, St. Jerome's	South	127	1.28	OhC, OhF, SuB	Within	6	121			Adjacent	66	0	19	9	65	6	52
J 20–21	La Media ITS	South	33	1.43	SuA, SuB	Outside		33			0.1	0	0	0	0	0	0	6
J 21	La Media Swale South	South	7	0.21	HrC	Outside		7			0.1	0	0	0	0	0	0	0
J 27	Empire Center	South	10	0.23	HrC, SuB	Outside		10			0.2	0	0	0	0	9	0	0
J 28 E	La Media Swale North	South	5	0.16	HrC, SuB	Within		5			0.2	0	0	0	0	0	0	0
J 29–30	Lonestar (Caltrans)	South	72	0.98	OhF, SuA	Within		61	11		Adjacent	1	0	0	0	42	0	0
J 3	J 3	South	1	0.01	OhC, OhE	Outside				1	0.1	0	0	0	0	0	0	0
J 30	Lonestar (State Route 125 and private)	South	103	4.81	LsE, SuA	Within			103		Adjacent	74	0	8	0	93	35	47
J 31	Dennery West, Hidden Trails	South	114	1.63	OhC, OhF, SuB	Within		114			0.1	0	0	0	0	0	10	38
J 32	West Otay A, B, C	South	44	0.34	HrC	Within		44			0.2	8	0	3	0	4	1	8
J 33	Sweetwater High School	South	8	0.07	OhC, OhF	Outside			8		0.0	5	0	3	0	2	3	8
J 34	Bachman, Candlelight	South	42	0.50	HrC, OhC, OhF, SuB	Within	28	14			0.0	0	0	0	0	0	2	16
J 35	Brown Field, Brown Field Basins	South	30	3.83	DaF, GP, OhF, SuA, SuB	Within	27	3			Adjacent	0	0	0	0	1	0	3
J 36	Southview	South	17	0.11	OhC, OhF, SuB	Within		17			0.0	0	0	0	0	0	0	12
J 4	Robinhood Ridge, California Crossings	South	94	0.65	OhF, SuB	Within		94			0.1	19	0	4	0	46	6	41
K 5	Otay Lakes	South	85	3.20	OhE, OhF, ReE, SmE, SnG, TuB	Within		85			1.6	0	0	2	0	46	0	0
KK 1	Lake Murray	Central	1	0.02	TuB	Within	1				0.5	0	0	0	0	0	0	0
KK 2	Pasatiempo	Central	10	0.04	BsC, DcD	Outside		10			0.5	0	0	0	0	0	0	0
MM 1	Marron Valley	South	18	0.18	HrC, HrC2, Rm, SvE, VbB	Within		18			8.2	0	0	0	0	0	0	0
N 1-4, N 5-6	Teledyne Ryan	Central	43	0.59	RdC	Outside		43			0.3	0	1	0	0	0	0	11
N 5-6	Montgomery Field	Central	282	8.35	CfB, CgC, OhE, RdC	Within	13	269			0.0	0	129	0	0	0	0	17
N 7	Serra Mesa Library	Central	26	0.41	RdC, RhC	Within		26			0.0	0	0	0	0	0	0	0
N 8	General Dynamics	Central	22	0.40	RdC	Within		22			0.2	0	20	0	0	2	0	6

Vernal Pool Complex ID	Complex Name	Geographic Area	Number of Pools in Complex	Total Surface Area of Pools (acre)	Soil Type(s)	Inside or Outside MHPA[1]	Pools Outside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Not Subject to City Jurisdiction	Pools on Lands Not Included[2]	Proximity to Other Complexes in Study Area (mile)	Number of Pools with Focal Species: Otay Mesa Mint	San Diego Mesa Mint	Spreading Navarretia	California Orcutt Grass	San Diego Button Celery	Riverside Fairy Shrimp	San Diego Fairy Shrimp
NC	Li Collins, Kelton	North, South	5	0.06	HrE2, LeE, OhC	Within		5			1.1	0	0	0	0	0	0	0
OO	Salk Institute	North	15	0.09	CbB, CfB	Within	1	14			2.4	0	0	0	0	0	0	0
Q 2	Mission Trails Regional Park	Central	19	0.27	OhF, RdC, ReE, VbB	Within		17	2		1.6	0	0	0	0	0	0	6
Q 3	Castlerock	North	9	0.04	DoE	Outside	4	5			1.6	0	0	0	0	0	0	4
QQ	Tecolote Canyon	Central	9	0.09	CgC, GaF, HrC, TaF	Within		9			1.7	0	0	0	0	0	0	0
R 1	Proctor Valley	South	124	1.87	DoE, FxE, OhC, OhE, PfC, Rm, SnG, VbB, W	Within		124			2.2	0	0	0	0	0	0	7
U 15	Sander, Maganatron	Central	39	0.83	RdC, ReE	Outside	1	38			0.3	0	1	0	0	0	0	2
U 19	Cubic	Central	29	0.45	RdC	Outside	1	23		5	0.1	0	1	0	0	2	0	0
X 5	Nobel Drive	North	11	0.10	HrE2, RdC	Within		11			0.1	0	0	1	0	0	0	6
X 7	Nobel Research	North	28	0.10	RdC	Within		28			0.1	0	0	0	0	0	0	1
N/A	Miramar (City Leased Sander)	Central	38	Data Not Available	Data Not Available	Data Not Available			38		-	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available
Subtotal for TWP 1 Analysis			**3,168**	**59.00**	**-**		**142**	**2,420**	**470**	**136**	**-**	**457**	**368**	**110**	**58**	**901**	**198**	**615**
N/A	MCAS Miramar	Central	4,807	Data Not Available	Data Not Available					4,807	-	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available
Total in Plan Area			**7,975**	**-**	**-**		**142**	**2,420**	**470**	**4,943**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

MHPA=Multi-Habitat Planning Area

[1] All or a portion of the complex is within the MHPA.

[2] Military, state, and federal lands, and special district properties such as school districts that are not in City of San Diego jurisdiction

Soil Types Legend

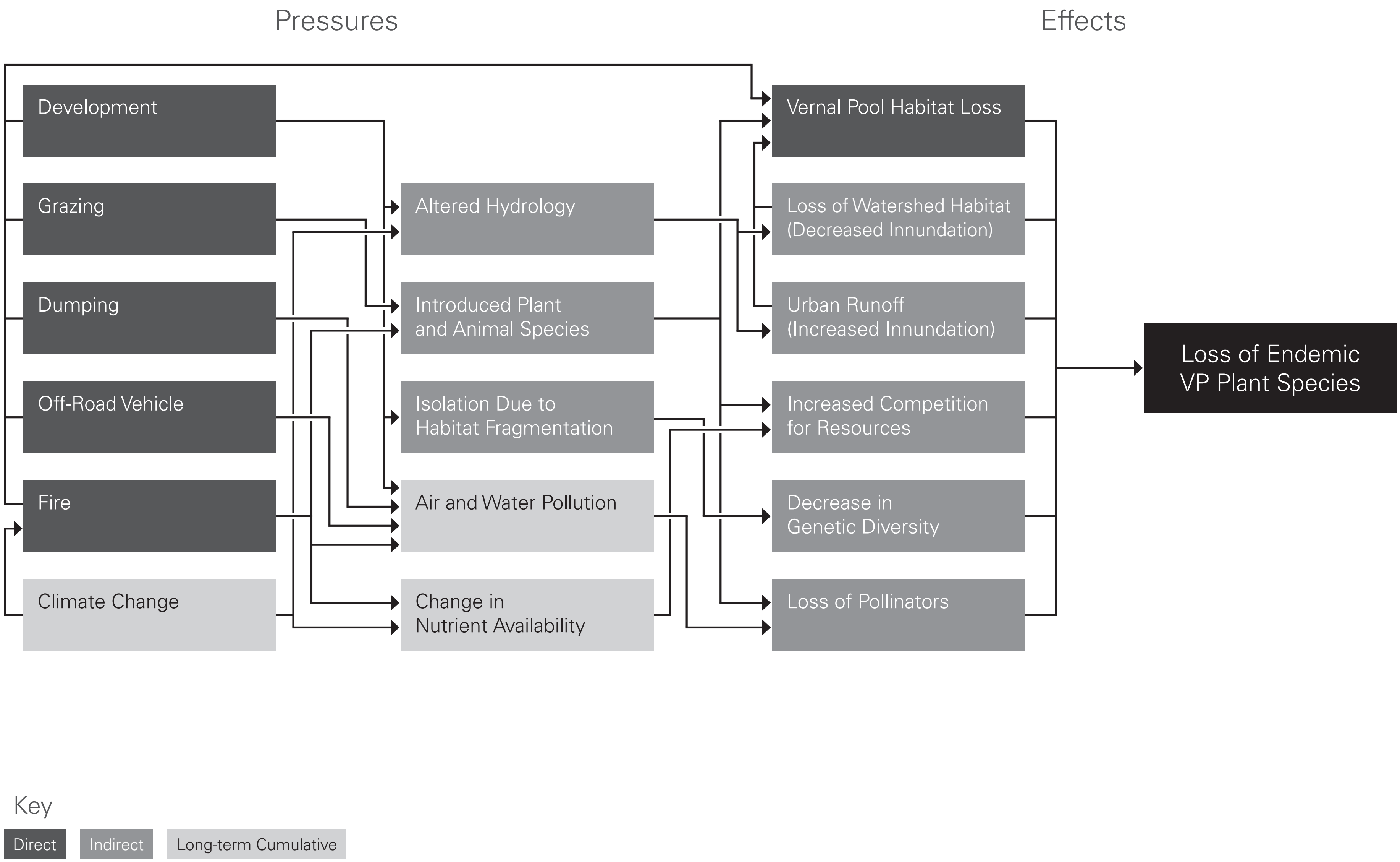
MUSYM	Description	Category
BsC	Bosanko clay, 2 to 9% slopes	Bosanko clay
CbB	Carlsbad gravelly loamy sand, 2 to 5% slopes	Carlsbad gravelly loamy sand
CbC	Carlsbad gravelly loamy sand, 5 to 9% slopes	Carlsbad gravelly loamy sand
CfB	Chesterton fine sandy loam, 2 to 5% slopes	Chestern fine sandy loam
CgC	Chesterton-Urban land complex, 2 to 9% slopes	Chestern-Urban land complex
DaF	Diablo clay, 30 to 50% slopes	Diablo clay
DcD	Diablo-Urban land complex, 5 to 15% slopes	Diablo-Urban land complex
DoE	Diablo-Olivenhain complex, 9 to 30% slopes	Diablo-Olivenhain complex
FxE	Friant rocky fine sandy loam, 9 to 30% slopes	Friant rocky fine sandy loam
GaF	Gaviota fine sandy loam, 30 to 50% slopes	Gaviota fine sandy loam
GP	Gravel pits	Gravel pits
HrC	Huerhuero loam, 2 to 9% slopes	Huerhuero loam

MUSYM	Description	Category
HrC2	Huerhuero loam, 5 to 9% slopes, eroded	Huerhuero loam
HrE2	Huerhuero loam, 15 to 30% slopes, eroded	Huerhuero loam
LeE	Las Flores loamy fine sand, 15 to 30% slopes	Las Flores loamy fine sand
LsE	Linne clay loam, 9 to 30% slopes	Linne clay loam
LsF	Linne clay loam, 30 to 50% slopes	Linne clay loam
LvF3	Loamy alluvial land-Huerhuero complex, 9 to 50% slopes, severely eroded	Loamy alluvial land-Huerhuero complex
MlC	Marina loamy coarse sand, 2 to 9% slopes	Marina loamy coarse sand
OhC	Olivenhain cobbly loam, 2 to 9% slopes	Olivenhain cobbly loam
OhE	Olivenhain cobbly loam, 9 to 30% slopes	Olivenhain cobbly loam
OhF	Olivenhain cobbly loam, 30 to 50% slopes	Olivenhain cobbly loam
PfC	Placentia sandy loam, thick surface, 2 to 9% slopes	Placentia sandy loam
RdC	Redding gravelly loam, 2 to 9% slopes	Redding gravelly loam
ReE	Redding cobbly loam, 9 to 30% slopes	Redding cobbly loam
RfF	Redding cobbly loam, dissected, 15 to 50% slopes	Redding cobbly loam
RhC	Redding-Urban land complex, 2 to 9% slopes	Redding-Urban land complex
RhE	Redding-Urban land complex, 9 to 30% slopes	Redding-Urban land complex
Rm	Riverwash	Riverwash
SmE	San Miguel rocky silt loam, 9 to 30% slopes	San Miguel rocky silt loam
SnG	San Miguel-Exchequer rocky silt loams, 9 to 70% slopes	San Miguel-Exchequer rocky silt loams
SuA	Stockpen gravelly clay loam, 0 to 2% slopes	Stockpen gravelly clay loam
SuB	Stockpen gravelly clay loam, 2 to 5% slopes	Stockpen gravelly clay loam
SvE	Stony land	Stony land
TeF	Terrace escarpments	Terrace escarpments
TuB	Tujunga sand, 0 to 5% slopes	Tujunga sand
VbB	Visalia gravelly sandy loam, 2 to 5% slopes	Visalia gravelly sandy loam
W	Water	Water

ATTACHMENT B
CONCEPTUAL MODELS OF SPECIES PRESSURES

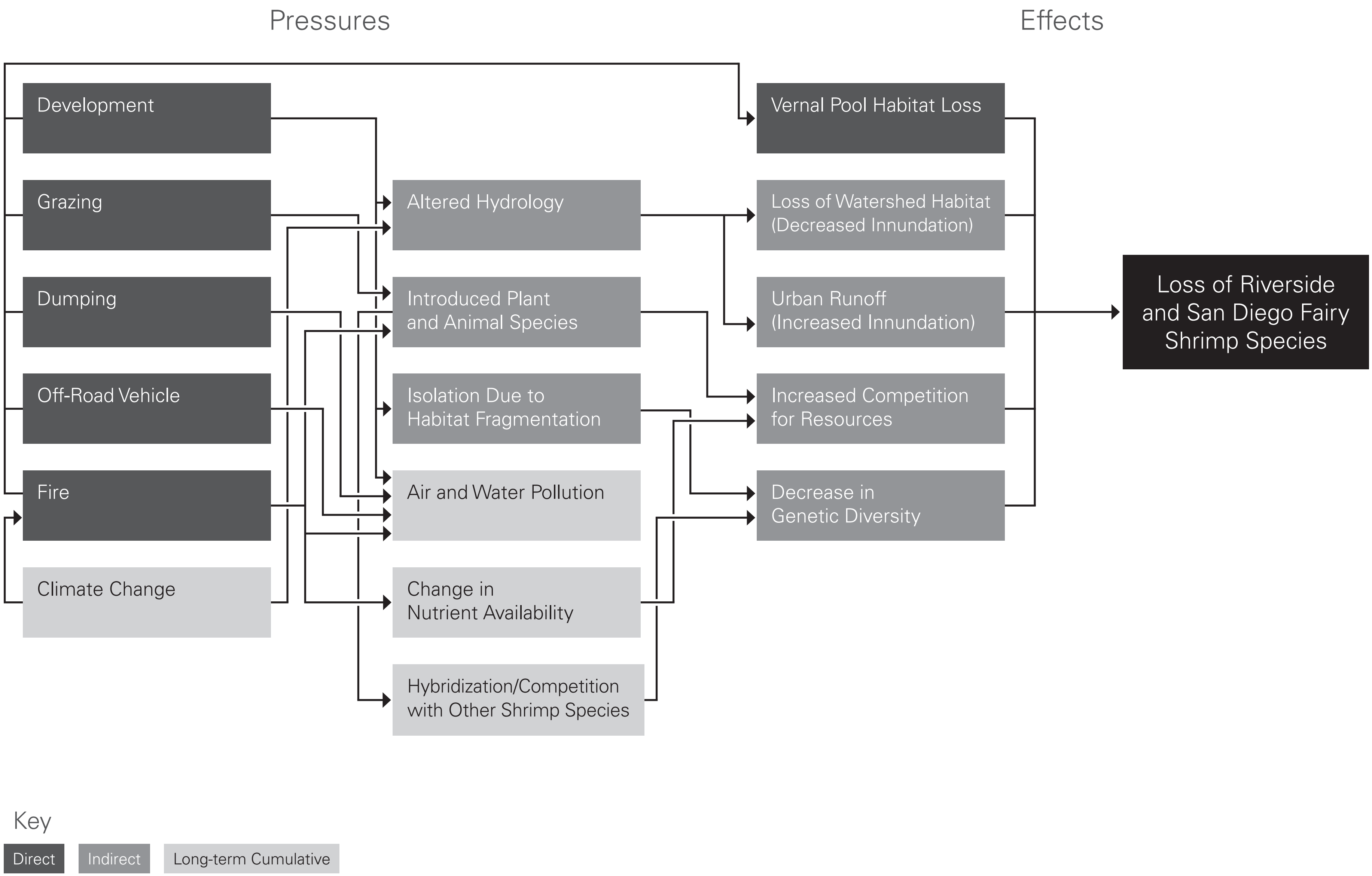
ATTACHMENT B-1

Conceptual Model of Pressures Affecting Endemic Vernal Pool Plant Species in San Diego, CA



ATTACHMENT B-2

Conceptual Model of Pressures Affecting Endangered Fairy Shrimp Species in San Diego, CA



ATTACHMENT C
USFWS VERNAL POOL RECOVERY PLAN EXCERPT

Attachment C
Excerpt from USFWS Vernal Pool Recovery Plan (1998)

Recovery Criteria

Reclassification to threatened status may be considered for *Eryngium aristulatum* var. *parishii, Pogogyne abramsii, Pogogyne nudiuscula, Orcuttia ca/Wornica;* San Diego and Riverside fairy shrimp; and the long-term conservation of *Navarretia fossalis,* a species proposed as threatened, will be assured when the following criteria are met:

1. The following conditions must be met to maintain the current status of *Navarretia fossalis, Eryngium aristulatum* var. *parishii, Pogogyne abramsii, Pogogyne nudiuscula, Orcuttia californica,* and San Diego and Riverside fairy shrimp in order to maintain genetic diversity and population stability of the listed species and other sensitive species:

   Existing vernal pools currently occupied by *Orcuttia californica,*
   Pogogyne nudiuscula, and Riverside fairy shrimp and their associated watersheds should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

   Existing vernal pools and their associated watersheds within the Transverse and Los Angeles Basin-Orange Management Areas should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

   Existing vernal pools and their associated watersheds within the San Marcos vernal pool complexes that contain *Navarretiafossalis, Eryngium aristulatum* var. *parishii,* or any other vernal pool species, should be secured from further loss and degradation. Habitat functions and species viability for any of the remaining vernal pools and their associated watersheds within the San Marcos complexes must be ensured;

   Existing vernal pools and their associated watersheds within the Ramona complexes that contain *Eryngium aristulatum* var. *parishii, Navarretia fossalis,* San Diego fairy shrimp, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability;

   Existing vernal pools and their associated watersheds within the Hemet complexes that contain *Navarretia fossalis,* and *Orcuttia californica,* or any other vernal pool species,

should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability,

Existing vernal pools and their associated watersheds located on Stockpen soils (Otay Mesa) should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability, to provide for the recovery of species restricted to this soil type (i.e., *Pogogyne nudiuscula);* and

Remaining vernal pools and their associated watersheds contained within the complexes identified in Table 4 must be secured in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks).

2. The existing vernal pools and their associated watersheds contained within the complexes identified in Table *5* are secured in a configuration that maintains habitat function and species viability (as determined by recommended research).

3. Secured vernal pools are enhanced or restored such that population levels of existing species are stabilized or increased.

4. Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to consideration for reclassification. Monitoring should continue for a period of at least 10 years following reclassification to ensure population stability.

Delisting of each of the species is conditional on the downlisting criteria shown above, improvement (stabilized or increasing population trends) at all currently known sites; restoration, protection, and management of the minimum habitat area and configuration needed to ensure long-term viability; and establishing historic but locally extirpated species populations when needed to ensure viability.

Technical White Paper 1
Draft analysis and number and distribution of vernal pools and seven focal species

Review

Ellen T. Bauder

Chapter 1. Introduction

1.1. Project Overview

The TWP begins with an outline of how the Vernal Pool Habitat Plan will be developed by SANDAG for the City of San Diego. The explanation of the process is clear enough, but the section on baseline data (p. 2) is inadequate. No statement of what is meant by baseline is given, nor is a justification for the inclusion of the sources referenced or, more importantly, for the exclusion of sources not referenced. Does baseline refer only to pool numbers and locations? Site conditions? What about baseline for the focal species? Are the US FWS review papers expected to be the baseline (whatever that means in this context) for the species? What about the Ogden Environmental vernal pool database developed for the MSCP? Or the Villasenor and Riggan (1979) vernal pool survey completed the same season as Beauchamp and Cass (1979)? Or the SANDAG City of San Diego Inventory (2011)?

1.2. Overview of Vernal Pools

This section is the most deficient in the entire TWP. Prior to consideration of the ecology and status of the 7 focal species, an accurate, rigorous and complete description of the habitat (geomorphology, soils, hydrology) and climate is needed. This is lacking in both the US FWS 5-yr reviews and this TWP. Without this important environmental information and analysis, knowledge-based decisions on vernal pool management cannot be made. Protection and acquisition goals cannot be prioritized. Nor can species-specific risks be assessed.

Please see Chapters 3 ("Characterization of the Temporary and Seasonally Ponded Vernal Pool Wetlands of Southern California") and 4 ("Wetland Functions and Assessment Models) of Bauder *et al*. (2009) for a comprehensive description of the ecosystem and the primary factors affecting ecosystem function.

As recognized elsewhere in this TWP, pool type is important because this categorization has traditionally been based on geomorphology (Holland, 1986; Keeler-Wolf et al., 1998). A recent, finer discrimination between pool types indicates there are more than were originally described by Holland (1986). Using age/origin and geography, 16 vernal pool types have been identified in southern California, out of a possible 24 (Tables 5.2 and 5.3, Chapter 5, Bauder *et al*. 2009).

Permeability and soil chemistry vary between pool types, as does geomorphology (Bauder and McMillan, 1998; Table 3.2, Chapter 3, Bauder *et al*., 2009).

Climate (precipitation amount and seasonality, likelihood of frost, temperature ranges) varies within the region, based primarily on distance from the coast, topography and elevation (Bauder and McMillan, 1998; Table 3.1, Chapter 3, Bauder *et al*., 2009). This in turn affects ponding, plant germination (or cyst hatching), survivorship and reproduction (Bauder, 1992; Bauder *et al*., 2002; Bauder in press, Philippi *et al*., 2001).

Prediction of the possible impacts of systemic climate change is not possible without a fundamental understanding of the current climate, the life history of the focal species and how both plant and animal species and communities interact with the environment and each other under different climate scenarios (Bauder, 2005).

Yearly variability in precipitation amount and storm pattern is a hallmark of the Mediterranean climate experienced by San Diego's vernal pools (Ebert and Balko, 1987; Bauder, 2005; Keeley and Zedler, 1998). Within year variability is likewise high. The implications of this environmental variability on the likelihood of ponding, ponding duration and seasonal fluctuation in water levels, individual species' responses to various hydrological regimes and the need for habitat diversity to sustain the characteristic vernal pool biota have been discussed in general terms by numerous authors (Holland and Jain, 1977; Zedler, 1987) and studied closely by this author over a 20-yr period (Bauder, 1987, 2000, 2005 and in press) and Bauder *et al*., 2009).

Weather and soil characteristics interact with each other, adding another level of complexity (Bauder, 1987; Bauder *et al*., 2009; Rains *et al*., 2006, 2008).

Other complexities arise from pool shape, area, depth and connectivity or network position (Bauder, 2005; "Hydrology," and Figure 3.5, Chapter 3, Bauder *et al*., 2009). Little consideration in the TWP is given to the importance of connectivity, networks, and network positions. See Chapter 4 in Bauder *et al*. (2009) for a lengthy discussion of water storage and pool networks. Networks provide an array of habitats, from shallow and rarely ponded headwater pools, to flow through pools and terminal or collector pools. Pools respond differently to the same weather events, depending on their network position (Bauder, 2005; Bauder *et al*., 2009). Connectivity (primarily surface) also provides a mechanism whereby nutrients and reproductive propagules can move between pools. Networks also slow the movement of water out of the system and provide additional storage in smaller pools that only fill in years of heavy rainfall, reducing overflow spillage and loss to the system.

Given the paucity of available life history data available for several of the focal species, a thorough description of the environmental characteristics of their known locations is essential to assessment of the risks to their persistence and to tailoring management and conservation plans to their unique attributes and species-specific requirements and tolerances. All seven species became imperiled due to loss of habitat and a variety of disturbances. Reduction in all the well-recognized threats will benefit all seven species, but when hard choices have to be made, the type, size, shape, depth, connectivity, etc. of the pools involved will be of greater or lesser importance depending on the species. The preferences and tolerances of individual species can be inferred, even when more specific data are unavailable, by their position on the elevation gradient within a pool, coupled with data on the rainfall amounts and patterns collected at the nearest weather station (Bauder, 1987, 2000; Bauder, in press).

1.3. Summary of Status Information for Focal Species

Table 1-1 provides important information in a useful format and could be expanded and improved.

First of all, a brief, but rigorous, section on annual plant life history/life cycle stages and transitions is needed, including definitions of basic terms (with appropriate citations). This should be applied to each species and incorporated into Table 1-1. The same should be done for morphology and habit. The same characters should be examined for each species: habit, stem, leaf and floral morphology, breeding system, maximum number of seeds produced per flower, height range (the maxima are rarely seen in nature) and so forth. Minor note: clay pan and hardpan refer to strata within soils series and are not soil series themselves.

Chapter 2. Otay Mesa Mint

2.1. Listing Status

I must assume this is correct since the source is the US FWS 5-yr review paper. This holds true for all 5 plant species I am focusing on.

2.2. Species description

This description should provide general characters of the family, including the number of seeds per fruit. Also, species descriptions of all the focal species should include the same characters discussed in the same order, as do most floras (Hickman, 1993). The statement on height should be modified to indicate this is rarely attained in nature, especially unmodified habitat.

2.3. Habitat

There is more to habitat than soil type. A description of the critical soil factors (chemistry, strata, origin, permeability rate) is relevant, as is a description of the historical microtopography. Climate as well. Complex codes are needed for locations mentioned. Do locations on each soil series refer to historical distributions? Or include restored/created/modified habitat? Have any soils data been collected as part of the various habitat manipulation projects that have been carried out or are in progress on Otay Mesa?

2.4. Life cycle

Because *P. nudiuscula* does not require ponding for germination or completion of its life cycle, this first sentence is ambiguous. The wet cycle prevents competitive exclusion by upland plants that are inundation intolerant (Figures 3 and 7, Tables 1 and 3, Bauder, 2000). And the dry season excludes wetland perennials, which would also dominate most vernal pool plant species. At low density, *Pogogyne abramsii* does better (survivorship, biomass and fecundity) in moist soil, compared to flooded conditions (Bauder, 1987 and in press). Inundation kills competitors (intra- and inter-specific), thereby reducing density and improving fecundity of the survivors (Bauder, 1987 and in press).

The phenology of *P. abramsii* is as follows: 1) Germination in the early winter when seasonal rains begin and temperatures are cool, 2) growth during the winter and early spring, followed by 3) flowering and fruiting in the late spring or early summer. In very dry years (1983/4, for example) I have seen it flower in March. I would expect *P. nudiuscula* to behave similarly.

Although population counts (censuses) are time consuming and variability between rainfall seasons causes fluctuations in population size, useful abundance estimates are possible using less intensive sampling (Bauder 1987, 2000; Bauder *et al*., 2009; Holland, pers. com.). These can be used to describe population trends and link them to variation in weather conditions, disturbance, etc. As noted, for annual plants, the seed bank is both important and generally unknowable, except by inference from long-term observations of population trends.

2.5. Status and Distribution

I would cite Silviera's MS thesis here.

Shinohara vernal pool restoration site? This needs to be located on a map. The resolution of the map in Figure 2.1 is too coarse to be useful, other than to place the species in the planning area. The extensive table in Appendix A cannot be used with this map. Additional maps are needed to indicate locations at a meaningful scale. They should include labels for pool locations by name or complex code, if available (See Beauchamp and Cass, 1979; Villsenor and Riggan, 1979; Bauder, 1986; and City of San Diego, 2004). Excluded lands should be indicated with polygons outlined in black and filled with white or black. This would provide a quick way to see the extent (area) and distribution of the lands not under the City's jurisdiction (and vice versa)

What was the rationale behind introducing *P. nudiuscula* to the Shinohara site?

The sentence beginning "Local conditions…." states the obvious. Omit the word likely and drop the citation, which isn't necessary nor the best one for this purpose. Germination success depends primarily on adequate moisture during the cool winter months. Growth to reproduction requires more moisture over a longer period of time.

Sentence beginning “Yearly variability….” This has been well documented (Bauder, 2005; Holland and Jain, 1984).

The annual precipitation in the rainfall year when data were collected for the City of San Diego survey were slightly above the mean (10.36 inches)(p. 6, City of San Diego, 2004), but preceded by a year of exceptionally low rainfall (2.03 inches)(US Weather Service, Lindbergh Field). I concur with the conclusion in the survey that their results are typical or representative, although the prior year’s drought likely had an unknown but adverse impact. I do not know about Brown Field on Otay Mesa.

2.6. Threats and Pressures

A generalized description of threats is not helpful. Neither is the conceptual model of Appendix B. All threats do not apply to all sites. Their intensity may vary as well. A management/conservation plan can only be developed based on threats to specific locations. Likewise, because of their requirements, tolerances and ability to respond to a variety of situations, threats are species-specific as well. A table is needed with the same categories of information contained on the Field Survey Forms found in Appendix 3 of the Bauder survey (1986).

2.7. Propagation and Restoration Potential

All restoration efforts involving *P. nudiuscula* need to be referenced. What information was gleaned from the greenhouse propagation program regarding germination, growth and seed production of this species? What herbicide was applied and during what season? How were species other than targeted weed species protected? Were any of these restoration efforts on Stockpen soils, the series thought to be associated with historical populations? What were the sizes, shapes, depths and connections of the pools post-manipulation? What kind of monitoring was done, and what did it show about population trends, responses to different hydrological regimes, etc. “Genetically and geographically local” has little meaning without reference to specific locations.
It is state that *P. nudiuscula* has been added to 300 pools. Has it been added to pools where it was extirpated or have pools been created where it has been introduced and established?

Are there any natural pools left to restore that have *P. nudiuscula*?

2.8. Status in Study Area

The maps are inadequate. See comment in section 2.5.

The documentation for soil/species association is in Bauder and McMillan (1998).

As indicated in the comments on Chapter 1, there is more to pool type than the clay vs. hardpan designation applied by Holland (1986).

Chapter 3. San Diego Mesa Mint

3.1. Listing Status

3.2. Species Description

Please see comment in section 2.2.

3.3. Habitat

This description is far too brief and completely inadequate. Please refer to the general discussion of habitat in section 1.2.

Much is known about the physical environment of pools supporting *Pogogyne abramsii*. The soils that support this species have been analyzed for both texture and chemistry along the elevation gradient from upland to low point in 7 pools (Bauder, 1987; Bauder *et al*., 2009).

Pool hydrology has been followed in a number of pools that support *P. abramsii* (Bauder 1987, 2000, 2005, in press and unpublished data; Zedler and Ebert, 1979; Black and Zedler, 1998). In addition, hydrology has been monitored in restored and created pools that support the species (Bauder, 1988, 1989, 1994; Bauder and Sakrison, 2001); Black and Zedler, 1998; AECOM, RECON). The movement of water through pool networks has been closely monitored (Figure 3.5, Bauder *et al*., 2009), as has the seasonal progression of specific conductance (Figure 3.6, Bauder *et al*., 2009).

A detailed study of one pool’s soil profile and hydrology was done on Del Mar Mesa (Greenwood, 1984; Greenwood and Abbott, 1980).

Soil surface temperatures have been documented (Bauder unpublished data). Temperatures range from the low 40’s (deg F) in the winter months to over 100 deg F in the summertime.

Rainfall amount and storm pattern for the Lindbergh Field weather station have been analyzed over a 20-yr period (1982-2002)(Bauder, 1987, 2005), and the amount of rain needed to trigger ponding has been documented by analyzing seasonal ponding data taken in a number of pools over the same period (Chapter 4 and Table 5.4, Bauder *et al*., 2009).

3.4. Life Cycle

Contrary to several statements in the US FWS 5-yr review of this species (pp. 5-7) a great deal has been learned about the habitat, life cycle and population trends of *P. abramsii* since it was listed in 1978. It may well be the most thoroughly studied and understood of any of the vernal pool species, in San Diego or all of California, for that matter (Bauder, 1987; Bauder, in press). This TWP does not correct the deficiencies and omissions of the 5 yr review and introduces additional errors.

The life cycle of *P. abramsii* is not dependent on inundation, as is stated. It germinates well in moist soil in pots and in the field (Bauder 1987, 1989, 2000). Under controlled conditions it germinates well at ambient winter surface soil temperatures, but also at warmer temperatures (Bauder *et al*., 2002). Moisture is the key to germination . Most of the area's vernal pool species are relatively insensitive to temperature (Bauder, 1992; Bauder *et al*., 2002).

P. abramsii also grows well and reproduces without inundation. In fact, *P. abramsii* has only moderate tolerance of inundation, and under controlled conditions, mortality increases with only 2 weeks of inundation and quite sharply after 60 continuous days of inundation (Bauder, 1987). In the field, % of quadrats occupied likewise drops where water stands for long periods, confirming the results of both field and greenhouse experiments (Bauder, 2000; Bauder, in press). In upland habitats where soil moisture is limited, supplemental waterings improved *P. abramsii* survivorship (Bauder, 1989).

Population trends over time have been well documented for this species, including a 20-yr study done by this author (partially published in 1987 and 2000); Bauder and Sakrison, 2001; Black and Zedler, 1998). As noted in the TWP, the total population numbers are rarely known, even when detailed censuses are taken of growing plants, because a substantial portion of the population resides in the soil as seeds (embryos). Population numbers and soil seed storage were estimated by Zedler (1986, 1987, 1991 reports to Caltrans). Ebert (1999) developed a stage-structured demographic model for *P. abramsii* based on the data collected under Zedler's direction.

Neighbors (both intra- and inter-specific) affect survivorship, biomass and fitness whether density starts out low (naturally or by design) or ends up low due to inundation related mortality (Bauder, 1987; Bauder, 1988; Bauder *et al*., 2002; Bauder in press). When moisture is limited, the effects of drought stress over top those of competitors (Bauder, 1989). *P. abramsii* has persisted despite the presence of abundant highly dispersible upland exotics because these species are highly intolerant of inundation and are knocked back in years with ponding (Bauder, 1987; Bauder, 2000; Bauder, 1997). Wetlands weeds that produce thatch have negative effects on *P. abramsii*, independent of plant density (Bauder, 1988 report; Bauder, 1997; Bauder *et al*., 2002).

Seed set and fecundity (survivorship X seeds/plant) have been studied under controlled conditions (Bauder, 1987; Bauder *et al*., 2002) and in the field (Bauder 1989; Zedler, 1986, 1987, 1991 reports to Caltrans), Schiller *et al*., 2000; Zammit and Zedler, 1990). Insect visitors (species and frequency) have been studied as well (Mills in Zedler, 1986, 1987; Schiller *et al*., 2000).

Dispersal of seeds is limited and where it occurs, establishment of new populations is rare, if it occurs at all. This is confirmed by long term monitoring of natural pools (Bauder, 1987, 2000 and unpublished data), field manipulations (Bauder, 1987, 1989, 2000) and attempts to introduce the species to restored or created pools (Bauder and Sakrison, 2001; Schiller *et al*. 2000; Black and Zedler 1998). It appears that unoccupied habitat must be inoculated with a large number of seeds for establishment to take place. Under natural conditions, occasional migrants are possible. Large introductions of seed into unoccupied habitat are extremely unlikely without human intervention.

3.5. Status and Distribution

Please see my comment on maps in section 2.5. Maps are inadequate, except to place the species in the planning area.

Population counts (censuses) were taken for this species by Zedler (1986, 1987, 1991 reports to Caltrans). Population trends monitored in small quadrats have been undertaken as well (See section 3.4) by various people in a number of pools over an extended period of time. Even less intensive methods would be sufficient to describe the health and population trajectories of *P. abramsii* populations (Bauder *et al*., 2009)

3.6. Threats and Pressures

See my comments in section 2.6. They hold for this species as well.

Upland exotics (primarily annuals from Asia) have been part of the system since the introduction of grazing by the Spaniards. Their lack of inundation tolerance has kept them in check within pool basins, where the flora until recently has remained almost entirely native (Holland and Jain, 1977; Bauder, 1987, 1997, 2000).

In the upland areas, dense shrub cover has reduced weed penetration of the native vegetation. Annual exotics have thrived, however, in the more open, grassy upland areas that support annual native herbs and perennial bunch grasses, some of which may be important to the insects that pollinate outcrossing vernal pool species. As noted, the increase in weeds my well have changed the population dynamics of granivores found in vernal pool uplands (Bauder, 1997, 1998; Hunt, 1992).

With the introduction of wetlands exotics such as *Lolium* spp., *Polypogon monspeliensis* and, especially *Agrostis avenacea*, the natural resistance of pools to weed invasion due to seasonal ponding is no longer sufficient because these species tolerate standing water as well or better than natives such as *P. abramsii* (Bauder, 1987 report; Bauder *et al*, 1992).

Fires like the Cedar Fire of 2003 have exacerbated the effect of exotics by destroying the shrub cover and releasing nutrients that support the rapid growth of exotics. These exotic species are characterized by a high growth rate sustained by fertile soils and copious production of seeds that can remain in the seed bank for long periods of time. Fire can result in permanent type conversion, as I fear it has at MCAB Miramar and on Otay at the J 26 pools.

To the threats described above, I would add loss of intact, small networks, along with restoration projects that focus on pools of average or greater size and depth. Lack of habitat diversity has implications for climate change (Bauder, 2005) and alters the hydrodynamics of the system (Figure 3.5, Chapter 3, Bauder *et al*., 2009).

3.7. Propagation and Restoration Potential

A fuller list of restoration projects needs to be presented. Many important, instructive enhancement/restoration/creation projects using a variety of techniques are absent from the citation list. A short summary of the successes, failures and cautions related to these projects is needed. Please identify the 50 pools to which *P. abramsii* has been added. Were these pools where it was historically present but was extirpated and reintroduced? Do these represent created (*de novo*) pools, such as those on Del Mar Mesa? Or heavily restored pools with introduction of the species where it may have occurred in the area but not the pool?

3.8. Status in Study Area

As indicated in sections 2.5 and 2.8, the maps associated with this TWP are inadequate. The scale renders them useless in conjunction with the table in Appendix A.

Please compare number of locations within the City of San Diego and within the Planning Area. Why is the J30 complex on Otay Mesa brought into the discussion?

Chapter 4. Spreading Navarretia

4.1. Listing Status

4.2. Species Description

The original description of the species was by Moran (1977), but the treatment of the genus Navarretia in Hickman (1993) is by Day. See also Wiggins (1980).

Each of the two chambers in the fruit contains only 1 to many seeds. Spencer and Rieseberg (1998) found an average of 16 ovules per flower and Day reports 5-25 seeds per flower (p. 847, Hickman, 1993). The number of flowers per inflorescence is unknown (or undescribed), and the proportion of the seed that is viable is also unknown. Based on pollen/ovule ratios, Spencer and Rieseberg (1998) speculated that the species may be predominantly a selfer. However, it is reported in the TWP that repeated insect visits to this species have been observed (Krombein, 1979). The Krombein citation is to an index, not reports of insect visitors, so perhaps there is an error in the citation.

4.3. Habitat

What do the all the occurrences have in common? In what ways are they dissimilar? What are the basic attributes of the alkali soil series where this species occurs in Riverside County? Do they have layers that retard permeability/infiltration similar to the five soil series in the Planning Area that support *N. fossalis*? What causes the floods in Riverside County? What is different about geomorphology and topography, compared to San Diego? Climate? More is needed on the Riverside hydrologic regime and how it differs from that experienced by San Diego County populations. The point that these floods cause shrub mortality and open up the habitat is comparable to the exclusion of shrub components of chaparral and coast sage scrub being excluded by ponding.

More intensive analysis of the habitat variables (soil series attributes, topography and climate) might yield a better understanding of the fundamental aspects of the species' habitat beyond temporary flooding, which would not explain its absence from pond and stream edges. Spencer and Rieseberg (1998) concluded it was not a vernal pool obligate, although it frequently occurs in vernal pools.

4.4. Life Cycle

The inflorescence does not shatter, and fruits are indehiscent. They break open to release the seeds when the fibers on the seeds' surface take up water and swell, as indicated in both the 5-yr review and the TWP. Seeds of this family may become gelatinous when wet (p. 844, Hickman, 1993). Seedlings respond to inundation by vertically orienting their leaves (Spencer and Rieseberg, 1998).

Is there more information on maturation and reproduction in the Glenn Lukos (2005) report? Any additional observations from Bramlet?

This is what appears to be known about germination, development, fruiting and flowering. Everything else is speculation. Therefore, as indicated in section 1.2 a more rigorous evaluation of the correlation between habitat, weather and *N. fossalis* presence is all we currently have to go on.

4.5. Status and Distribution

This account of distribution and occurrences would be well served by expansion of Table 1 and reference to it.

4.6. Threats and Pressures

Since so little is known about the ecology of this species, threats to its continued existence do not differ from those that apply to other species. I think this should be acknowledged and refer back to a general section on threats at the beginning of the TWP rather than repeat what has already been said.

4.7. Propagation and Restoration Potential

This paragraph sheds no light on why the restoration efforts were successful with this particular species. Seed collections were made. Was any of the collected seed tested for viability or germinability? Was any of it grown in the greenhouse to augment seed supply? If so, there must be information on this plant's germination and growth to maturity, even if only anecdotal.

How large (area or population estimates) were the source populations and how much plant material was collected? Are there any data or even anecdotal reports of seed output/plant (either in the greenhouse or in the wild), effort needed to collect sufficient seed for successful restoration, how much seed and/or plant material was applied as inoculum?

Was *N. fossalis* restored to pools where it had been previously found but was extirpated? Was it seeded into created or heavily restored pools? What are the locations of the 25 pools where it has been "added?"

Chapter 5. San Diego Button-celery

5.1. Listing status

5.2. Species Description

Although biennial is often used to describe *Eryngium aristulatum* var. *parishii*'s growth habit, it is not appropriate. Biennial refers to a specific growth plan, *i.e*. germination and establishment in year 1 and reproduction and death in year 2 (Little and Jones, 1980; Barbour *et al*., 1980). Short-lived perennial better describes this plant's life span.

The below ground storage/perennating organ is a root stock, also known as a caudex (Sheikh, 1978; Little and Jones, 1980; Marsden and Simpson, 1999). This is a form of underground stem that may have fibrous roots and also sprout adventitious roots each growing season after the seedling becomes established.

Although Constance prepared the family treatment (Apiaceae), Sheikh is credited with description of the genus Eryngium (p. 146, Hickman, 1993).

Sheikh (1978) estimated that each Eryngium species may produce as few as seven flowers per head or up to 130 flowers per head, with 25-50 flowers per head more common. Each flower produces a maximum of two seeds.

5.3. Habitat

There is information in the "Life Cycle" section that would be more appropriate in this section. As indicated in this section, it is primarily a vernal pool species that can also be found in wet meadows and swales. Please note that *E. aristulatum* var. *parishii* appears to be absent from the deepest regions of pools (Figure 5, Bauder, 2000; but see Table 5 and Figure 11, Bauder and Sakrison, 2001).

5.4. Life Cycle

Morphological and physiological adaptations should be moved to section 5.2. Also see Sheikh (1978). He also provides additional observations on the phenology and seasonal development of Eryngium species.

I don't believe Zedler (1987) was implying that the insects observed in a study focused on *Pogogyne abramsii* (Mills in Zedler 1986, 1987 Caltrans reports and also cited in Zedler, 1987) were pollinators of *E. aristulatum* var. *parishii*.

In pools where it is found, Eryngium occurs in sampling quadrats at a lower frequency than other pool obligates like *Downingia cuspidata* and *Pogogyne abramsii* (Table 3, Bauder, 2000; Zedler 1986 report). It is common for Eryngium to be found in <30 % of quadrats sampled across the elevation/inundation gradient. Twenty years of censuses of seedlings and adults in two pools provides no clear picture of this species' response to precipitation (Bauder, unpublished data).

5.5. Status and Distribution

5.6. Threats and Pressures

> Acquisition of land and conservation easements have preserved vernal pool habitat, but some loss of vernal pool habitat has continued. Threats associated with OHVs continue throughout the range of the variety, including on preserve lands (*e.g.*, Santa Rosa Plateau) and conserved lands (*e.g.*, some sites within the jurisdiction of the San Diego MSCP).
>
> TWP#1, p. 38

The situation described in this quote applies to other locations/occurrences of other focal species as well, most notably *P. nudiuscula* on the J14 complex on Otay Mesa, which, the last time I was on Otay Mesa (2007), had become a *de facto* OHV/motorcycle track.

The word "conserve" needs to be defined in the very beginning of the document, and the important facts related to "conserved" parcels should be noted in a table. For example, a table containing the following columns would be useful: conserved (yes or no), date conserved status attained, type/mechanism of conservation/conserved status (if relevant), protection applied (or not), current condition, and condition improved since conserved. Perhaps this table belongs in TWP#2.

The breeding system of this species has not been explored (obligate outcrosser, facultative outcrosser, predominantly outcrosser), nor have pollinators/insect visitors been identified. Studies in northern California suggest pollinators of some vernal pool plants need the upland vegetation to sustain their populations (Thorp and Leong, 1998).

The very modest number of seedlings noted above suggests this species has a low reproductive output. It is unknown if this is related to lack of pollinators or some other important step in the development of viable seeds or germination. Populations don't bounce back after a drought when rainfall is adequate. This suggests minimal seed storage in the soil. Very few seedlings make the transition to adults.

In one restoration project (Bauder and Sakrison, 2001), Eryngium did better in restored pools compared to unrestored reference pools. However, *Downingia cuspidata*, *Pogogyne abramsii* and *Deschampsia danthoniodes* did less well in restored pools.

5.7. Propagation and Restoration Potential

As indicated under this topic in regard to other species, if this Eryngium has been gathered from the wild and introduced to restored pools or grown in the greenhouse to augment the natural seed crop, more details need to be provided.

My germination experiments indicate low germination percentage (< 40) for this species, regardless of temperature regime (Bauder, unpublished data). In general, the vernal pool seeds I have germinated do well (>50% germination) over a wide range of temperatures (Downingias excepted)(Bauder *et al.*, 2002 and unpublished data).

5.8. Status in Study Area

As indicated several times in the discussion of the other focal species, the maps are wholly inadequate.

The percent of pools restored needs to be noted by complex.

Chapter 6. California Orcutt Grass

6.1. Listing Status

6.2. Species Description

Per Mason (1969) and the US FWS 5-yr review, the species description is by Vasey (Bull. Torrey Bot. Club 13:219, 1886).

6.3. Habitat

This section is seriously deficient. Griggs (1976, 1980, 1984) discusses habitat at length. Mason (1969) indicates the species grows on mud flats as well as in pools. I have seen it several times in the J13S pools, which are neither shallow nor large. Size (area) is often correlated with depth and therefore long periods of inundation. Extremely low permeability of the soil might serve the same purpose as large and deep, *i.e*. promote long periods of ponding.

The physical attributes of pools that support *Orcuttia californica* throughout its range need to be carefully described.

6.4. Life Cycle

One aspect of the life cycle not mentioned is that "Each spikelet exhibits indeterminate growth. The number of florets in a spikelet is directly proportional to the duration of favorable growing conditions after the inflorescence was formed." (p. 5, Griggs, 1980). Presumably the "favorable growing conditions" do not include extremely long periods of deep inundation that could diminish reproduction, rather than enhance it. All these species are on an environmental knife's edge, with too little or too much water adversely affecting germination, growth and reproduction.

6.5. Status and Distribution

The various populations need to be located on a map. Most of the pools within the City of San Diego are at one heavily restored complex (J2S). The only natural occurrence I know on Otay is at the J13S pools [Please note the error in Appendix A]. It is also the only complex where I found *Myosurus minimus var. apus*, *Navarretia fossalis* and *O. californica* co-occurring (p. 9-1, Bauder 1986). The City of San Diego Vernal Pool Survey (2004) found both Navarretia and Orcuttia at this site.

6.6. Threats and Pressures

Although this species faces the same threats as the entire ecosystem does, the patchiness of its distribution and the limited number of populations puts it at even greater risk compared to more widespread, abundant focal species like *Pogogyne abramsii* and *Eryngium aristulatum var. parishii*. The fact that one of the best natural populations remaining in the county (J13S) is not conserved in any sense of the word, is of great concern. This complex also supports another focal species, *Navarretia fossalis*, also with limited and patchy distribution and likely far fewer numbers.

Attachment A

I am no longer qualified to review the status of these pool complexes.

The source(s) of the data need to be identified, to complex level, if necessary.

I did what I could by spot checking the species locations for the three focal plant species with the most limited distributions: *Pogogyne nudiuscula*, *Navarretia fossalis* and *Orcuttia californica*. J13S has, as recently as 2003, supported *Myosurus minimus* var. *apus*, *Navarretia fossalis* and *O. californica* (City of San Diego 2004 and Bauder, pers. obs. 2003). In Appendix A, neither of the two focal species is reported as present.

The conservation status of the pools needs to be included, as well as the proportion unrestored, lightly restored, heavily restored and created.

Beginning with the 1979 surveys, MCAB Miramar has been well studied and much of that material is available.

Attachment B

I found this of no value. One section of text at the beginning of the entire TWP that fully explores the threats, risks and pressures affecting vernal pools in general would be sufficient, with additions in the species chapters **only** when that species' habitat associations; requirements or tolerances (if known); life cycle; or distribution indicate the threats to its persistence differ in nature or extent due one or more of its unique attributes.

Attachment C

The Recovery Plan excerpts are useful.

Technical White Paper 1
Draft analysis and number and distribution of vernal pools and seven focal species

Responses to Questions

Ellen T. Bauder

1. Are there additional sources of literature/information not in the TWP that should be consulted?

Given the sequence of production and review of the seven Technical White Papers (TWPs), my assumption is that the first two TWPs are the foundation of the process. Therefore, they should contain the information necessary for development of the subsequent TWPs and eventually a VP HCP. They do not.

Trying to summarize the extensive vernal pool literature in a short TWP is a daunting task, unnecessarily repeats work already completed by others and can result in a serious loss of information, as well as the introduction of ambiguities, errors and contradictions. I don't see how these white papers could contain all the source material that is required for a full and nuanced understanding of the ecosystem and its resident species and the development of a fact-supported HCP.

The most serious deficiencies in the literature are related to the environmental elements of the vernal pool ecosystem. These include pool origins (geomorphology), relevant attributes of the soil series, hydrology and hydrodynamics and climate. A recent, concise and rigorous description of the southern California vernal pool ecosystem already exists (Bauder *et al*., 2009).

The species profiles are based primarily on the US FWS 5-yr reviews. This is a reasonable starting point, but problems exist (See response to question 2). For example, Chapter 3 on *Pogogyne abramsii*, relies heavily upon the 5-yr review, which was incomplete and out of date. This species is probably the most studied of all the vernal pool species, and there is wealth of available information that should have been included in both the 5-yr review and the TWP.

An important start on the literature problem would be a list of general publications on vernal pools that have extensive literature sections of their own. These would include the proceedings of the four vernal pool conferences (1976, 1981, 1998 and 2010-in press); the US FWS Recovery Plan for Vernal Pools of Southern California (1998), 5-yr species reviews and vernal pool community profile (Zedler 1987); and the draft regional HGM Guidebook on vernal pool depressional wetlands (Bauder *et al*., 2009). The draft guidebook is the most recent comprehensive document available on the vernal pool ecosystem. All of these publications need to be made available on a regularly maintained website to read or download.

We need a comprehensive, accessible vernal pool literature database and central document repository for literature relevant to San Diego County's vernal pools and their biota. After over 30 years of study of this ecosystem and its species, it is disturbing that most of the literature and data are not held in one central place so that this store of knowledge could be accessible to planners and decision makers.

I have no problems with the so-called grey literature. Reports, by their nature, contain far more information (data tables, figures, maps, appendices) than shorter, peer-reviewed journal articles. In many instances, these data can be re-analyzed to serve different purposes. With modest effort, most of the relevant reports should be available to those who are responsible for developing the VP HCP, although some may need to be scanned.

Peer reviewed papers that appear in journals or conference proceedings have their own merits, including brevity and the benefits usually associated with the peer review process and professional editing. A downside is accessibility. To those not associated with a university, access may be limited and costly.

For a fuller discussion of the literature in relation to particular portions of the TWP, please see the essay review of the TWP#1.

2. Are the descriptions of the species, including their listing status, description, habitat, life cycle, status and distribution presented accurately?

The 5-year species reviews published by the US FWS are comprehensive, and portions have been summarized and incorporated into this TWP. Rather than summarizing these documents or extracting small portions of them, a better approach would have been to incorporate the US FWS 5-year species reviews by reference (including the urls), then provide additional information not presented in these reviews, correct their deficiencies (errors, imprecise descriptions, omissions, etc.), and include updates on occurrences and habitat quality since they were written and published. As indicated in the general review of TWP#1, the greatest weakness of the document is the lack of focus on the habitat. This carries over into the discussion of each species.

Simply stating that each species is dependent on the wet/dry cycle of the vernal pool ecosystem is not helpful in developing a conservation/management plan. There are numerous studies that show the specific impacts of drought, ponding duration, lack of ponding, fluctuation in water level and population trends over time. Several studies have been done on germination under controlled conditions, as well as in the field. Most of these studies have focused on *Pogogyne abramsii*, but work on other pool species with different life histories, requirements and tolerances and morphologies has been done as well.

In several instances the suggestion is made that pool plant species require inundation to germinate. Most of them do not. Nor do they require ponding to complete their life cycle, unlike the fairy shrimp that require standing water of a certain period to hatch and reproduce. The primary function of standing water, from the standpoint of most of the characteristic flora, is to exclude upland perennials and every so often knock back the upland annuals, both native and exotic, that disperse easily into the pools, grow well when soils are moist but not flooded (which they cannot tolerate) and can successfully outcompete many pool species.

3. Are the threats and pressures described accurately for each species? Are there missing elements?

The threats and pressures that apply to the vernal pool ecosystem should be summarized at the beginning of the document. Within the discussion of each species, only those threats that are **unique to that species** due to its association with a particular pool or soil type, life cycle traits, requirements and tolerances should be discussed. For the most part, this has not been done.

Furthermore, complexes or portions of complexes are faced with different threats and pressures. Even when the same threats are associated with many complexes, the intensity, frequency, and duration of the disturbance within each complex must be taken into account. This information is not available in this document. See the review for additional comment and suggestions.

4. *In the TWP, threats and pressures are grouped into four categories: direct pressures, indirect pressures, long-term cumulative pressures and potential future climate change. Please comment on the completeness/appropriateness of these four categories?*

The categories seem appropriate, but the discussion is inadequate, and the information is not summarized or presented in a useful manner.

5. *Are the four categories sufficient for documenting the pressures and threats to each of the species?*

My problem isn’t with the categories, but the lack of species and complex specific discussion.

6. *Please comment on the conceptual models included in the appendix, which will be used to identify management and monitoring strategies to address specific threats to the focal species. One is on vernal pool plant focal species and the other pressures on focal fair shrimp species.*

Is this model only intended to identify the relationship of indirect and cumulative effects and specific direct effects? If so, then it is deficient.

Take dumping, for example. We all know (or should know) the direct impacts of dumping, although a summary table of the salient impacts of each of the direct pressures or impacts would be useful to help understand the relationship to cumulative and indirect effects. [Note: the word "pressure" is too vague to be useful.] The model suggests the only cumulative effects are on air and water quality, and via those the indirect impacts are on pollinators. This makes no sense to me.

The only cumulative or indirect impacts for vehicles are apparently the same as for dumping. Over time vehicle tires remove soil from the basins, often exposing the hardpan and causing ponds to fill immediately after a storm when normally the soil surface would absorb the water for some time before ponding would commence. Therefore, an indirect effect is altered hydrology. The wet soil is a buffer for plants that allows them to continue to grow when rains cease, so indirectly the ability of plants to complete their life cycle can be affected.

I find no value in this conceptual model. In fact, it overly simplifies, confuses and complicates the relationships between direct effects (which should be spelled out), cumulative and indirect effects.

7. *Are the models appropriate/complete/accurate for identifying management and monitoring strategies to address specific threats to the focal species?*

No.

8. *Please comment on the completeness of the study area baseline for each species.*

I am not certain what is meant by "baseline" in this context. The baseline studies mentioned at the beginning of the TWP? If so, this essentially repeats question one. I have addressed my concerns regarding the "baseline" literature in my review and my answer to question 1.

Or is it referring to Appendix A? Proofing this for completeness and accuracy is beyond the duties of a reviewer. To put my stamp of approval on it, I would have to come to San Diego and revisit all of the complexes listed because changes occur constantly and many have occurred since I last worked in the county. A reviewer has an expectation that the data presented are accurate and the calculations are correct.

9. *Are the four categories on threats and pressures scientifically reasonable and defensible based on available data?*

I have no problem with the four categories, but the discussion of the implications and likely effects of the threats and "pressures" is inadequate and not tailored to the specific conditions of individual complexes or species.

10. *Are there other changes/impacts from climate change that were not addressed?*

As indicated in the review, a thorough understanding of the physical and climatic setting is needed, as well as a full understanding of possible species responses to the various climatic scenarios that might result from systemic change. A few of the possible scenarios are as follows: greater or lesser year-to-year variability; changes in the lengths of the season (shorter or longer); year around precipitation with two peaks; more rainfall or less rainfall; and more, fewer intense storms or more dispersed storms. If rain occurred when temperatures were hot, seeds might germinate but not survive to reproduction (Bauder, 1992). Deeper or longer inundation periods would likely have strong effects on populations of individual species and community composition, as well as biotic interactions (Bauder, 2005).

11. *Are there other vernal pool sites that are known or recorded in the City?*

Other than in Appendix A? I would have no way of knowing.

12. *Are there other vernal pools that are occupied by seven focal species that are known or recorded in the City?*

I do not know.

13. *Is there some other component of the life history (e.g., pollinators) that isn't captured in TWP1?*

The life history sections are in general incomplete and poorly written. The one on *Pogogyne abramsii* is particularly deficient and inexcusably so. More is known about this species than any other vernal pool species. Please see the review for species-specific details.

14. *Is there any literature that indicates how larger of a native buffer around the vernal pools is required to promote continued existence of the focal species.*

I am not aware of any. This cannot easily be quantified. The effects of an inadequate "buffer" might be multiple, be expressed differently under different circumstances (think climate change, a viral or fungal disease or large-scale fire) and reveal themselves over an extended period of time. Certainly the natural watershed is a good beginning, but many animals (insects, birds, small and large mammals), including pollinators, range over distances far greater than watersheds.

Landscape and watershed scale disturbances were considered in the HGM guidebook (Bauder *et al*., 2009).

The inter-relationship of the surrounding habitat with the pool basin(s) is receiving increasing attention, especially in northern California. At a vernal pool conference held in Chico, CA in March of 2010, several papers were presented that studied pollinator (Leong) and amphibian (Searcy) movement between uplands and pools. There was also a presentation on climate change and vernal pools (Loarie). The proceedings for this conference will be published in the coming months.

On a shorter time frame, buffers are necessary to prevent edge effects from altering hydrology (J26, for example), dumping, vehicles and pedestrians, pollution from run off or spills, etc. Small "handkerchief" preserves could easily be wiped out with one unfortunate incident (U Magnatron pools). Not so with adequate uplands preserved around the pools.

15. *Do you have any comments on easy of creating/restoring the seven focal species (i.e., potential for restoration success).*

There needs to be a serious discussion of the enhancement/restoration/creation continuum. There is a tension between trying to re-establish a site to a reasonable state of naturalness and trying to make certain that focal species have maximally large populations.

If the pools do not represent an array of hydrological types in a relatively natural relationship to each other, the species may not be able to adjust to changed conditions, whether a change in climate or some other environmental or biological change. Average or deeper than average pools may support thriving populations now, but drown out species if rainfall increases in amount or storms increase in intensity.

Please look to the review for additional comments.

16. *Is climate change a real threat given the high inter-annual variability of the pools in any given year?*

The pool biota has evolved within a range of variability. If there is a shift in the mean precipitation amount, pattern and intensity of storms or even the season of rainfall (shifts to summer or bimodal), changes in species relative abundances should be expected, as well as changes in community interactions. Longevity in the seed or cyst bank must reflect the maximum interval between favorable years, so the storage in the seed bank (including genetic diversity) would be altered. Where the ecosystem would end up would depend on the nature and degree of change, as well as the responses of the members of the plant and animal communities (Bauder, 2005).

17. *Is there any literature of understanding of the seed bank/cyst bank dynamics of the seven focal species?*

More is known about the cyst than the seed bank, although data on the seed bank, primarily of *Pogogyne abramsii*, were collected under the direction of Zedler (reports to Caltrans in 1986, 1987 and 1991). Plant population fluctuations in response to dry and wet years suggest indirectly that the seed bank can be substantial. My long-term data suggest this my not be true for *Eryngium aristulatum* var. *parishii*.

18. *Are there any indirect threats that are not included in the model?*

Here is a partial list: loss of pool network functions (hydrological, chemical and biotic connections); loss of habitat diversity; altered species interactions (within pools, between pools and uplands, within uplands); changes in community composition (uplands and basin); reduction or increase in water storage; changes in biogeochemical processes; and siltation.

Response to Questions: Marie Simovich
Technical White Paper 1
Draft analysis and number and distribution of vernal pools and seven focal species

1. *Are there additional sources of literature/information not in the TWP that should be consulted?*

   Yes. Large portions of the available faunal literature both primary and grey are missing. Some of those which are cited are not utilized as extensively as needed. There are more specifics noted in the comments on the paper itself and in later questions. There is a large amount of literature listed in the HGM (Bauder et al. 2009) and also in a very large and detailed literature search prepared for EDAW/AECOM by Bohonak (2006). Just because this is not coming from an academic institution is no reason why the literature describing the causes and consequences of threats to natural systems should be ignored. Without it, how can you hope to make predictions or plan for preservation or recovery?

   a. At the preliminary meeting, we (the advisory group) *specifically* requested that the HGM (Bauder et al. 2009) be considered. This was also discussed of this in the preliminary public workshop (see Collinsworth Letter 1/14/2011, attached). It is not mentioned or even referenced.
   b. The references which are used rely too heavily on grey literature, particularly the non-reviewed reports from EDAW.
   c. The format in the references section is inconsistent and contains numerous errors. I did not try to fix them.
   d. The citations are not consistent in the text – choose chronological or alphabetically order but don't switch back and forth.
   e. See Ripley and Simovich (2008) and King et al. (1996). These are papers on community ecology and the importance of pool duration. **All pools are not created equal.**
   f. No animal based surveys are mentioned as serving as baseline for the paper. Not even Bohonak (2005) which was done for the City itself for fairy shrimp genetics although it appears that the data from this report was used. It appears that the City inventory was the only source of data for shrimp (and much of what is reported is incorrect). There are numerous such reports and papers available (e.g. Simovich/Branchiopod Research Group 1996, 2007, Simovich 2005, Ripley and Simovich 2008, Bauder et al. 2009, eight year worth of work on Salk/McAuliffe plus the USFWS data base).
   g. They are missing habitat and genetic homogenization literature (see for example Olden et al. 2004, Olden 2006, Devictor et al. 2008).
   h. They briefly describe the hatching and development of the two fairy shrimp (Table 1-1) but do not include the citation – Hathaway and Simovich (1996). Later they cite another paper incorrectly for this information (see comment 16).
   i. The literature regarding the specific effects of soil compaction, vehicles, pesticides, grazing, and fire, movement of cysts by natural and artificial vectors is missing. (See for example -Simovich 2005 for a general list of considerations, Hathaway et al. 1996 for

crushing, Wells et al. 1997 for fire, Ripley et al. 2004 for pesticides, Waterkeyn et al. 2010 for human vectors, Bohonak and Whiteman 1999, Green et al. 2005 and Vanschoenwikel et al. 2008 for animal vectors). See below also.

2. *Are the descriptions of the species, including their listing status, description, habitat, life cycle, status and distribution presented accurately?*

   No.

   a. The primary literature is not cited for the species descriptions (Fugate 1993, Eng, Belk and Eriksen 1990). Terms are used which are not understood by non-specialists and diagrams are needed.
   b. The diet described for *S. woottoni* is speculative. There is no published data on the diet of this species. At least they should report on what they are basing this speculation.
   c. They do not discuss the population genetic structure literature (e.g. Davies et al. 1997, Fugate 1998, Bohonak 2005).
   d. There is very little on habitat requirements, critical habitat or tolerance limits (see Gonzalez at al. 1996, Eriksen and Belk 1999 plus the Federal Register).
   e. They do not discuss the finding that there are two genetically distinct Evolutionarily Significant Units (ESUs) within this "species" (Bohonak 2005). While they are genetically distinct, they may also be ecologically distinct and possible somewhat incompatible. We have some preliminary data on this, but the point remains that this is extremely important and needs to be considered in decisions regarding which pools to save and in any restoration attempts.

3. *Are the threats and pressures described accurately for each species? Are there missing elements?*

   No. The threats are simply listed not described or discussed. Yes, there are several missing elements. The causes and consequences need to be addressed in order to evaluate the extent of the threat and how to approach dealing with it or minimizing it.

   a. First – what are the natural vs disturbed habitats for these species? Simovich and Fugate 1992, Eriksen and Belk 1999, Bauder et al. 2009).
   b. How do you evaluate pool function? (Bauder et al. 2009)
   c. No description of the actual threat of disturbance by OHV in terms of soil compaction, crushing of cysts (Hathaway et al. 1996) or movement of cysts (Waterkeyn et al 2010) or community diversity decline.
   d. No discussion of grazing (Marty 2005) or fire (Wells et al. 1997).
   e. No discussion of population genetic structure (Davies et al. 1997, Bohonak 2005, Vandergast et al. 2010).
   f. No discussion of the effects of pesticides, herbicides or other pollutants (Ripley et al. 2004).
   g. No discussion of the causes and impacts of natural vs artificial dispersal (see for example Waterkeyn et al. 2010 for human vectors, Proctor et al. 1967, Bohonak and Whiteman 1999, Figuerola and Green 2002, Green et al. 2005 and Vanschoenwikel et al. 2008 for

animal vectors, Brendonck and Riddoch 1997 for wind). Also please see Bohonak and Jenkins 2003.

h. No discussion of the breakdown of population structure.
    i. No details on the actual threat of hybridization (see numerous references in Simovich et al. in revision for Animal Conservation – draft given to the authors- . for example Rhymer and Simberloff 1996, Wolf et al. 2001, Levin 2002)
    ii. No discussion of the breakdown of local adaptation.
    iii. No discussion of ESUs (Bohonak 2005).

i. Climate change is not fully developed relative to current climate models (See paper by Pyke and Matry (2005) plus various other climate models.

j. Inaccurate interpretation of the singular genetic effect of disturbance being isolation and not considering homogenization. The breakdown of local adaptation can be as bad as reduced gene flow and can result in outbreeding depression and genetic swamping (see for example Levin 2002, Olden et al. 2004).

k. Lacking the threats of non-native species (See for example Wilcove et al. 1998, Enserink 1999, Mooney and Cleland 2001, Levin 2002, Perry et al. 2002).

l. Missing causes and consequences of habitat homogenization? (see for example Olden et al. 2004, Olden 2006, Devictor et al. 2008).

m. Missing impacts of vehicles on soil and vegetation of pools – therefore habitat characteristics, quality and suitability (see foe example Iverson et al. 1981, Thurow et al 1993, Prosser at al 2000, Grantham et al. 2001, Quist et al 2003, Bohonak 2005, Bhat et al. 2007, Perkins et al. 2007, Warren et al. 2007).

4. *In the TWP, threats and pressures are grouped into four categories: direct pressures, indirect pressures, long-term cumulative pressures and potential future climate change. Please comment on the completeness/appropriateness of these four categories?*

   The treatment is very superficial. See above questions. Most indirect are really direct. There is little here concerning cumulative or climatic effects– see above.

5. *Are the four categories sufficient for documenting the pressures and threats to each of the species?*

   No – see above. Furthermore, *S. woottoni* is found in so few places it should be considered in a very different context from *B.sandiegonensis* for some threats. I see no way it can recover in terms of number of populations.

6. *Please comment on the conceptual models included in the appendix, which will be used to identify management and monitoring strategies to address specific threats to the focal species. One is on vernal pool plant focal species and the other pressures on focal fair shrimp species.*

   The model for fairy shrimp is not much of a model as it is missing key elements, connections, consequences and interpretations. It is not useful or heuristic. Please see the review page comments.

7. *Are the models appropriate/complete/accurate for identifying management and monitoring strategies to address specific threats to the focal species?*

No. See above. I find the study to be incomplete. While topics and threats are listed, causes and consequences are glossed over and key references to surveys and studies are not considered. There is no interpretation. Unless consequences of threats are considered, how can one devise a plan to reduce them? They need to consider how to assess function = HGM.

8. *Please comment on the completeness of the study area baseline for each species.*

There are no baseline studies which specifically focus on fauna referenced or discussed. While the data in Attachment A surely took time to compile, much of it is incorrect or incomplete. Apparently, it is largely based on the City Vernal Pool Inventory for shrimp (actually, Bohonak 2005 which was attached to the inventory). Apparently, many of the reports available and the collecting records of the Service were not consulted. Furthermore, the City inventory is a huge underestimate of shrimp presence. When we collected, we only collected from a few pools at each site. We have noted specific places where we have differing numbers in the table.

9. *Are the four categories on threats and pressures scientifically reasonable and defensible based on available data?*

No. Actual data were not included, referred to or referenced.

10. *Are there other changes/impacts from climate change that were not addressed?*

Climate change models themselves were not addressed. Literature on the potential consequences of climate change on fairy shrimp was not included or considered. See above.

11. *Are there other vernal pool sites that are known or recorded in the City?*

I don't have those data.

12. *Are there other vernal pools that are occupied by seven focal species that are known or recorded in the City?*

Yes. Please see question 8. The data reported in Attachment A contains many errors and omissions. A few examples follow.

a. There is over eight years worth of data available for the Winterwood /McAuliffe and Salk Elementary School sites which is not referenced and the number of pools occupied is underreported. These data were given to AECOM when they took over the project from BRG as a series of reports. The fact that these data were not incorporated into the restoration plan for Winterwood/McAuliffe was brought to the attention of one of the authors of this paper at a meeting with the USFWS at which I discussed my review of the plan over a year ago.
b. The statement that the number of pools occupied on Miramar is not available is simply not true. Much of these data are available in two publications: the HGM (Bauder et al. 2009) or a paper available for some time (Ripley and Simovich 2008). Furthermore, the reports

for the surveys which accumulated these data are available and are not restricted. Finally, these data are available from the USFWS data base.

i. Simovich/Branchiopod Research Group 1996 for the DOD.
    1. One year, Ten Management Units across the base, 70 pools, 27 species of crustaceans (up to 22 per pool), *B. sandiegonensis* in 80%, *S. woottoni* in one pool.

ii. Simovich/Branchiopod Research Group 2007 for the DOD in conjunction with and partial sub-contract with KEA/EDAW- later AECOM (they have to have this report in their office).
    1. Five years (1997-2003), three complexes, 46 pools including 13-15 created by EDAW, *B. sandiegonensis* in 90%.
    2.

13. Is *there some other component of the life history (eg: pollinators) that isn't captured in TWP1?*
    a. See above questions for the references for these points.
    b. The genetic threats are not well covered or considered.
    c. Population structure is not addressed.
    d. The cyst bank dynamics are not covered at all.
    e. The associated vernal pool faunal community is not addressed.
    f. Vernal pool function criteria are not addresses = HGM.
    g. Assessing population viability is not addressed. A PVA is really needed.

14. *Is there any literature that indicates how larger of a native buffer around the vernal pools is required to promote continued existence of the focal species.*

As for a buffer area, this would be associated with the literature on the effects of watershed, vehicles, cyst transport by humans and animals, fire, pollinator habitat and adult amphibian habitat among other things. I saw no real treatment of buffer zones in the TWP. Please see the HGM. It does address these things.

15. *Do you have any comments on easy of creating/restoring the seven focal species (i.e., potential for restoration success).*

Actually, despite what is said in the paper, I know of no reference in the primary literature relative to restoration/creation projects as having been monitored for shrimp population viability or crustacean community structure and diversity. The projects that I have seen or been involved with have not worked (e.g. Miramar, EDAW). Just because shrimp hatch from cysts in the inoculums does not mean the population is viable and self-sustaining. Furthermore, apparently many projects have resulted in inoculation of the weedy *B. lindahli* which is a hybridization threat to *B. sandiegonensis*. I personally think restoration is difficult beyond recontouring basins and that actual creation should not be conducted.

Is climate change a real threat given the high inter-annual variability of the pools in any given year?

Absolutely. Each time the pool holds water long enough for some cysts to hatch but not long enough for the shrimp to reproduce results in a depletion of the population (in the cyst bank). The fairy shrimp (and presumably other pool obligates) have evolved the adaptation of incomplete hatch in order to hedge their reproductive bets against poor (failure) fillings. The percent hatch at a filling is roughly proportional to the probability of success (sufficient filling) (Simovich and Hathaway 1997, Philippi et al. 2001, Ripley et al. 2004). This surely evolved over thousands/millions of years. The current anthropogenically induced climate change is occurring more rapidly than natural change. The species involved may not be able to adapt fast enough.

16. *Is there any literature of understanding of the seed bank/cyst bank dynamics of the seven focal species?*

    Yes. Simovich and Hathaway 1997, Philippi et al. 2001. Ripley et al. 2004. Also see the Section 6 Grant report from Bohonak and Simovich (2011) to USFWS and CDFG.

17. *Are there any indirect threats that are not included in the model?*

    Most of the indirect threats they list I would consider direct.

In summary, I find this paper lacking important detail and seemingly largely boilerplate from previous reports. A few points follow:

- I find this paper lacking important reference to baseline information. Much of the data reporting occupation of pools by endangered shrimp is incorrect and/or under-reported. It appears to have been taken (with some errors) from Bohonak (2005) which was attached to the City Vernal Pool Inventory but is not a thorough survey – more of a spot check for species on City property. Many published papers and reports containing more detailed baseline data have apparently been missed or ignored. Most importantly, there is a huge amount of data available from the Service in their annual reports.
- Much of the important and pertinent literature is missing – grey and primary.
- Many aspects of the species life history, population structure and physiology are missing.
- Threats are listed but the causes and consequences are not considered.
- Many threats are not included.
- The full, functioning community is not considered.
- Quantity (number of pools and acreage) is considered but not quality.
- There is no consideration of the total system as in the HGM.
- I do not think this paper will be useful in establishing or supporting the preparation of an HCP or in supporting the persistence of the focal species or their habitat. There is more information and deeper consideration of the situation in many other places including published papers, available reports and the Federal Register. There is a far more complete evaluation of pool structure and function in the HGM. I do not see that this paper adds to or constructively summarizes or synthesizes what is available. Furthermore, I do not see that it identifies what further information is needed or presents a functional outline upon which to develop a habitat conservation plan.

- I realize that there is probably some size limit in the contract. However, a large amount of the general text is simply copied and pasted in numerous places throughout the text. Reduction of this boiler approach and better organization would have allowed for more useful consideration of causes and consequences.

Plant Section: I have briefly looked over the sections on the plant species of interest and see the same basic problems.

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DRAFT

TECHNICAL WHITE PAPER 1: FOCAL SPECIES STATUS UPDATE FOR THE CITY OF SAN DIEGO VERNAL POOL HABITAT CONSERVATION PLAN

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INTRODUCTION

1.1 PROJECT OVERVIEW

The San Diego Association of Governments (SANDAG) will prepare a Vernal Pool Habitat Conservation Plan (HCP) for the City of San Diego (City) largely based on information contained in a series of Technical White Papers (TWPs). The TWPs focus on seven target vernal pool species including:

- Otay Mesa mint (*Pogogyne nudiuscula*)
- San Diego Mesa mint (*Pogogyne abramsii*)
- Spreading navarretia (*Navarretia fossalis*)
- San Diego button-celery (*Eryngium aristulatum* var. *parishii*)
- California Orcutt grass (*Orcuttia californica*)
- Riverside fairy shrimp (*Streptocephalus wootoni*)
- San Diego fairy shrimp (*Branchinecta sandiegonensis*)

The eight TWP topics are as follows:

- TWP 1: Focal Species Status Update in the City of San Diego
- TWP 2: Assessment of Conservation of Seven Target Species
- TWP 3: Development of Adaptive Management Strategy
- TWP 4: Development of Monitoring Strategy
- TWP 5: Property Analysis Record
- TWP 6: Recommendations for Conditions of Coverage
- TWP 7: Conservation Analysis
- TWP 8: Preserve Management Funding Mechanisms

This is TWP 1. It provides a status update on the seven focal species consisting of an analysis of the number and distribution of these species within the City, and habitat conditions, consisting of threats and risks to each species.

The Planning Area for the HCP is the geographical extent of land that will be included in the HCP and for which the protections provided under the HCP are afforded to the seven focal species. For the City's HCP, these lands include the entire jurisdictional boundaries of the City and three areas owned by the City's Public Utilities Department in the unincorporated portion of San Diego County. The Planning Area's extent is, by design, the area covered by the City's Multiple Species Conservation Program (MSCP); however, the HCP is a separate but compatible conservation plan for vernal pools and seven endangered focal species not covered under the City's MSCP.

Many lands included in the Planning Area are not under the local land use jurisdiction of the City. These lands could include special districts such as school districts, military lands, federal properties, and state lands. These lands not under the land use jurisdiction of the City are included in the HCP for the purpose of conservation analysis. However, the regulatory requirements of the HCP will not be applicable. If land ownership is transferred and comes under the City's jurisdiction, or if the owner voluntarily requests inclusion, the HCP regulatory requirements will be applied after undergoing the appropriate amendment process, as outlined within the HCP.

The Planning Area includes 7,975 known vernal pools. Of that total, 4,807 known vernal pools occur on Marine Corps Air Station (MCAS) Miramar. Data for MCAS Miramar vernal pools is confidential and, therefore, not included in this analysis. As such, the study area for TWP 1 is a subset of the Planning Area and includes 3,168 known vernal pools.

TWP 1 is based on review of historical and current vernal pool data within the study area. Baseline data consisted of Beauchamp and Cass (1979), Bauder (1986), City of San Diego (2004), EDAW (2007), 5-year review of species status reports from the U.S. Fish and Wildlife Service (USFWS; various dates), designated critical habitat and the vernal pool recovery plan (USFWS 1998), review of geodatabase and key ancillary data on species that would contribute to knowledge of its status, and additional data from USFWS and the City since 2004. TWP 1 also includes data and information provided by renowned local vernal pool and native plant experts Scott McMillan and Tom Oberbauer of AECOM. Scott McMillan and Tom Oberbauer each have more than 20 years of experience with vernal pools in San Diego County, and are recognized as leading vernal pool and rare plant experts by the local resource agencies.

TWP 1 includes a summary overview of key data (refer to Section 1.5 and Attachment A), as well as a detailed chapter for each focal species.

Attachment A includes a table summarizing the vernal pool and focal species information contained in the City's vernal pool database for the Planning Area. For each complex, data provided includes the geographic planning area (North, Central, or South), total number of pools, size (total surface area) of vernal pools, number of pools with any one of the seven focal species, soils, location within or outside of preserved lands, and proximity to other complexes within the study area). As noted above, confidential data for the 4,807 known vernal pools on MCAS Miramar is not available and, therefore, not included in this analysis.

Key data is summarized for the seven focal species in Section 1.5 and discussed in more detail in each of the respective species chapters.

Attachment B includes two conceptual models. One illustrates pressures on the endemic vernal pool plant focal species and one illustrates pressures on focal fairy shrimp species. Direct, indirect, and long-term cumulative pressures are identified, as well as the inter-relationship of these various pressures. The pressures identified in these conceptual models are discussed in further detail relative to each species in the following chapters. The conceptual models will be used in subsequent TWPs as part of the process of identifying management and monitoring strategies to address specific threats to the focal species.

1.2 OVERVIEW OF VERNAL POOLS

Vernal pools are ephemeral wetlands that occur from southern Oregon through California into northern Baja California, Mexico (USFWS 1998). They require a unique combination of climatic, topographic, geologic, and evolutionary factors for their formation and persistence. They form in regions with Mediterranean climates where shallow depressions fill with water during fall and winter rains, and then dry up when the water evaporates in the spring (Collie and Lathrop 1976; Holland 1976, 1988; Thorne 1984).

An impervious subsurface layer consisting of claypan, hardpan, or volcanic stratum prevents downward percolation of water within the pools (Holland 1976, 1988). Figure 1-1 shows a schematic cross-section of a vernal pool. Seasonal inundation makes vernal pools too wet for adjacent upland plant species adapted to drier soil conditions, while rapid drying during late spring makes pool basins unsuitable for typical marsh or aquatic species that require a more persistent source of water. Groups of vernal pools are sometimes referred to as vernal pool complexes, which may include two to several hundred individual vernal pools (Keeler-Wolf et al. 1998). These vernal pool complexes were given identification numbers by Bauder (1986). The numbers were updated by the City of San Diego's Vernal Pool Inventory (2004), and again updated by SANDAG (2011). Local upland vegetation communities associated with vernal pools include needlegrass grassland, annual grassland, coastal sage scrub, maritime succulent scrub, and chaparral (USFWS 1998).

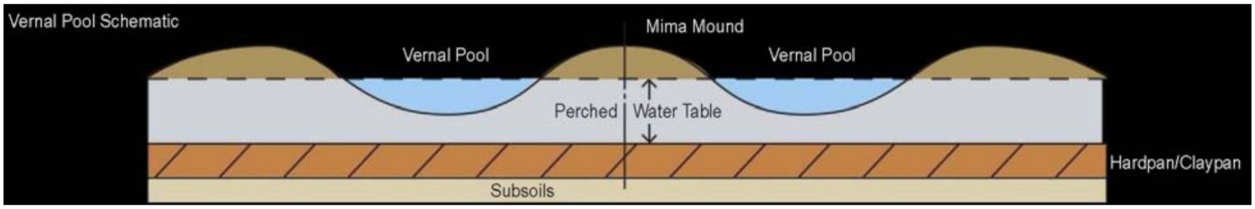


Figure 1-1. Schematic Cross-Section of a Vernal Pool

Historically, San Diego vernal pool habitat probably covered as much as 6% of the county, approximately 520 square kilometers (200 square miles). Current estimates indicate a loss of vernal pool habitat in San Diego County around 95 to 97% because of intensive cultivation and urbanization (Bauder and McMillan 1998).

Vernal pools are also known from northwestern Baja California, Mexico, from the border at Otay Mesa to the south as far as El Rosario (approximately 225 miles from the U.S./Mexican border). While there are more than 20 different locations for vernal pools in Baja California, most of these sites have either been destroyed in part, or at least impacted by cattle grazing, farming, and, more recently, development. AECOM senior restoration ecologist Scott McMillan estimates the loss of vernal habitat for Baja California is 75% or greater.

Vernal pools within a complex are generally hydrologically connected, such that water flows over the surface from one vernal pool to another and/or water flows and collects below ground such that the soil becomes saturated with water, thus filling the vernal pool through the perched water table that lies beneath (Figure 1-1). For overland flow to occur, the precipitation rate must exceed the infiltration rate or the soil column becomes completely saturated. Typically, significant watershed contributions only occur when the upland soils are fully recharged to the point where a perched groundwater table develops; this usually only occurs when seasonal precipitation is greater than average. Given rainfall patterns and amounts typical for Southern California, the direct precipitation into the pools is by far the most important source of water to the vernal pools (Hanes et al. 1990).

As shown in Attachment A, there are 63 vernal pool complexes identified within the study area, encompassing approximately 3,168 vernal pools and more than 59 acres of basin area. The majority of these complexes (42 complexes or 67%) are within the City's existing Multi-Habitat Preserve Area boundary, which includes 2,745 (87%) of the City's 3,168 vernal pools.

1.3 SUMMARY OF STATUS INFORMATION FOR FOCAL SPECIES

Table 1-1 summarizes key information and status data for each species. More detail is presented in the respective chapters. The chapters are intended to provide “stand alone” information for each species. Much of the data provided is similar for two or more species; therefore, some inherent redundancy exists in the presentation of the species information from chapter to chapter.

Threats and pressure to the focal vernal pool endemic plant and animal species are illustrated in the conceptual models included in Attachment B. To summarize, threats and pressures generally include:

- Direct pressures, such as construction, grazing, dumping, fire, off-road vehicle traffic
- Indirect pressures, such as altered hydrology, draining, exposure to pesticides, runoff from adjacent operations, competition by introduced species, loss of pollinators, habitat fragmentation
- Long-term, cumulative pressures, such as effects of isolation on genetic diversity and local genotypes, air and water pollution, and changes in nutrient availability
- Potential future climate change

Table 1-1
Summary of Focal Species Information

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
Otay Mesa mint	FE	No designated critical habitat	• Annual herb • Six flowers per node • Plant emit a strong, turpentine mint odor	Known from clay-pan-type vernal pools on Otay Mesa	• Dependent on inundation and drying cycles of vernal pools • Blooms from May or June through early July • Primarily bee pollinated • Gene dispersal occurs via pollen or seed	• Found only in southern San Diego County vernal pools on Otay Mesa • Extirpated from Baja due to development	• Occurs in 457 (14.4%) vernal pools within nine vernal pool complexes • All but one of the pools have had some habitat restoration • Found on Stockpen, Olivenhain, Linne, and Huerhuero soils
San Diego Mesa mint	FE	No designated critical habitat	• Annual herb • Two flowers per node • Plant emit a strong, sweet mint odor	Known from hard-pan-type vernal pools in San Diego County	• Dependent on inundation and drying cycles of vernal pools • Blooms from May or June through early July • Primarily bee pollinated • Gene dispersal occurs via pollen or seed	• Mesas of western San Diego County including Del Mar mesa, Mira Mesa, Marine Corps Air Station Miramar, Kearny Mesa, and western Tierrasanta • Historically, thought to have occurred around Linda Vista, the vicinity of Balboa Park, Normal Heights, and the area surrounding San Diego State University	• Occurs in 368 vernal pools (11.6%) within 16 vernal pool complexes • Estimated approximately 10% or less of pools have had habitat restoration • Found on Redding soils, with Olivenhain or Linne on several complexes • Hard-pan spoils acidic in pH

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
Spreading navarretia	FT	6,720 acres	• Annual herb • Flat-topped, compact, leafy head flowers with white to lavender-white petals • Seed is covered by a layer that becomes sticky and viscous when the capsule is moistened	Known from hardpan, claypan, alkali playas, and alluvial terrace pool complexes	• Pollination and dispersal mechanisms not well known • Ability to self-pollinate, but is not an obligate self-pollinator • Blooms in May and June through summer months • Minimal information on seed dispersal	• Found in widely disjointed and restricted vernal pool complexes extending from the Santa Clarita region of Los Angeles County, to the western lowlands of Riverside County, through coastal and foothill San Diego County, and south to San Quintin, Baja	• Occurs in 110 vernal pools (3.5%) within 12 complexes • Estimated that at least 80% of these pools have had some habitat restoration • Redding, Huerhuero, Stockpen, Olivenhain, and Linne • Primarily claypan-type soils associated with marine sediments and typically have basic pH subsurface layers
San Diego button-celery	FE	No designated critical habitat	• Biennial perennial gray-green herb that has a storage tap-root • stems and lanceolate leaves give the plant a prickly appearance	• Found in almost every type of Southern California vernal pool, including claypan-, hardpan-, and alluvial-terrace-type pools • Does not appear to be restricted to any particular type of soil type	• Vernal pool obligate and relies on ephemerally wet conditions to reproduce, blooming from April through June • Seems more tolerant of a wider range of vernal pool habitat than most obligate vernal pool species • Can tolerate disturbance factors better than most endemic species	• San Diego County at Otay Mesa, Kearny Mesa, Del Mar Mesa, MCAS Miramar, and Marine Corps Base (MCB) Camp Pendleton, and in northern Baja California, Mexico • Historically, habitat included a coastal swath from Mesa de Colonet and San Quintin in	• Occurs in 901 vernal pools (28.4%) within 28 vernal pool complexes • Estimated that at least 45% of these pools have had some habitat restoration • Occurs across various types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, and Linne

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
					• Presumably insect-pollinated	Baja north to Los Angeles County	
California Orcutt grass	FE	No designated critical habitat	• Annual grass • Bright gray-green in color and secretes sticky droplets • Inflorescences consist of seven spikelets arranged in two ranks, with the upper spikelets overlapping on a somewhat twisted axis	Restricted to vernal pools in Southern California	• Flowers from April through July and then sets seed • Adapted to conditions in the wettest, longest lasting portion of vernal pools • Typically require at least 30 days of inundation before germination begins • Believed to be wind pollinated	• Ventura, Los Angeles, Riverside, and San Diego counties • Several historical occurrences reported from northern Baja	• Occurs in 58 vernal pools (1.8%) with California Orcutt grass within six vernal pool complexes • Estimated that at least 90% of pools have had some habitat restoration • Occurs on Huerhuero, Olivenhain, Stockpen, and Linne soils • Claypan-type soils associated with marine sediments with subsurface layers that are basic in pH
Riverside fairy shrimp	FE	306 acres currently designated, with an additional 481 acres proposed, for a total of 847 acres	• Small aquatic crustacean • Feed on algae, bacteria, protozoa, rotifers, and bits of detritus	Restricted to vernal pools and other non-vegetated ephemeral pools greater than 30.5 centimeters (12 inches) in depth in Riverside, Orange, and San Diego Counties	• Usually observed January through March, although the hatching period may be extended in years with early or late rainfall • Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool,	• Riverside, San Diego, and Orange counties • Historical occurrences reported from Ventura County, Los Angeles County, and northwestern Baja	• Identified in198 vernal pools (6.3%) within 11 vernal pool complexes • Estimated that at least 95% of these pools have had some habitat restoration • Occurs on Huerhuero, Stockpen,

Focal Species	Listing Status	Critical Habitat in Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
					depending on water temperature • Cysts are capable of withstanding temperature extremes and prolonged drying		Olivenhain, Diablo, and Linne soils • Claypan-type soils associated with marine sediments with subsurface layers that are basic in pH
San Diego fairy shrimp	FE	3,082 acres	• Small aquatic crustacean • Feed on algae, diatoms, and particulate organic matter	• Occur in vernal pools and other non-vegetated ephemeral pools from 2 to 12 inches in depth in coastal areas of San Diego County, Orange County, and northwestern Baja • Restricted to dilute vernal pools, having relatively low sodium concentrations, low alkalinity, and neutral pH	• Usually observed January through March, although the hatching period may be extended in years with early or late rainfall • Individuals hatch, mature, and reproduce within 7 to 14 days of rainfall filling a pool, depending on water temperature	• Coastal areas of San Diego County, Orange County, and northwestern Baja • Historic occurrence in Santa Barbara County	• Occurs in 611 vernal pools (19.4%) within 36 vernal pool complexes • Estimated that at least 60% of these pools have had some habitat restoration • Occurs across all types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, Linne, and Chesterton. • Occur on both claypan- and hardpan-type soils

FE = federally endangered
FT = federally threatened

CHAPTER 7
RIVERSIDE FAIRY SHRIMP

Photograph: C. Brown, USGS

7.1 LISTING STATUS

Riverside fairy shrimp was federally listed as endangered on August 3, 1993. The USFWS 5-year review was completed on September 29, 2008 (USFWS 2008a). A final designation of critical habitat for this species was made on April 12, 2005. The current critical habitat consists of 306 acres of land in four units in Ventura, Orange, and San Diego Counties. USFWS drafted a proposed rule, dated June 1, 2011, to revise the critical habitat for Riverside fairy shrimp. This revision would designate approximately 2,984 acres of land in five units in Ventura, Orange, Riverside, and San Diego Counties, which, if finalized as proposed, would result in an increase of approximately 2,678 acres of critical habitat for this species (USFWS 2011b). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

7.2 SPECIES DESCRIPTION

Riverside fairy shrimp is a small aquatic crustacean in the order Anostraca. Mature males are between 13 and 25 millimeters (0.5 to 1.0 inch) long. The frontal appendage is cylindrical, bibbed at the tip, and extends only part way to the distal end of the basal segment of the antenna. The spur of the thumb is a simple blade-like structure. The finger has two teeth; the proximal tooth is shorter than the distal tooth. The distal tooth has a lateral shoulder that is equal to about half the tooth's total length measured along the proximal edge. The cercopods, which enhance

the rudder-like function of the abdomen, are separate, with plumose setae (feathery bristles) along the medial and lateral borders. Mature females are between about 13 and 22 millimeters (0.5 to 0.87 inch) in length. The brood pouch extends to abdominal segments seven, eight, or nine. The cercopods of females and males are the same (USFWS 1998).

Riverside fairy shrimp feed on algae, bacteria, protozoa, rotifers, and bits of detritus. Male Riverside fairy shrimp are distinguished from other fairy shrimp species primarily by the second pair of antennae. The females carry their cysts in an oval or elongate ventral brood sac (Eng et al. 1990; Eriksen and Belk 1999).

7.3 HABITAT

This species is restricted to vernal pools and other non-vegetated ephemeral pools greater than 30.5 centimeters (12 inches) in depth in Riverside, Orange, and San Diego Counties.

7.4 LIFE CYCLE

The life cycle of Riverside fairy shrimp is dependent on the function of the vernal pool ecosystem. As mentioned above, this species is known from pools that are greater than 30.5 centimeters (12 inches) in depth. The species cannot persist in perennial water bodies because the re-wetting of the dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999). Riverside fairy shrimp are usually observed January through March, although the hatching period may be extended in years with early or late rainfall. Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool, depending on water temperature (Simovich and Hathaway 1997).

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in the same or subsequent rainy seasons. Therefore, cyst "banks" develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the Riverside fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce. If all cysts hatched during an insufficient filling, the species could be extirpated from a pool (Philippi et al. 2001; Simovich 2005; Simovich and Hathaway 1997). The ability of Riverside fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of the species (Ripley et al. 2004; Simovich 2005).

7.5 STATUS AND DISTRIBUTION

Riverside fairy shrimp is currently considered to be extant at 45 known occupied vernal pool complexes (approximately 200 occupied pools), covering an area of approximately 59 acres. Twenty-six of the extant known occupied complexes are in San Diego County, 11 are in Riverside County, and eight are in Orange County. Of the 26 extant occurrences in San Diego County, two are located in MCAS Miramar, one is located in Ramona, one is located in the City of Carlsbad, eight are located in MCB Camp Pendleton, and the remaining 14 are located in Otay Mesa. Eleven of the 14 pool complexes located on Otay Mesa fall within the jurisdiction of the City of San Diego (USFWS 2008a).

Historical occurrences are also reported from the Tierra Rejada Preserve complex in Ventura County, the Los Angeles Airport and Madrona Marsh complexes in Los Angeles County, and from Valle de las Palmas and at Bajamar (north of Ensenada) in Baja California, Mexico. The population formerly present at the Los Angeles Airport complex is known to be extirpated, and there is no current knowledge confirming the contemporary existence of the species in the other locations described above (USFWS 2008a).

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, Riverside fairy shrimp was found in 11.7% (134) of pools (City of San Diego 2004). Due to the small size and life history traits of Riverside fairy shrimp, surveying occurrences for changes in numbers of individuals and demographic trends over time is not feasible. Therefore, population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time (USFWS 2008a).

7.6 THREATS AND PRESSURES

Threats to endangered fairy shrimp species are illustrated in a conceptual model provided in Attachment B. Specific threats to Riverside fairy shrimp can be divided into three major categories:

1. direct destruction of Riverside fairy shrimp from construction, grazing, dumping, trampling, plowing, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy Riverside fairy shrimp habitat, including altered hydrology, exposure to pesticides, invasion by nonnative plant species, habitat fragmentation, and military training activities; and

3. potential long-term cumulative impacts, such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat continues to be a significant threat to the Riverside fairy shrimp, especially in areas where urbanization is expected to expand. Since its listing in 1993, at least nine complexes known to be occupied by Riverside fairy shrimp have been lost to urban development, another 10 complexes have been partially lost to urban development, and eight contain pools that have been damaged, but not lost. Most of these losses and impacts are the result of urban development, international border security, and military-related development and training. Conservation of land and restoration programs have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private lands. Additionally, even preserved lands are often subject to impacts, such as invasion by nonnative plants, OHV use, trespassing, and other conditions and effects that degrade the quality of habitat (USFWS 2008a).

Riverside fairy shrimp habitat is also threatened by indirect impacts resulting from the proximity of its habitat to urban development, including OHV use and other human access and disturbance impacts, runoff and altered hydrology, dumping, and water and air pollution. OHV use for recreation, law enforcement (including Border Patrol), and military activities threatens this species throughout much of its range. Nonnative plants also threaten Riverside fairy shrimp habitat throughout its range by causing nonnative thatch accumulation in pools, which can often result in a reduction in ponding depth and duration, and decrease in water quality (McMillan 2011). Riverside fairy shrimp habitat is naturally fragmented, and development projects and other disturbance factors continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species (USFWS 2008a).

Riverside fairy shrimp may also be affected by factors associated with climate change, which has the potential to adversely affect this species through changes in vernal pool inundation patterns and consistency. It is possible that climate warming will cause shifts in the distribution and abundance of species, and the ability of Riverside fairy shrimp to survive will likely depend, in part, on the species' ability to disperse to pools where conditions are suitable (Bohonak and Jenkins 2003; Bonte et al. 2004). However, loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shifts induced by climate change may be more difficult for the species to successfully accommodate. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality, and even modest changes in climate could alter the seasonality and duration of vernal pool hydration (Cayan et al. 2001; Field et al. 1999). These changes could adversely affect

Riverside fairy shrimp, as this species is adapted to complete its life cycle within a limited temperature range and requires a minimum length of inundation to reach maturity and reproduce. Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual occurrences, even where occurrences are already known to fluctuate widely (McLaughlin et al. 2002).

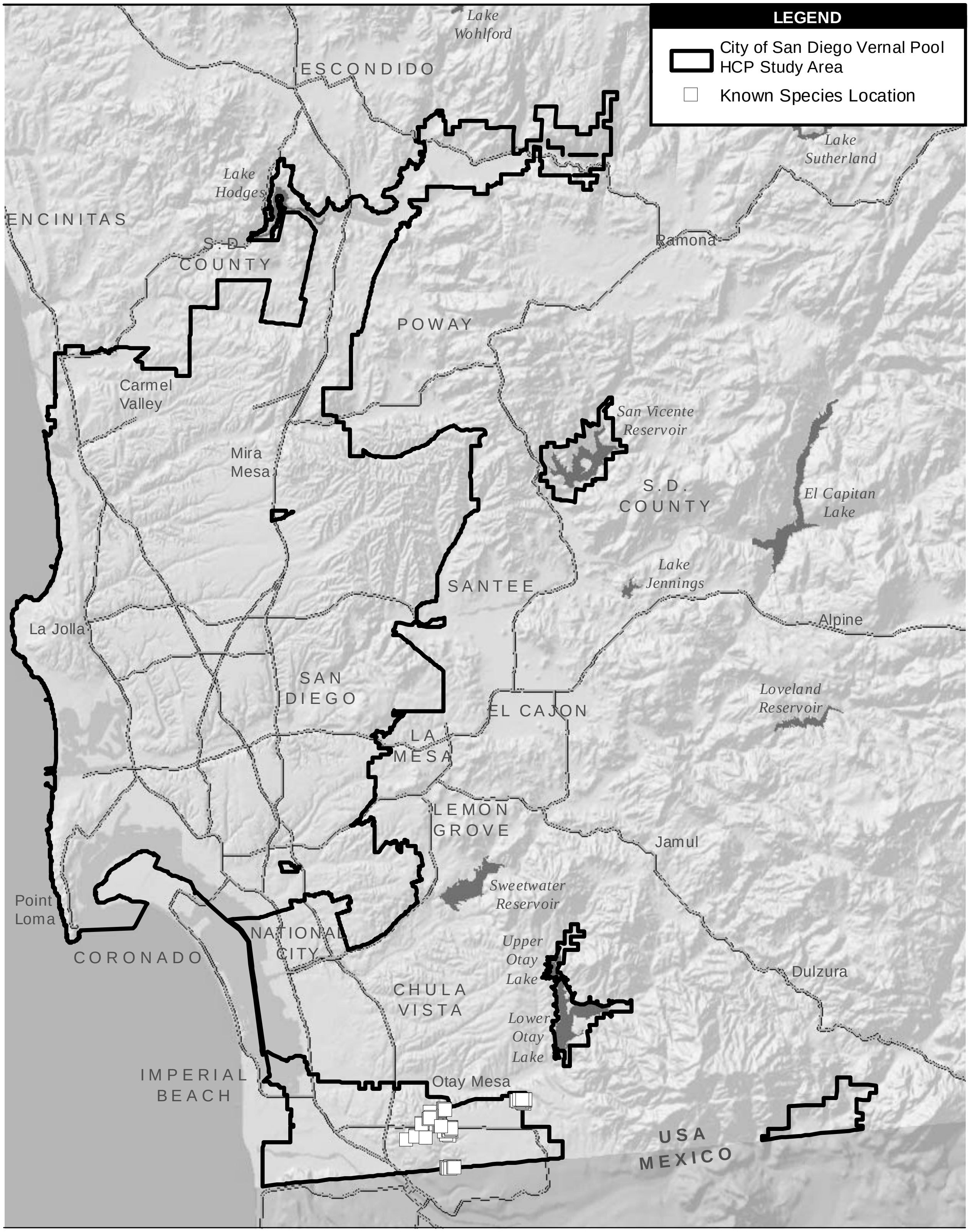
Riverside fairy shrimp is restricted to 26 vernal pool complexes in San Diego County, 11 of which occur within the jurisdiction of the City and are located on Otay Mesa. As with other vernal pool species, Riverside fairy shrimp is dependent on a maintained hydrology and surrounding watershed.

7.7 INNOCULATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring Riverside fairy shrimp populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successful restoration efforts have been achieved by a combination of conducting topographic reconstruction, applying aggressive programs for weed and thatch control, reestablishing cyst banks through inoculation, and improving upland habitat for watershed protection and water quality improvements. Topographic reconstruction has been achieved through a combination of hand and mechanical grading; effective weed and thatch control in vernal pools with San Diego fairy shrimp has been achieved through the use of hand weeding and herbicide applications. Cyst banks have been rebuilt using a program of soil collection and redistribution—cyst soil was collected from genetically and geographically appropriate local populations. These methods resulted in the addition of Riverside fairy shrimp to more than 50 pools.

7.8 STATUS IN STUDY AREA

Figure 7-1 shows the distribution of Riverside fairy shrimp within the study area. The locations of Riverside fairy shrimp within the various vernal pool complexes in the study area are included in Attachment A. Riverside fairy shrimp has been identified in 198 vernal pools (6.3%) within 11 vernal pool complexes. While the exact number of restored vernal pool with Riverside fairy shrimp is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 95% of these pools have had some habitat restoration or enhancement (McMillan 2011).



Source: ESRI; USGS 2004; SANDAG 2011

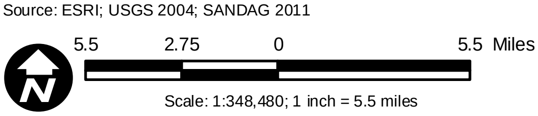


Figure 7-1
Distribution of Riverside Fairy Shrimp

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\RiversideFairyShrimp.mxd, 9/13/2011, augellop

Within the study area, all of the complexes and pools with Riverside fairy shrimp occur on Otay Mesa. The soil types that underlie the 11 complexes with Riverside fairy shrimp are Huerhuero, Stockpen, Olivenhain, Diablo, and Linne**.** All of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH, which may be important to the distribution of Riverside fairy shrimp.

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CHAPTER 8
SAN DIEGO FAIRY SHRIMP

Source: Diolinda Parsick

8.1 LISTING STATUS

San Diego fairy shrimp was federally listed as endangered on February 3, 1997. The USFWS 5-year review was completed on September 30, 2008 (USFWS 2008b). Critical habitat for the San Diego fairy shrimp was designated on October 23, 2000. Critical habitat was remanded but not vacated by the Central District Court of California on June 12, 2002. Critical habitat was re-proposed on April 22, 2003. Revised critical habitat for the San Diego fairy shrimp was designated on December 12, 2007. This final rule designated five critical habitat units (with 29 subunits) for San Diego fairy shrimp on 3,082 acres of land in Orange and San Diego Counties (USFWS 2007). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

8.2 SPECIES DESCRIPTION

San Diego fairy shrimp is a small aquatic crustacean in the order Anostraca. San Diego fairy shrimp have large stalked compound eyes, no carapace, and 11 pairs of swimming legs. Mature males attain 16 millimeters (0.6 inch) in length, and females attain 14 millimeters (0.5 inch) in length (USFWS 1998). San Diego fairy shrimp feed on algae, diatoms, and particulate organic matter (Parsick 2002). Male San Diego fairy shrimp are distinguished from other *Branchinecta*

species males by differences in the distal tip of the second antennae. The females carry their cysts in an oval or elongate ventral brood sac (Eriksen and Belk 1999). Females are distinguishable from other *Branchinecta* species females by the shape and length of the brood sac, length of the ovary, and presence of paired dorsolateral spines on five of the abdominal segments. The San Diego fairy shrimp is often misidentified with the versatile fairy shrimp (*Branchinecta lindahli*) (Fugate 1993), which is native to and commonly found throughout western North America (Eng et al. 1990; Simovich 1998).

8.3 HABITAT

This species is restricted to vernal pools and other non-vegetated ephemeral pools from 2 to 12 inches in depth in coastal areas of San Diego County, Orange County, and northwestern Baja California, Mexico. San Diego fairy shrimp are restricted to dilute vernal pools, having relatively low sodium concentrations, low alkalinity, and neutral pH (Gonzales et al. 1996).

8.4 LIFE CYCLE

The life cycle of San Diego fairy shrimp is dependent on the function of the vernal pool ecosystem. The species cannot persist in perennial water bodies because the re-wetting of the dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999). San Diego fairy shrimp are usually observed January through March when seasonal rainfall fills vernal pools and initiates cyst hatching. Individuals hatch and mature within 7 to 14 days of rainfall filling a pool, depending on water temperature (Simovich and Hathaway 1997). This hatching period may be extended in years with early or late rainfall.

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in the same or subsequent rainy seasons. Therefore, cyst “banks” develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the San Diego fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce. If all cysts hatched during an insufficient filling, the species could be extirpated from a pool (Philippi et al. 2001; Simovich 2005; Simovich and Hathaway 1997). The ability of San Diego fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of the species (Ripley et al. 2004; Simovich 2005).

8.5 STATUS AND DISTRIBUTION

San Diego fairy shrimp is currently considered to be extant at 137 known occupied vernal pool complexes in the United States. One hundred thirty-two of the extant known occupied complexes in the U.S. are in San Diego County and five are in Orange County. Of the 132 occupied pool complexes in San Diego County, 57 fall within the jurisdiction of the City. These pool complexes are located in Del Mar Mesa, Kearny Mesa, Mira Mesa, Chollas Heights, Mission Trails Regional Park, Marron Valley, and Otay Mesa. Additional occupied vernal pool complexes located in San Diego County, but not in the City, are found on MCAS Miramar, MCB Camp Pendleton, Poway, Carlsbad, San Marcos, Santee, Ramona, Santa Fe Valley, Naval Base Coronado, Otay Mesa, Sweetwater Reservoir, and Tijuana Slough (USFWS 2008b).

In Baja California, San Diego fairy shrimp have been recorded at two localities: Valle de Palmas, south of Tecate, and Baja Mar, north of Ensenada. The status of these populations is currently unknown. A single isolated female was previously reported from vernal pools in Isla Vista, Santa Barbara County, California; however, directed surveys have not located any additional individuals (USFWS 1998).

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, San Diego fairy shrimp was found in 35.7% (408) of pools. *Branchinecta* spp. was identified in an additional 220 pools (City of San Diego 2004). Due to the small size and life history traits of San Diego fairy shrimp, surveying occurrences for changes in numbers of individuals and demographic trends over time is not feasible. Therefore, population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time. In 2008, a project was been funded by an Endangered Species Act Section 6 grant to develop a protocol to estimate San Diego fairy shrimp population sizes and conduct population viability analyses in real time to detect a decline preceding the likely extinction of a population (USFWS 2008b).

8.6 THREATS AND PRESSURES

Threats to endangered fairy shrimp species are illustrated in a conceptual model found in Attachment B. Specific threats to San Diego fairy shrimp can be divided into three major categories:

1. direct destruction of San Diego fairy shrimp from construction, grazing, dumping, trampling, plowing, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego fairy shrimp habitat, including altered hydrology, exposure to pesticides, invasion by nonnative plant species, habitat fragmentation, and military activities; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, competition/hybridization with other species, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat continues to be a significant threat to San Diego fairy shrimp, especially in areas where urbanization is expected to expand. As of 2008, 28 (14 of which are in the City of San Diego HCP Planning Area) of the 137 vernal pool complexes occupied by the species had been partially lost to urban development, and about five additional complexes contained pools that had been damaged, but not lost. Most of these losses and impacts are the result of urban development, followed by industrial/commercial development, international border security, and military facilities and training. Acquisition of land and conservation easements have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private land. Additionally, even preserved lands are often subject to impacts, such as invasion by nonnative plants, OHV use, trespassing, and other conditions and effects that degrade the quality of habitat (USFWS 2008b).

Indirect impacts to San Diego fairy shrimp result from the proximity of the species' habitat to urban development. These include OHV use and other human access and disturbance impacts, runoff and altered hydrology, dumping, and water and air pollution. OHV use for recreation, law enforcement (including Border Patrol), and military activities threatens this species throughout much of its range. Nonnative plants also threaten San Diego fairy shrimp habitat throughout its range by causing nonnative thatch accumulation in pools, which can often result in a reduction in ponding depth and duration, as well as water quality (McMillan 2011). San Diego fairy shrimp habitat is naturally fragmented, but development projects and other disturbance factors continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species (USFWS 2008b).

San Diego fairy shrimp may also be affected by factors associated with climate change, which has the potential to adversely affect this species through changes in vernal pool inundation patterns and consistency. It is possible that climate warming will cause shifts in the distribution and abundance of species, and the ability of San Diego fairy shrimp to survive will likely depend, in part, on the species' ability to disperse to pools where conditions are suitable

(Bohonak and Jenkins 2003; Bonte et al. 2004). In addition, loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shifts induced by climate change may be more difficult for the species to successfully accommodate. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality, and even modest changes in climate could alter the seasonality and duration of vernal pool hydration (Cayan et al. 2005; Field et al. 1999). These changes could adversely affect San Diego fairy shrimp, as this species is adapted to complete its life cycle within a limited temperature range and requires a minimum length of inundation to reach maturity and reproduce. Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual occurrences, even where occurrences are already known to fluctuate widely (McLaughlin et al. 2002).

Other potential threats to San Diego fairy shrimp are hybridization and direct competition with the versatile fairy shrimp. The versatile fairy shrimp is common throughout western North America, is found in a wide variety of habitats, and tends to inhabit disturbed sites (Gonzalez et al. 1996). The versatile fairy shrimp has been documented within the range of the San Diego fairy shrimp in relatively disturbed pools at Otay Mesa, MCAS Miramar, Del Mar Mesa, and MCB Camp Pendleton. The two species are known to hybridize in the laboratory (Fugate 1998) and in the field (Simovitch et al. in press). The disturbance of vernal pool habitat by vehicles used in military training may increase the distribution of the versatile fairy shrimp on MCB Camp Pendleton. Although the known distribution of versatile fairy shrimp is still fairly limited within the range of the San Diego fairy shrimp, hybridization and competition could threaten the San Diego fairy shrimp in the future should the range of the versatile fairy shrimp expand (USFWS 2008b).

Another recent issue of concern for San Diego fairy shrimp reproduction and genetics is the cytoplasmic incompatibility induced by *Wolbachia* (or similar) bacteria. These bacteria reside in the intracellular space of reproductive tissue of many invertebrates and are maternally inherited from generation to generation. If males and females are infected with different strains of the bacteria, they are usually not reproductively compatible. Because of this, the bacteria can initiate lineage isolation and speciation (Werren et al. 2008). In addition to incompatibility, the bacteria can also lead to biased sex ratios, parthenogenesis (female asexual reproduction), feminization of males, and a high juvenile male mortality. There is substantial evidence that the versatile fairy shrimp harbors feminizing endoparasitic bacteria (Krumm 2006). While there is no evidence of the bacteria in San Diego fairy shrimp, the potential hybridization of the two species suggests that this could be a concern for the genetics and reproduction of the San Diego fairy shrimp.

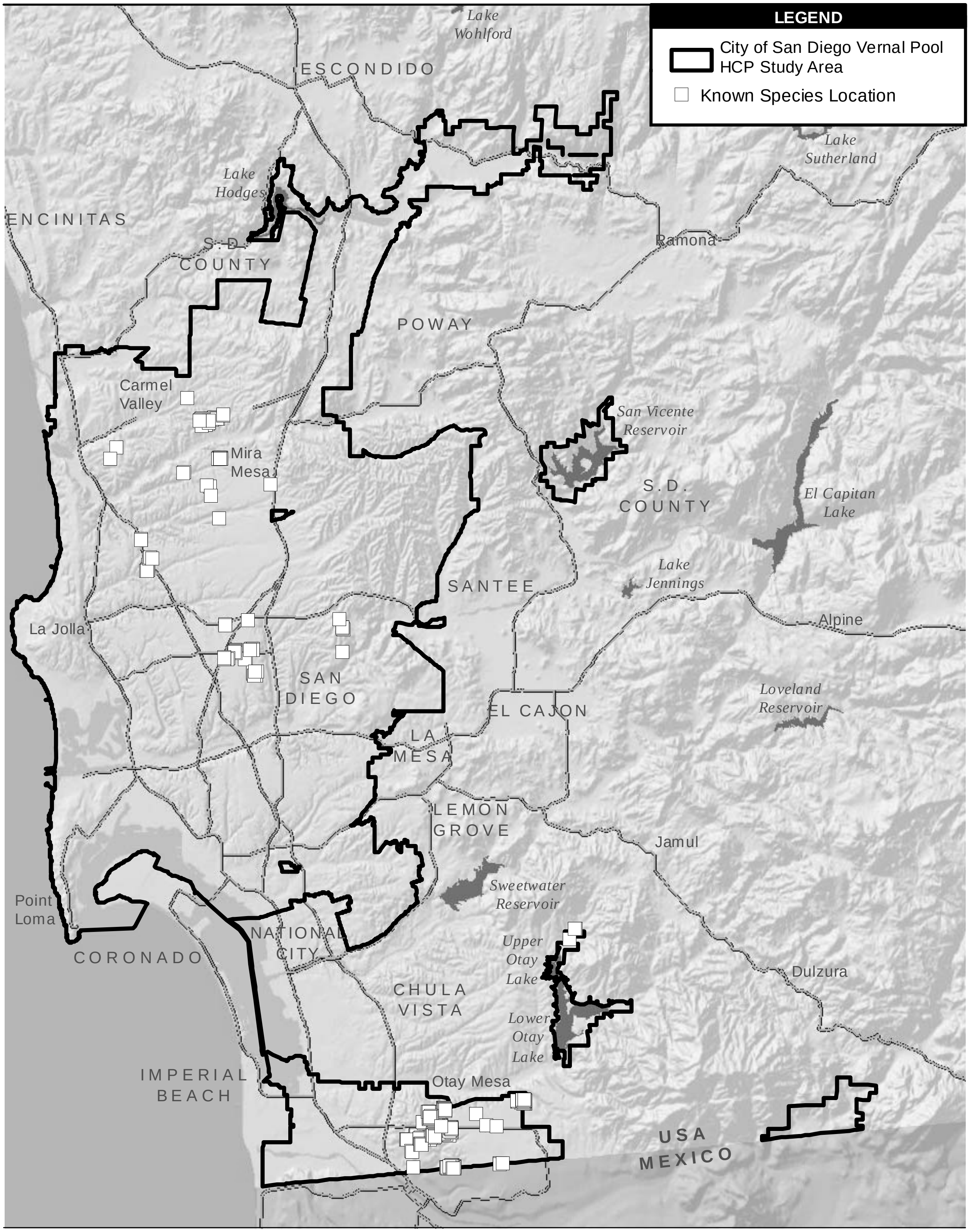
8.7 INNOCULATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring San Diego fairy shrimp populations and the habitat that supports them (AECOM 2006, 2010a, 2010b, and 2011). These successful restoration efforts were achieved through a combination of conducting topographic reconstruction, applying aggressive programs for weed and thatch control, reestablishing cyst banks through inoculation, and improving upland habitat for watershed protection and water quality improvements. Topographic reconstruction has been achieved through a combination of hand and mechanical grading; effective weed and thatch control in vernal pools with San Diego fairy shrimp has been achieved through hand weeding and herbicide application. Cyst banks have been rebuilt using a program of soil collection and redistribution. Cyst soil was collected from genetically and geographically appropriate local populations. These methods have resulted in the addition of San Diego fairy shrimp to more than 300 pools.

8.8 STATUS IN STUDY AREA

Figure 8-1 shows the distribution of San Diego fairy shrimp within the study area. The locations of San Diego fairy shrimp within the various vernal pool complexes in the study area are included in Attachment A. San Diego fairy shrimp has been identified in 615 vernal pools (19.4%) within 36 vernal pool complexes. While the exact number of restored vernal pool with San Diego fairy shrimp is not evaluated here, it is estimated that at least 60% of these pools have had some habitat restoration or enhancement (McMillan 2011).

San Diego fairy shrimp occurs across all types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, Linne, and Chesterton. These complexes occur on both claypan- and hardpan-type soils, and include every soil type that has been identified to support vernal pools.



Source: ESRI; USGS 2004; SANDAG 2011

5.5 2.75 0 5.5 Miles

Scale: 1:348,480; 1 inch = 5.5 miles

Figure 8-1
Distribution of San Diego Fairy Shrimp

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\SanDiegoFairyShrimp.mxd, 9/13/2011, augellop

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CHAPTER 9
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ATTACHMENT A
VERNAL POOL AND FOCAL SPECIES DATA

Attachment A
Vernal Pool Complex Data in City of San Diego Vernal Pool Habitat Conservation Plan Planning Area

Vernal Pool Complex ID	Complex Name	Geographic Area	Number of Pools in Complex	Total Surface Area of Pools (acre)	Soil Type(s)	Inside or Outside MHPA[1]	Pools Outside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Not Subject to City Jurisdiction	Pools on Lands Not Included[2]	Proximity to Other Complexes in Study Area (mile)	Number of Pools with Focal Species						
												Otay Mesa Mint	San Diego Mesa Mint	Spreading Navarretia	California Orcutt Grass	San Diego Button Celery	Riverside Fairy Shrimp	San Diego Fairy Shrimp
B 11	Mesa Norte	North	44	0.60	RdC, TeF	Outside		44			0.9	0	12	0	0	10	0	24
B 5–6	Tierra Alta	North	1	0.01	RdC, TeF	Within		1			0.1	0	0	0	0	0	0	0
B 5–8	Crescent Heights, Lopez Ridge	North	18	0.64	RdC, TeF	Within		18			0.1	0	11	0	0	1	0	2
C 10–16	Winterwood	North	61	0.81	RdC, TeF	Within		61			0.2	0	27	0	0	7	0	2
C 17–18	Fieldstone	North	9	0.32	RdC	Within		9			0.2	0	8	0	0	0	0	0
C 27	Mira Mesa Market Center	North	1	0.06	RdC	Outside		1			2.0	0	1	0	0	0	0	1
C 28	Jonas Salk Elementary School	North	81	0.97	RdC	Within				81	0.2	0	0	0	0	0	0	1
D 5–8	Parkdale Carroll Canyon Carroll Canyon	North	123	1.21	RdC, ReE, TeF	Within		123			0.2	0	42	1	0	65	0	0
F 16–17	Menlo KM Parcel, Marine Corps Air Station (MCAS) Miramar	Central	48	0.92	RdC, ReE	Outside		14		34	0.1	0	0	0	0	0	0	1
H 1–15	Del Mar Mesa, Rhodes	North	516	6.52	OhF, RdC, RfF, TeF	Within	14	252	248	2	0.3	0	70	0	0	193	0	29
H 17	Shaw Texas	North	28	0.24	RdC, RfF, TeF	Within		28			0.9	0	0	0	0	0	0	0
H 33	SDG&E/East Ocean Air Drive	North	14	0.37	GaF, RdC	Outside		2		12	0.2	0	0	0	0	6	0	0
H 38	Carmel Mountain	North	64	0.61	CvC, LvF3, RdC	Within		64			0.2	0	0	0	0	0	0	2
H 39	Greystone Torrey Highlands	North	19	0.68	OhC, OhE	Outside		19			0.3	0	5	0	0	3	0	0
I 1	Arjons	North	34	0.73	RdC, TeF	Outside		34			0.2	0	22	0	0	15	0	1
I 12	Pueblo Lands North, Pueblo Lands South	North	7	0.08	RdC, TeF	Within	4	2		1	0.2	0	0	0	0	0	0	6
I 6 B	Bob Baker (Ford Leasing)	North	8	0.08	RdC, TeF	Outside		8			0.0	0	7	0	0	0	0	0
I 6 C	Bob Baker (Facilities Development)	North	15	0.24	OhE, OhF	Outside		15			0.0	0	11	0	0	2	0	0
J 11 E	Slump Block Pools	South	2	0.63	OhE	Within		2			0.2	0	0	0	0	0	0	0
J 11 W	J 11W	South	5	0.49	OhE, OhF	Within		5			0.4	0	0	0	0	0	0	1
J 12	J 12	South	5	0.28	OhE, OhF	Within		5			0.1	0	0	0	0	0	0	0
J 13 E	South Otay J-13E	South	8	0.06	HrC, OhF	Within	3	5			0.1	0	0	0	0	1	0	0
J 13 N	South Otay 1 acre, NDU 1 and 2	South	37	0.31	HrC	Outside	20	17			0.1	0	0	2	1	3	0	13
J 13 S	Otay South J-13S, NDU 1 and 2	South	45	0.79	HrC	Outside	17	28			Adjacent	0	0	0	0	7	0	2
J 14	Bachman, 905, Brown Field, Cal Terraces (South), Anderprises	South	138	2.12	GP, OhF, SuB	Within	2	135	1		Adjacent	64	0	7	5	55	29	38

Vernal Pool Complex ID	Complex Name	Geographic Area	Number of Pools in Complex	Total Surface Area of Pools (acre)	Soil Type(s)	Inside or Outside MHPA[1]	Pools Outside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Not Subject to City Jurisdiction	Pools on Lands Not Included[2]	Proximity to Other Complexes in Study Area (mile)	Number of Pools with Focal Species						
												Otay Mesa Mint	San Diego Mesa Mint	Spreading Navarretia	California Orcutt Grass	San Diego Button Celery	Riverside Fairy Shrimp	San Diego Fairy Shrimp
J 15	Arnie's point	South	57	2.46	DaF, OhF, SuA, SuB	Within			57		0.1	0	0	0	0	6	16	41
J 16–18	Goat Mesa/Wruck Canyon	South	25	0.51	DaF, LsF, OhF, SuA, SuB	Within		23	2		0.1	0	0	0	0	4	0	0
J 2 N	Cal Terraces (North)	South	63	0.45	OhF, SuB	Within		63			0.1	56	0	5	7	48	10	32
J 2 S	Cal Terraces (North), Otay Mesa Road Helix, Otay Mesa Road Recon	South	172	2.48	OhF, SuB	Within		172			Adjacent	164	0	55	36	163	80	128
J 2 W	Cal Terraces (North), Clayton Parcel, Otay Mesa Road Recon, St. Jerome's	South	127	1.28	OhC, OhF, SuB	Within	6	121			Adjacent	66	0	19	9	65	6	52
J 20–21	La Media ITS	South	33	1.43	SuA, SuB	Outside		33			0.1	0	0	0	0	0	0	6
J 21	La Media Swale South	South	7	0.21	HrC	Outside		7			0.1	0	0	0	0	0	0	0
J 27	Empire Center	South	10	0.23	HrC, SuB	Outside		10			0.2	0	0	0	0	9	0	0
J 28 E	La Media Swale North	South	5	0.16	HrC, SuB	Within		5			0.2	0	0	0	0	0	0	0
J 29–30	Lonestar (Caltrans)	South	72	0.98	OhF, SuA	Within		61	11		Adjacent	1	0	0	0	42	0	0
J 3	J 3	South	1	0.01	OhC, OhE	Outside				1	0.1	0	0	0	0	0	0	0
J 30	Lonestar (State Route 125 and private)	South	103	4.81	LsE, SuA	Within			103		Adjacent	74	0	8	0	93	35	47
J 31	Dennery West, Hidden Trails	South	114	1.63	OhC, OhF, SuB	Within		114			0.1	0	0	0	0	0	10	38
J 32	West Otay A, B, C	South	44	0.34	HrC	Within		44			0.2	8	0	3	0	4	1	8
J 33	Sweetwater High School	South	8	0.07	OhC, OhF	Outside			8		0.0	5	0	3	0	2	3	8
J 34	Bachman, Candlelight	South	42	0.50	HrC, OhC, OhF, SuB	Within	28	14			0.0	0	0	0	0	0	2	16
J 35	Brown Field, Brown Field Basins	South	30	3.83	DaF, GP, OhF, SuA, SuB	Within	27	3			Adjacent	0	0	0	0	1	0	3
J 36	Southview	South	17	0.11	OhC, OhF, SuB	Within		17			0.0	0	0	0	0	0	0	12
J 4	Robinhood Ridge, California Crossings	South	94	0.65	OhF, SuB	Within		94			0.1	19	0	4	0	46	6	41
K 5	Otay Lakes	South	85	3.20	OhE, OhF, ReE, SmE, SnG, TuB	Within		85			1.6	0	0	2	0	46	0	0
KK 1	Lake Murray	Central	1	0.02	TuB	Within	1				0.5	0	0	0	0	0	0	0
KK 2	Pasatiempo	Central	10	0.04	BsC, DcD	Outside		10			0.5	0	0	0	0	0	0	0
MM 1	Marron Valley	South	18	0.18	HrC, HrC2, Rm, SvE, VbB	Within		18			8.2	0	0	0	0	0	0	0
N 1-4, N 5-6	Teledyne Ryan	Central	43	0.59	RdC	Outside		43			0.3	0	1	0	0	0	0	11
N 5-6	Montgomery Field	Central	282	8.35	CfB, CgC, OhE, RdC	Within	13	269			0.0	0	129	0	0	0	0	17
N 7	Serra Mesa Library	Central	26	0.41	RdC, RhC	Within		26			0.0	0	0	0	0	0	0	0
N 8	General Dynamics	Central	22	0.40	RdC	Within		22			0.2	0	20	0	0	2	0	6

Vernal Pool Complex ID	Complex Name	Geographic Area	Number of Pools in Complex	Total Surface Area of Pools (acre)	Soil Type(s)	Inside or Outside MHPA[1]	Pools Outside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Subject to City Jurisdiction	Pools Inside Preserve, Not Subject to City Jurisdiction	Pools on Lands Not Included[2]	Proximity to Other Complexes in Study Area (mile)	Number of Pools with Focal Species						
												Otay Mesa Mint	San Diego Mesa Mint	Spreading Navarretia	California Orcutt Grass	San Diego Button Celery	Riverside Fairy Shrimp	San Diego Fairy Shrimp
NC	Li Collins, Kelton	North, South	5	0.06	HrE2, LeE, OhC	Within		5			1.1	0	0	0	0	0	0	0
OO	Salk Institute	North	15	0.09	CbB, CfB	Within	1	14			2.4	0	0	0	0	0	0	0
Q 2	Mission Trails Regional Park	Central	19	0.27	OhF, RdC, ReE, VbB	Within		17	2		1.6	0	0	0	0	0	0	6
Q 3	Castlerock	North	9	0.04	DoE	Outside	4	5			1.6	0	0	0	0	0	0	4
QQ	Tecolote Canyon	Central	9	0.09	CgC, GaF, HrC, TaF	Within		9			1.7	0	0	0	0	0	0	0
R 1	Proctor Valley	South	124	1.87	DoE, FxE, OhC, OhE, PfC, Rm, SnG, VbB, W	Within		124			2.2	0	0	0	0	0	0	7
U 15	Sander, Maganatron	Central	39	0.83	RdC, ReE	Outside	1	38			0.3	0	1	0	0	0	0	2
U 19	Cubic	Central	29	0.45	RdC	Outside	1	23		5	0.1	0	1	0	0	2	0	0
X 5	Nobel Drive	North	11	0.10	HrE2, RdC	Within		11			0.1	0	0	1	0	0	0	6
X 7	Nobel Research	North	28	0.10	RdC	Within		28			0.1	0	0	0	0	0	0	1
N/A	Miramar (City Leased Sander)	Central	38	Data Not Available	Data Not Available	Data Not Available			38		-	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available
Subtotal for TWP 1 Analysis			**3,168**	**59.00**	**-**		**142**	**2,420**	**470**	**136**	**-**	**457**	**368**	**110**	**58**	**901**	**198**	**615**
N/A	MCAS Miramar	Central	4,807	Data Not Available	Data Not Available					4,807	-	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available	Data Not Available
Total in Plan Area			**7,975**	**-**	**-**		**142**	**2,420**	**470**	**4,943**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

MHPA=Multi-Habitat Planning Area

[1] All or a portion of the complex is within the MHPA.

[2] Military, state, and federal lands, and special district properties such as school districts that are not in City of San Diego jurisdiction

Soil Types Legend

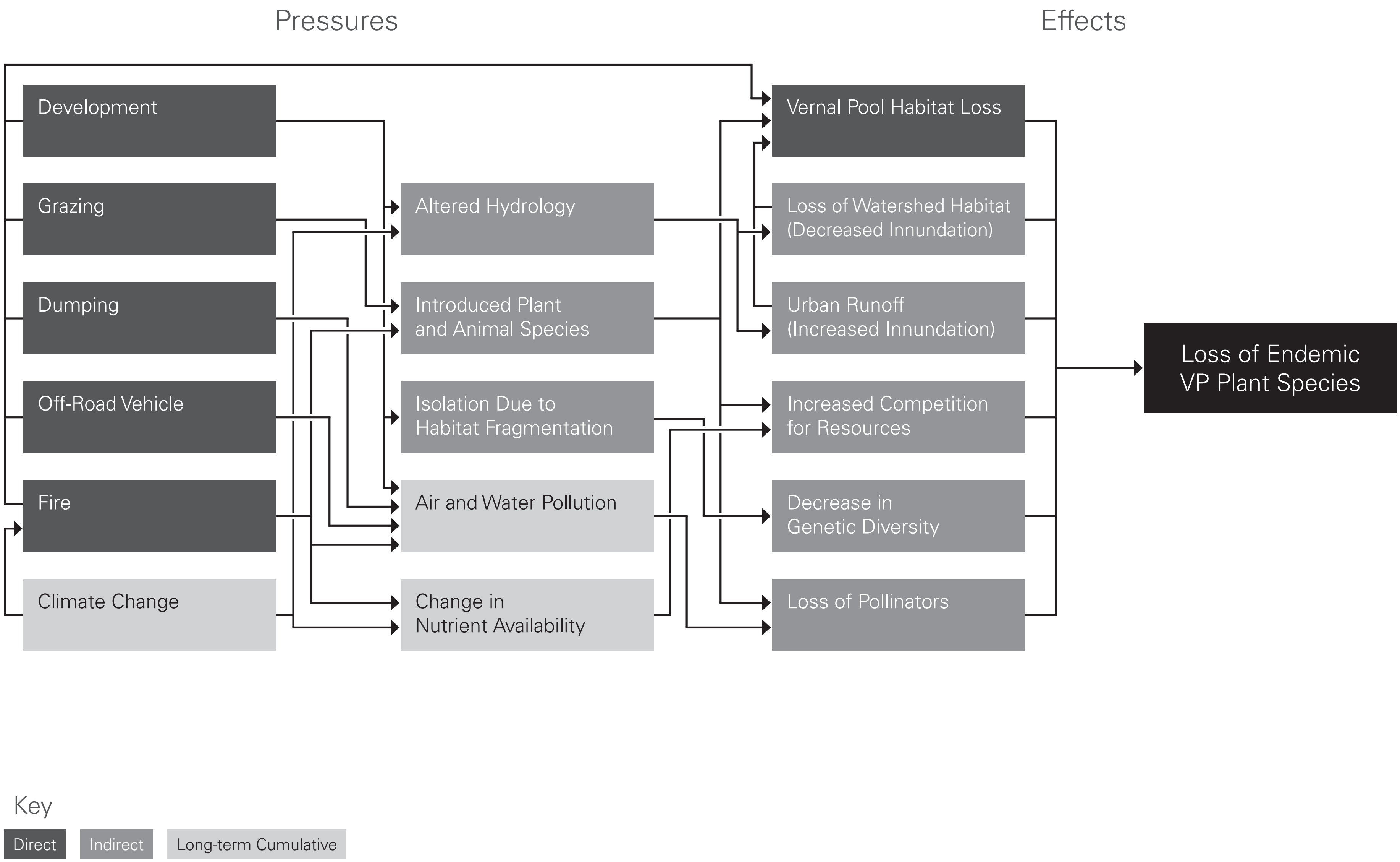
MUSYM	Description	Category
BsC	Bosanko clay, 2 to 9% slopes	Bosanko clay
CbB	Carlsbad gravelly loamy sand, 2 to 5% slopes	Carlsbad gravelly loamy sand
CbC	Carlsbad gravelly loamy sand, 5 to 9% slopes	Carlsbad gravelly loamy sand
CfB	Chesterton fine sandy loam, 2 to 5% slopes	Chestern fine sandy loam
CgC	Chesterton-Urban land complex, 2 to 9% slopes	Chestern-Urban land complex
DaF	Diablo clay, 30 to 50% slopes	Diablo clay
DcD	Diablo-Urban land complex, 5 to 15% slopes	Diablo-Urban land complex
DoE	Diablo-Olivenhain complex, 9 to 30% slopes	Diablo-Olivenhain complex
FxE	Friant rocky fine sandy loam, 9 to 30% slopes	Friant rocky fine sandy loam
GaF	Gaviota fine sandy loam, 30 to 50% slopes	Gaviota fine sandy loam
GP	Gravel pits	Gravel pits
HrC	Huerhuero loam, 2 to 9% slopes	Huerhuero loam

MUSYM	Description	Category
HrC2	Huerhuero loam, 5 to 9% slopes, eroded	Huerhuero loam
HrE2	Huerhuero loam, 15 to 30% slopes, eroded	Huerhuero loam
LeE	Las Flores loamy fine sand, 15 to 30% slopes	Las Flores loamy fine sand
LsE	Linne clay loam, 9 to 30% slopes	Linne clay loam
LsF	Linne clay loam, 30 to 50% slopes	Linne clay loam
LvF3	Loamy alluvial land-Huerhuero complex, 9 to 50% slopes, severely eroded	Loamy alluvial land-Huerhuero complex
MlC	Marina loamy coarse sand, 2 to 9% slopes	Marina loamy coarse sand
OhC	Olivenhain cobbly loam, 2 to 9% slopes	Olivenhain cobbly loam
OhE	Olivenhain cobbly loam, 9 to 30% slopes	Olivenhain cobbly loam
OhF	Olivenhain cobbly loam, 30 to 50% slopes	Olivenhain cobbly loam
PfC	Placentia sandy loam, thick surface, 2 to 9% slopes	Placentia sandy loam
RdC	Redding gravelly loam, 2 to 9% slopes	Redding gravelly loam
ReE	Redding cobbly loam, 9 to 30% slopes	Redding cobbly loam
RfF	Redding cobbly loam, dissected, 15 to 50% slopes	Redding cobbly loam
RhC	Redding-Urban land complex, 2 to 9% slopes	Redding-Urban land complex
RhE	Redding-Urban land complex, 9 to 30% slopes	Redding-Urban land complex
Rm	Riverwash	Riverwash
SmE	San Miguel rocky silt loam, 9 to 30% slopes	San Miguel rocky silt loam
SnG	San Miguel-Exchequer rocky silt loams, 9 to 70% slopes	San Miguel-Exchequer rocky silt loams
SuA	Stockpen gravelly clay loam, 0 to 2% slopes	Stockpen gravelly clay loam
SuB	Stockpen gravelly clay loam, 2 to 5% slopes	Stockpen gravelly clay loam
SvE	Stony land	Stony land
TeF	Terrace escarpments	Terrace escarpments
TuB	Tujunga sand, 0 to 5% slopes	Tujunga sand
VbB	Visalia gravelly sandy loam, 2 to 5% slopes	Visalia gravelly sandy loam
W	Water	Water

ATTACHMENT B
CONCEPTUAL MODELS OF SPECIES PRESSURES

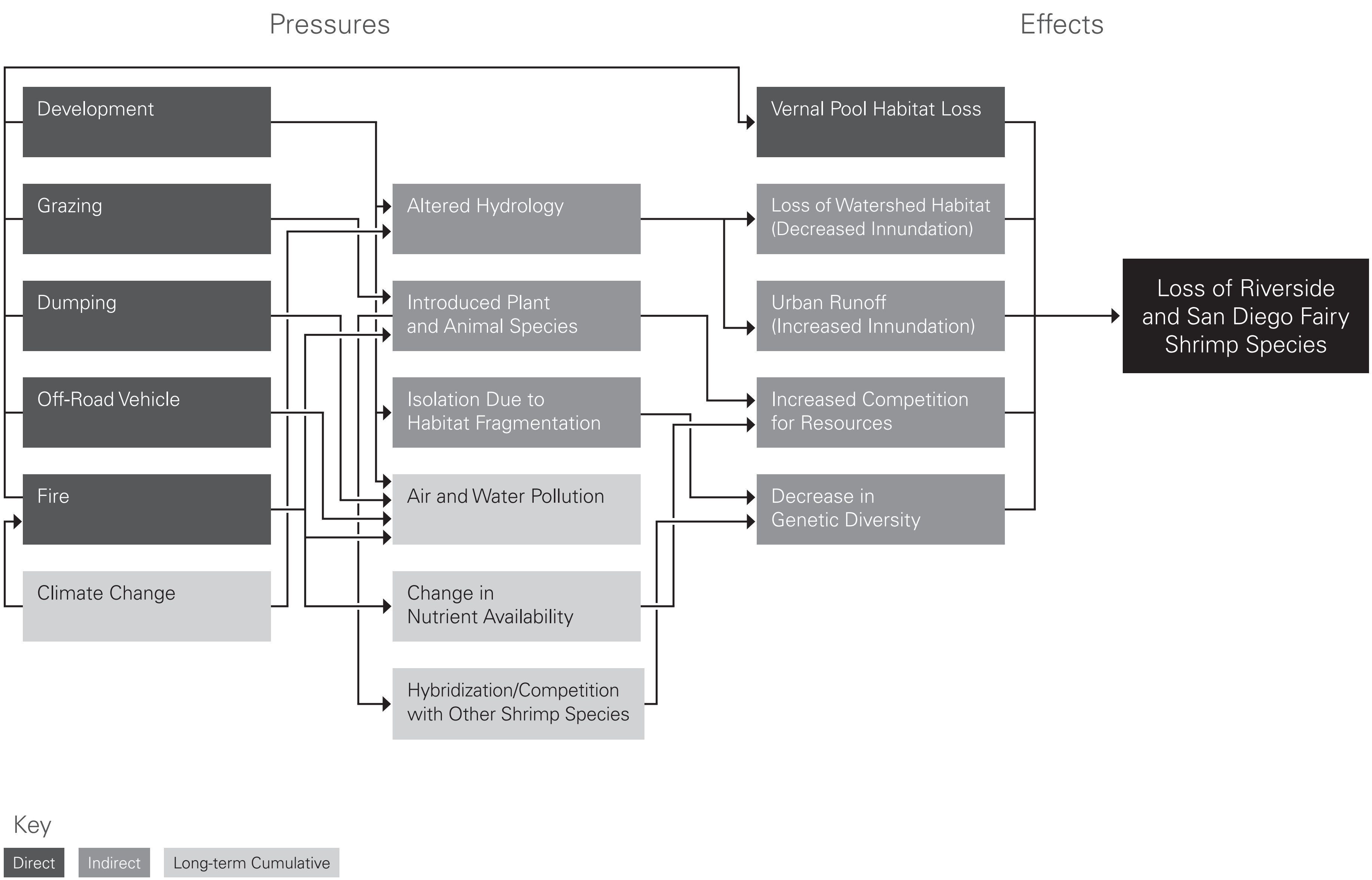
ATTACHMENT B-1

Conceptual Model of Pressures Affecting Endemic Vernal Pool Plant Species in San Diego, CA



ATTACHMENT B-2

Conceptual Model of Pressures Affecting Endangered Fairy Shrimp Species in San Diego, CA



ATTACHMENT C
USFWS VERNAL POOL RECOVERY PLAN EXCERPT

Attachment C
Excerpt from USFWS Vernal Pool Recovery Plan (1998)

Recovery Criteria

Reclassification to threatened status may be considered for *Eryngium aristulatum* var. *parishii, Pogogyne abramsii, Pogogyne nudiuscula, Orcuttia ca/Wornica;* San Diego and Riverside fairy shrimp; and the long-term conservation of *Navarretia fossalis,* a species proposed as threatened, will be assured when the following criteria are met:

1. The following conditions must be met to maintain the current status of *Navarretia fossalis, Eryngium aristulatum* var. *parishii, Pogogyne abramsii, Pogogyne nudiuscula, Orcuttia californica,* and San Diego and Riverside fairy shrimp in order to maintain genetic diversity and population stability of the listed species and other sensitive species:

   Existing vernal pools currently occupied by *Orcuttia californica, Pogogyne nudiuscula,* and Riverside fairy shrimp and their associated watersheds should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

   Existing vernal pools and their associated watersheds within the Transverse and Los Angeles Basin-Orange Management Areas should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

   Existing vernal pools and their associated watersheds within the San Marcos vernal pool complexes that contain *Navarretiafossalis, Eryngium aristulatum* var. *parishii,* or any other vernal pool species, should be secured from further loss and degradation. Habitat functions and species viability for any of the remaining vernal pools and their associated watersheds within the San Marcos complexes must be ensured;

   Existing vernal pools and their associated watersheds within the Ramona complexes that contain *Eryngium aristulatum* var. *parishii, Navarretia fossalis,* San Diego fairy shrimp, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability;

   Existing vernal pools and their associated watersheds within the Hemet complexes that contain *Navarretia fossalis,* and *Orcuttia californica,* or any other vernal pool species,

should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability,

Existing vernal pools and their associated watersheds located on Stockpen soils (Otay Mesa) should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability, to provide for the recovery of species restricted to this soil type (i.e., *Pogogyne nudiuscula);* and

Remaining vernal pools and their associated watersheds contained within the complexes identified in Table 4 must be secured in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks).

2. The existing vernal pools and their associated watersheds contained within the complexes identified in Table *5* are secured in a configuration that maintains habitat function and species viability (as determined by recommended research).

3. Secured vernal pools are enhanced or restored such that population levels of existing species are stabilized or increased.

4. Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to consideration for reclassification. Monitoring should continue for a period of at least 10 years following reclassification to ensure population stability.

Delisting of each of the species is conditional on the downlisting criteria shown above, improvement (stabilized or increasing population trends) at all currently known sites; restoration, protection, and management of the minimum habitat area and configuration needed to ensure long-term viability; and establishing historic but locally extirpated species populations when needed to ensure viability.

FINAL DRAFT

TECHNICAL WHITE PAPER 1:
FOCAL SPECIES STATUS UPDATE FOR THE CITY OF SAN DIEGO VERNAL POOL HABITAT CONSERVATION PLAN

Prepared for:

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Tom Oberbauer, and Linnea-Spears Lebrun

Please note that the Technical White Papers are the products of professional consultants hired by SANDAG Service Bureau, and that the City of San Diego and/or Wildlife Agencies may not concur with the recommendations contained in these reports.

August 2012

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CHAPTER 1
INTRODUCTION

1.1 PROJECT OVERVIEW

The San Diego Association of Governments Service Bureau (SANDAG SB) will prepare a Vernal Pool Habitat Conservation Plan (VPHCP) for the City of San Diego (City) largely based on information contained in a series of Technical White Papers (TWPs). The TWPs focus on seven target vernal pool species, consisting of five plants and two crustaceans:

- Otay Mesa mint (*Pogogyne nudiuscula*)
- San Diego Mesa mint (*Pogogyne abramsii*)
- Spreading navarretia (*Navarretia fossalis*)
- San Diego button-celery (*Eryngium aristulatum* var. *parishii*)
- California Orcutt grass (*Orcuttia californica*)
- Riverside fairy shrimp (*Streptocephalus wootoni*)
- San Diego fairy shrimp (*Branchinecta sandiegonensis*)

The eight TWP topics are as follows:

- TWP 1: Focal Species Status Update in the City of San Diego
- TWP 2: Assessment of Focal Species Conservation
- TWPs 3 & 4: Adaptive Management and Monitoring Strategy for the City of San Diego Vernal Pool Habitat Conservation Plan (a combined document)
- TWP 5: Cost Evaluation for Implementation of Management and Monitoring
- TWP 6: Recommendations for Conditions of Coverage
- TWP 7: Conservation Analysis
- TWP 8: Preserve Management Funding Mechanisms

This is TWP 1. It provides a status update on the seven focal vernal pool species, including information on:

- listing status
- species description
- habitat

- life cycle
- status and distribution
- threats and pressures
- propagation and restoration potential
- status in study area

The Planning Area for the VPHCP is the geographical extent of land that will be included in the VPHCP and for which the protections provided under the VPHCP are afforded to the seven focal species. For the City's VPHCP, these lands include the entire jurisdictional boundaries of the City and three areas owned by the City's Public Utilities Department in the unincorporated portion of San Diego County. The Planning Area's extent is, by design, the area covered by the City's Multiple Species Conservation Program (MSCP); however, the VPHCP is a separate but compatible conservation plan for vernal pools and seven endangered focal species not covered under the City's MSCP.

Many lands included in the Planning Area are not under the local land use jurisdiction of the City. These lands could include special districts such as school districts, military lands, federal properties, and state lands. These lands not under the land use jurisdiction of the City are included in the VPHCP for the purpose of conservation analysis. However, the regulatory requirements of the VPHCP will not be applicable. If land ownership is transferred and comes under the City's jurisdiction, or if the owner voluntarily requests inclusion, the VPHCP regulatory requirements will be applied after undergoing the appropriate amendment process, as outlined within the VPHCP.

The Planning Area includes 10,668 known vernal pools. Of that total, 7,531 known vernal pools occur on Marine Corps Air Station (MCAS) Miramar. Data for MCAS Miramar vernal pools is confidential and, therefore, not included in this analysis. The study area for TWP 1 includes the entire Planning Area except the MCAS Miramar lands with the 7,531 vernal pools. As such, the study area for TWP 1 is a subset of the Planning Area and includes 3,137 known vernal pools.

The intent of TWP 1 is to synthesize and present existing key data for each focal species related to the topics listed above. This data will be used to support the discussion and analysis included in the subsequent TWPs and the VPHCP. TWP 1 is based on review of historical and current vernal pool data within the study area. Baseline data consisted of Beauchamp and Cass (1979), Bauder (1986), City of San Diego (2004), EDAW (2007), 5-year review of species status reports from the U.S. Fish and Wildlife Service (USFWS; various dates), designated critical habitat and the vernal pool recovery plan (USFWS 1998), review of the City's vernal pool geodatabase

(2012) and key ancillary data on species that would contribute to knowledge of its status, and additional data from USFWS and the City since 2004. Other key references are also cited throughout. TWP 1 also includes data and information provided by renowned local vernal pool and native plant experts Scott McMillan and Tom Oberbauer of AECOM. Scott McMillan and Tom Oberbauer each have more than 20 years of experience with vernal pools in San Diego County, and are recognized as leading vernal pool and rare plant experts by the local resource agencies. Per the direction of USFWS and the City, no additional fieldwork or independent research was conducted to prepare this TWP, as the data contained in the City's vernal pool database is considered comprehensive and current. TWP 1 includes a summary overview of key data (refer to Section 1.3 and Attachment A), as well as a detailed chapter for each focal species.

Attachment A includes a table summarizing the vernal pool and focal species information contained in the City's vernal pool database for the VPHCP Planning Area. For each complex, data provided includes the geographic planning area (North, Central, or South), total number of pools on City-controlled land and on land under other control, size (total surface area) of vernal pools, location within or outside of preserved lands, proximity to other complexes within the study area, soils, and number of pools occupied by any one of the seven focal species. As noted above, vernal pools on MCAS Miramar are not included in this analysis. Focal species data for the 7,531 vernal pools on MCAS Miramar lands is provided in Attachment A for informational purposes only.

Attachment B includes two conceptual models. One illustrates pressures on the endemic vernal pool plant focal species and one illustrates pressures on focal fairy shrimp species. Direct, indirect, and long-term cumulative pressures are identified, as well as the inter-relationship of these various pressures. The pressures identified in these conceptual models are discussed in further detail relative to each species in the following chapters. The conceptual models can be used for subsequent TWPs as part of the process of identifying management and monitoring strategies to address specific threats to the focal species.

1.2 OVERVIEW OF VERNAL POOLS

Vernal pools are ephemeral wetlands that occur from southern Oregon through California into northern Baja California, Mexico (USFWS 1998). They require a unique combination of climatic, topographic, geologic, and evolutionary factors for their formation and persistence. They form in regions with Mediterranean climates where shallow depressions fill with water during fall and winter rains, and then dry up when the water evaporates in the spring (Collie and Lathrop 1976; Holland 1976, 1988; Thorne 1984).

An impervious subsurface layer consisting of claypan, hardpan, or volcanic stratum prevents downward percolation of water within the pools (Holland 1976, 1988). Figure 1-1 shows a schematic cross-section of a vernal pool. Seasonal inundation makes vernal pools too wet for adjacent upland plant species adapted to drier soil conditions, while rapid drying during late spring makes pool basins unsuitable for typical marsh or aquatic species that require a more persistent source of water. Groups of vernal pools are sometimes referred to as vernal pool complexes, which may include two to several hundred individual vernal pools (Keeler-Wolf et al. 1998). These vernal pool complexes were given identification numbers by Bauder (1986). The numbers were updated by the City of San Diego's Vernal Pool Inventory (2004), and again updated by SANDAG SB (2012). Local upland vegetation communities associated with vernal pools include needlegrass grassland, annual grassland, coastal sage scrub, maritime succulent scrub, and chaparral (USFWS 1998).

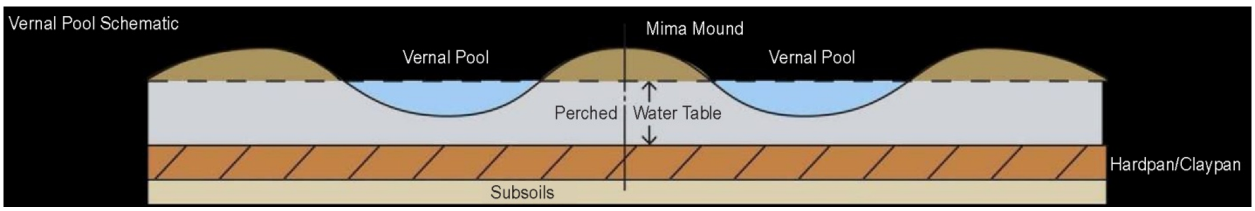

Figure 1-1. Schematic Cross-Section of a Vernal Pool

Historically, San Diego vernal pool habitat probably covered as much as 6% of the county, approximately 520 square kilometers (200 square miles). Current estimates indicate a loss of vernal pool habitat in San Diego County around 95 to 97% because of intensive cultivation and urbanization (Bauder and McMillan 1998).

Vernal pools are also known from northwestern Baja California, Mexico, from the border at Otay Mesa to the south as far as El Rosario (approximately 225 miles from the U.S./Mexican border). While there are more than 20 different locations for vernal pools in Baja California, most of these sites have either been destroyed in part, or at least impacted by cattle grazing, farming, and, more recently, development. AECOM senior restoration ecologist Scott McMillan estimates the loss of vernal habitat for Baja California is 75% or greater.

Vernal pools within a complex are generally hydrologically connected, such that water flows over the surface from one vernal pool to another and/or water flows and collects below ground such that the soil becomes saturated with water, thus filling the vernal pool through the perched water table that lies beneath (Figure 1-1). For overland flow to occur, the precipitation rate must exceed the infiltration rate or the soil column becomes completely saturated. Typically, significant watershed contributions only occur when the upland soils are fully recharged to the point where a perched groundwater table develops; this usually only occurs when seasonal precipitation is greater than average. Given rainfall patterns and amounts typical for Southern California, the direct precipitation into the pools is by far the most important source of water to the vernal pools (Hanes et al. 1990).

The upland areas that support the vernal pool watershed also support pollinator populations and habitat for adult amphibians. Pollinators often require upland habitat for nesting, breeding, and sustenance, and amphibians often use upland habitat for burrows and foraging of food sources. Upland habitat areas provide an important role in maintaining the vernal pool habitat health and persistence.

As shown in Attachment A, 61 vernal pool complexes are identified within the study area, encompassing approximately 3,137 vernal pools and nearly 59 acres of basin area. The majority of these complexes (41 complexes or 67%) are within the City's existing Multi-Habitat Preserve Area boundary, which includes 2,745 (over 87%) of the City's 3,137 vernal pools.

1.3 SUMMARY OF STATUS INFORMATION FOR FOCAL SPECIES

Table 1-1 summarizes key information and status data for each species. More detail is presented in the respective chapters. The chapters are intended to provide "stand alone" information for each species. Much of the data provided is similar for two or more species; therefore, some inherent redundancy exists in the presentation of the species information from chapter to chapter.

Table 1-1
Summary of Focal Species Information

Focal Species	Listing Status	Critical Habitat in VPHCP Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
Otay Mesa mint	FE	No designated critical habitat	• Annual herb • Six flowers per node • Plant emits a strong, turpentine mint odor	Known from clay-pan-type vernal pools on Otay Mesa	• Dependent on saturated soils of vernal pools • Blooms from May or June through early July • Primarily bee pollinated • Gene dispersal occurs via pollen or seed	• Found only in southern San Diego County vernal pools on Otay Mesa • Extirpated from Baja due to development	• Occurs in 398 (12.7%) vernal pools within seven vernal pool complexes • All but one of the pools have had some habitat restoration • Found on Stockpen, Olivenhain, Linne, and Huerhuero soils
San Diego Mesa mint	FE	No designated critical habitat	• Annual herb • Two flowers per node • Plant emit a strong, sweet mint odor	Known from hard-pan-type vernal pools in San Diego County	• Dependent on saturated soils of vernal pools Blooms from May or June through early July • Primarily bee pollinated • Gene dispersal occurs via pollen or seed	• Mesas of western San Diego County including Del Mar mesa, Mira Mesa, Marine Corps Air Station Miramar, Kearny Mesa, and western Tierrasanta • Historically, thought to have occurred around Linda Vista, the vicinity of Balboa Park, Normal Heights, and the area surrounding	• Occurs in 368 vernal pools (11.7%) within 17 vernal pool complexes • Estimated approximately 10% or less of pools have had habitat restoration • Found on Redding soils, with Olivenhain or Linne on several complexes • Hard-pan spoils acidic in pH

Focal Species	Listing Status	Critical Habitat in VPHCP Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
						San Diego State University	
Spreading navarretia	FT	Approximately 624 acres (out of 6,720 total acres in species range)	• Annual herb • Flat-topped, compact, leafy head flowers with white to lavender-white petals • Seed is covered by a layer that becomes sticky and viscous when the capsule is moistened	Known from hardpan, claypan, alkali playas, and alluvial terrace pool complexes	• Pollination and dispersal mechanisms not well known • Ability to self-pollinate, but is not an obligate self-pollinator • Blooms in May and June through summer months • Minimal information on seed dispersal	• Found in widely disjointed and restricted vernal pool complexes extending from the Santa Clarita region of Los Angeles County, to the western lowlands of Riverside County, through coastal and foothill San Diego County, and south to San Quintin, Baja	• Occurs in 112 vernal pools (3.6%) within 10 complexes • Estimated that at least 80% of these pools have had some habitat restoration • Redding, Huerhuero, Stockpen, Oliven-hain, and Linne • Primarily claypan-type soils associated with marine sediments and typically have basic pH subsurface layers
San Diego button-celery	FE	No designated critical habitat	• Biennial perennial gray-green herb that has a storage tap-root • stems and lanceolate leaves give the plant a prickly appearance	• Found in almost every type of Southern California vernal pool, including claypan-, hardpan-, and alluvial-terrace-type pools • Does not appear to be restricted to any particular type of soil type	• Vernal pool obligate and relies on ephemerally wet conditions to reproduce, blooming from April through June • Seems more tolerant of a wider range of vernal pool habitat than most obligate vernal pool species • Can tolerate disturbance factors	• San Diego County at Otay Mesa, Kearny Mesa, Del Mar Mesa, MCAS Miramar, and Marine Corps Base (MCB) Camp Pendleton, and in northern Baja California, Mexico • Historically, habitat included a coastal swath	• Occurs in 860 vernal pools (27.4%) within 26 vernal pool complexes • Estimated that at least 45% of these pools have had some habitat restoration • Occurs across various types of vernal pool soils, including Redding,

Focal Species	Listing Status	Critical Habitat in VPHCP Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
					better than most endemic species • Presumably insect-pollinated	from Mesa de Colonet and San Quintin in Baja north to Los Angeles County	Olivenhain, Huerhuero, Stockpen, Diablo, and Linne
California Orcutt grass	FE	No designated critical habitat	• Annual grass • Bright gray-green in color and secretes sticky droplets • Inflorescences consist of seven spikelets arranged in two ranks, with the upper spikelets overlapping on a somewhat twisted axis	Restricted to vernal pools in Southern California	• Flowers from April through July and then sets seed • Adapted to conditions in the wettest, longest lasting portion of vernal pools • Typically require at least 30 days of inundation before germination begins • Believed to be wind pollinated	• Ventura, Los Angeles, Riverside, and San Diego counties • Several historical occurrences reported from northern Baja	• Occurs in 61 vernal pools (1.9%) with California Orcutt grass within four vernal pool complexes • Estimated that at least 90% of pools have had some habitat restoration • Occurs on Huerhuero, Olivenhain, Stockpen, and Linne soils • Claypan-type soils associated with marine sediments with subsurface layers that are basic in pH
Riverside fairy shrimp	FE	Approximately 847 acres proposed (out of 2,986 acres in species range)	• Small aquatic crustacean	Restricted to vernal pools and other non-vegetated ephemeral pools greater than 30.5 centimeters (12 inches) in depth in Riverside, Orange,	• Usually observed January through March, although the hatching period may be extended in years with early or late rainfall	• Riverside, San Diego, and Orange counties • Historical occurrences reported from Ventura County,	• Identified in 215 vernal pools (6.9%) within 12 vernal pool complexes • Estimated that at least 95% of these pools have had

Focal Species	Listing Status	Critical Habitat in VPHCP Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
				and San Diego Counties	• Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool, depending on water temperature • Cysts are capable of withstanding temperature extremes and prolonged drying	Los Angeles County, and northwestern Baja	some habitat restoration • Occurs on Huerhuero, Stockpen, Olivenhain, Diablo, and Linne soils • Claypan-type soils associated with marine sediments with subsurface layers that are basic in pH
San Diego fairy shrimp	FE	Approximately 1,834 acres (out of 3,085 acres in species range)	• Small aquatic crustacean • Feed on algae, diatoms, and particulate organic matter	• Occur in vernal pools and other non-vegetated ephemeral pools from 2 to 12 inches in depth in coastal areas of San Diego County, Orange County, and northwestern Baja • Restricted to dilute vernal pools, having relatively low sodium concentrations, low alkalinity, and neutral pH	• Usually observed January through March, although the hatching period may be extended in years with early or late rainfall • Individuals hatch, mature, and reproduce within 7 to 14 days of rainfall filling a pool, depending on water temperature	• Coastal areas of San Diego County, Orange County, and northwestern Baja • Historic occurrence in Santa Barbara County	• Occurs in 678 vernal pools (21.6%) within 42 vernal pool complexes • Estimated that at least 60% of these pools have had some habitat restoration • Occurs across all types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, Linne, and Chesterton.

Focal Species	Listing Status	Critical Habitat in VPHCP Planning Area	Key Description Information	Habitat	Lifecycle	Status and Distribution	Status in Study Area
							• Occur on both claypan- and hardpan-type soils

FE = federally endangered
FT = federally threatened

1.4 OVERVIEW OF THREATS TO THE FOCAL SPECIES

Threats and pressure to the focal vernal pool endemic plant and animal species are illustrated in the conceptual models included in Attachment B. More detail is provided in each of the respective focal species chapters. To summarize, threats and pressures generally include:

- Direct pressures, such as construction, grazing, dumping, fire, off-road vehicle traffic
- Indirect pressures, such as altered hydrology, draining, exposure to pesticides, runoff from adjacent operations, competition by introduced species, loss of pollinators, habitat fragmentation
- Long-term, cumulative pressures, such as effects of isolation on genetic diversity and local genotypes, air and water pollution, and changes in nutrient availability
- Potential future climate change

Past evaluations have generally concluded that the greatest threats to the stability of the vernal pools in Southern California are direct habitat loss and alteration of pool and watershed hydrology (Bauder 1986; USFWS 1998). While this conclusion may have been true 10 or more years ago, most of the remaining vernal pools in San Diego are now preserved in perpetuity with access protection measures that restrict illegal off-road access and types of trespass that could lead to physical disturbance to vernal pool hydrology. Although some vernal pool complexes may still be unprotected and subject to hydrological impacts, topographic disturbance is no longer considered a major threat.

Currently, based over a decade of AECOM's observations in the field, the greatest threat to vernal pool habitat, including both the focal plants and animal species, is invasion of nonnative plant species. This includes secondary threats that ultimately lead to an increase in nonnative plant species, such a grazing and fire. Since grazing is not a common problem for vernal pools in San Diego, fire is likely to be the greatest secondary threat related to invasion of nonnative plants. The most recent example of fire leading to type conversion is the 2003 Cedar Fire, which burned a number of large vernal pool complexes and their associated watersheds on MCS Miramar and elsewhere in San Diego. Following the Cedar Fire, most of the burned complexes were immediately invaded by nonnative plants, including grasses and forbs, ultimately resulting in type conversion of chaparral and coastal sage scrub habitat to nonnative grasslands. Based on incidental observations, the vernal pools that are within these type converted watersheds have suffered dramatically, and an obvious decline in the focal species population has been observed.

Some past studies have also concluded that competition from nonnative plant species is balanced by the seasonal inundation in the pools, as evidenced by the persistence of focal vernal pool species. This theory suggests that while nonnative plants occur in the upland watershed areas, these species are controlled by inundation of vernal pools (Bauder 1987, 1997, 2000; Bauder et al. 2002; Bauder et al. 2009). The reduction or complete extirpation of many of the focal species populations in Southern California's vernal pools in the last 10 years would strongly contradict this theory. First, an increasing number of nonnative plant species are tolerant of the wetland environment and are not controlled by the inundation cycle (e.g., *Lolium, Polypogon, Lythrum, Spergularia, Agrostis*) (Bauder 1992b). Also, in years with average or below average rainfall, common upland weed species (e.g., *Erodium, Bromus, Avena*) are increasingly invading vernal pools and have become a serious threat to the focal species. Southern California's rainfall patterns and amounts are simply not consistent enough to control competition from upland weeds.

Drought stress is a natural phenomenon and, given that no proven solution to drought stress is apparent, it is not clear what, if any, management methods would be appropriate to address drought stress in years with low rainfall. On the other hand, invasion of nonnative species is a human-induced threat and many proven methods exist for controlling weed invasion. Most of the vernal pool complexes that have experienced loss of focal species do not appear to have been affected by anything other than an increase in nonnative plant invasion (AECOM 2007). In addition, management of nonnative plant invasion in a number of vernal pool complexes in the last 10 years has proven to not only stabilize focal species populations, but also restore populations that were thought to be extirpated (AECOM 2010a).

Vernal pool ecology is directly affected by precipitation and inundation, along with drought and occasional dry periods. However, effects of inundation and drought on the focal species are not always clear. For many of the species, an increase in precipitation and inundation is beneficial, in particular the species that persist well with longer inundations, such as the San Diego fairy shrimp and Riverside fairy shrimp, and Orcutt's grass. Inundation that is too deep or lengthy can lead to a shift in the flora and fauna composition toward longer inundation species, and can ultimately transition the vernal pools into true wetland habitat. Reduced inundation is likely to result in weed invasion, asdrier conditions could indirectly lead to a decline in one or more of the focal species populations through competition. While it is not clear whether climate change in Southern California will lead to more or less rainfall, changes in inundation periods and frequencies will likely lead to a shift in species distribution and population health.

CHAPTER 2
OTAY MESA MINT

2.1 LISTING STATUS

Otay Mesa mint was federally listed as endangered on August 3, 1993. The USFWS 5-year review was completed on September 1, 2010 (USFWS 2010a). No critical habitat has been designated for Otay Mesa mint, but the Recovery Plan for Vernal Pools of Southern California (Recovery Plan) calls for all populations of Otay Mesa mint to be conserved and protected (USFWS 1998). An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

2.2 SPECIES DESCRIPTION

Otay Mesa mint is an annual herb in the mint family (*Lamiaceae*). Howell (1931) considered Otay Mesa mint to be diagnosable from San Diego Mesa mint (*Pogogyne abramsii*) by having a glabrous (smooth) calyx and bract with a different morphology. This distinction is supported by Jokerst (1993). Otay Mesa mint is also diagnosable by usually having at least six flowers (occasionally more) per node on the stem, a glabrous to minutely pubescent (hairy) calyx, while San Diego Mesa mint typically only has two flowers per node. Otay Mesa mint bracts and leaves are wider than San Diego Mesa mint.

Otay Mesa mint can reach 30 centimeters (1 foot) or more. The plant is typically minimally branched, and the vegetative and floral portions of the plant emit a strong, turpentine mint odor. Otay Mesa mint displays internodal elongation, adventitious roots, reduced branching when grown under water (but are branched), and shorter when never inundated (Bauder 1987, 1992a). In contrast to San Diego Mesa mint, the vegetative portions of the plant do not develop a reddish tinge until the plant is past the flowering period. The flowers are purple with a white throat.

2.3 HABITAT

Otay Mesa mint is restricted to vernal pools on Otay Mesa in the City and County of San Diego. Vernal pools that support Otay Mesa mint are found on Huerhuero or Stockpen soils and the one complex on the San Diego National Wildlife Refuge that has Olivenhain and Diablo clay soils (Bauder and McMillan 1998; Beauchamp and Cass 1979). All Otay Mesa mint populations are known from clay-pan-type vernal pools.

2.4 LIFE CYCLE

The life cycle of the Otay Mesa mint is dependent on soil saturation of vernal pools. The link between the onset of germination, temporal conditions associated with vernal pool inundation, and soil moisture are critical to the germination, maturation, flowering, and fruiting of Otay Mesa mint. The interaction of these factors provides the plants favorable conditions in the spring rather than in the summer, autumn, or winter. Natural differences in the precipitation and the saturation/drying time of vernal pools from year to year may influence the distribution and abundance of Otay Mesa mint. These environmental factors make it difficult to obtain an accurate measure of the population. Additionally, a portion of the population is represented by seeds remaining in the seed bank, which is not accounted for each year.

Flowering commences in May and continues through June or July; by early to mid-summer, the pools become dry. The family is primarily bee pollinated (Proctor and Yeo 1973). AECOM senior restoration ecologist Scott McMillan has observed potential pollinators such as hover flies (Syrphids), bee flies (Bombylids), sweet bees (Halictids), and the common honey bee (*Apis mellifera*) visiting Otay Mesa mint flowers.

Pollinator studies specific to vernal pool species have been conducted in the California Central Valley where the upland habitat may play a crucial role in supporting native bee populations (Thorp and Leong 1998). While native bee species may visit and pollinate vernal pool plants, they often nest in upland areas and are directly affected by changes in the quality of the upland habitats. None of the VPHCP focal species or their genera were monitored during these referenced studies, but it is assumed that upland areas for the vernal pools in Southern California play a similar role for pollinators.

Gene dispersal may occur via pollen or seed. Otay Mesa mint does not have seed morphology associated with animal or wind dispersal, although scattered occurrences of pool plants along well-worn trails that link individual pools over wide areas suggest that large animals may contribute to seed dispersal (Cole 1995). Waterfowl use pools, especially the larger ponds or vernal lakes, and they are presumed to carry seeds and invertebrate eggs from pool to pool (Proctor et al. 1967; Zedler 1987). While the seed does not have any apparent special adaptations for dispersal, it can be readily dispersed when it is retained in the heavy clay soils common to vernal pools. The seed can stick to the heavy clay and then be transferred, along with other inoculums, via wildlife movement or other means of dispersal.

Zedler and Black (1992) found that San Diego Mesa mint seeds germinated and grew from pellets of brush rabbits and Audubon's cottontail rabbits (*Sylvilagus bachmani* and *S. auduboni*), which were collected from vernal pools on Del Mar Mesa and Miramar Mesa. They postulated that rabbit movement might be a potential mechanism for dispersal and genetic mixing of vernal pool obligate species, such as Otay Mesa mint. Otay Mesa mint seeds can sometimes float, which may result in limited dispersal opportunities when pools interconnect or lakes fill their basins in years of greater than average precipitation (Scheidlinger 1981).

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2010a).

2.5 STATUS AND DISTRIBUTION

Otay Mesa mint is found only in southern San Diego County. This mint grows in vernal pools near the Otay Mesa region. Historically, Otay Mesa mint was believed to be found beyond Otay Mesa and occurred at 10 locations in southern San Diego County, including sites farther north near University Heights, Balboa Park, and Mission Valley (refer to USFWS 2010a, Appendix 1). However, upon review of these historical herbarium collections from the central part of San Diego County, it was determined that these historical occurrences were actually the San Diego Mesa mint.

Otay Mesa mint also historically grew in vernal pools near the Tijuana Airport in Baja California, Mexico, but has likely been extirpated there due to urban development. Most recently, the San Diego National Wildlife Refuge introduced it into the vernal pool complex ("S" series) located just south of the Sweetwater Reservoir. Seeds were distributed at the Shinohara vernal pool restoration site prior to the 2011 growing season. The seeds have sprouted, but it is too soon to tell whether this population will be successfully established.

No estimate of numbers of individual Otay Mesa mint plants at specific sites is currently available. This is likely due to the difficulty of measuring temporal abundance at each occurrence. Local site conditions, rainfall, and fresh water pooling likely influence numbers of standing plants and their local distribution (Schiller et al. 2000). Like most annual plants, the germination success of Otay Mesa mint differs annually depending, in part, on timing and amount of rainfall. Yearly variability in rainfall will result in variability in water depth and duration of vernal pools, which can alter the proportion of each pool experiencing particular moisture conditions in a given year. This can have implications for species distribution within and among pools given the narrow habitat preferences and tolerances of many vernal pool plant species (Bauder 2005). The number of individuals may differ at any site for any year because numbers also depend, in part, on reproductive success of previous cohorts, the number of seeds deposited in the seed bank, and the survivorship of the annual seedling cohort in the year the survey was conducted. In 2003, the City conducted a survey of vernal pools within its jurisdiction. At that time, of the 1,142 vernal pools surveyed with sensitive plant species, Otay Mesa mint was found in 376 pools, with a mean percent cover per pool of 18% (City of San Diego 2004).

2.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model shown in Attachment B. Specific threats to Otay Mesa mint can be divided into three major categories:

1. direct destruction of Otay Mesa mint from construction, grazing, dumping, fire, off-road vehicle traffic (including Border Patrol activity), and other mechanical disturbances;

2. indirect threats that degrade or destroy Otay Mesa mint, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, habitat fragmentation; and,

3. potential long-term, cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support Otay Mesa mint could become filled with upland native and nonnative species that outcompete Otay Mesa mint in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could outcompete Otay Mesa mint in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact soil moisture, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which Otay Mesa mint currently grows more vulnerable to the threats of subsequent erosion and nonnative/native plant invasion (Ackerly 2005; Graham 1997; Miller et al. 2003).

As with other vernal pool species, Otay Mesa mint is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators. Due to its restricted range and small population size, conservation of Otay Mesa mint is dependent on preservation of extant populations and re-establishment of populations of Otay Mesa mint within other pools on Otay Mesa.

2.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring Otay Mesa mint populations and the habitat that supports them (AECOM 2006, 2010b, 2010c, 2011). These successful restoration efforts were achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvement to protect the watershed and attract pollinators. Effective weed control in vernal pools with Otay Mesa mint was achieved through the use of hand weeding and herbicide applications; seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for Otay Mesa mint was collected from genetically and geographically local populations. These methods have resulted in the addition of Otay Mesa mint to more than 300 vernal pools.

2.8 CURRENT STATUS IN STUDY AREA

Figure 2-1 shows the distribution of Otay Mesa mint within the study area. The locations of Otay Mesa mint within the various vernal pool complexes in the study area are included in Attachment

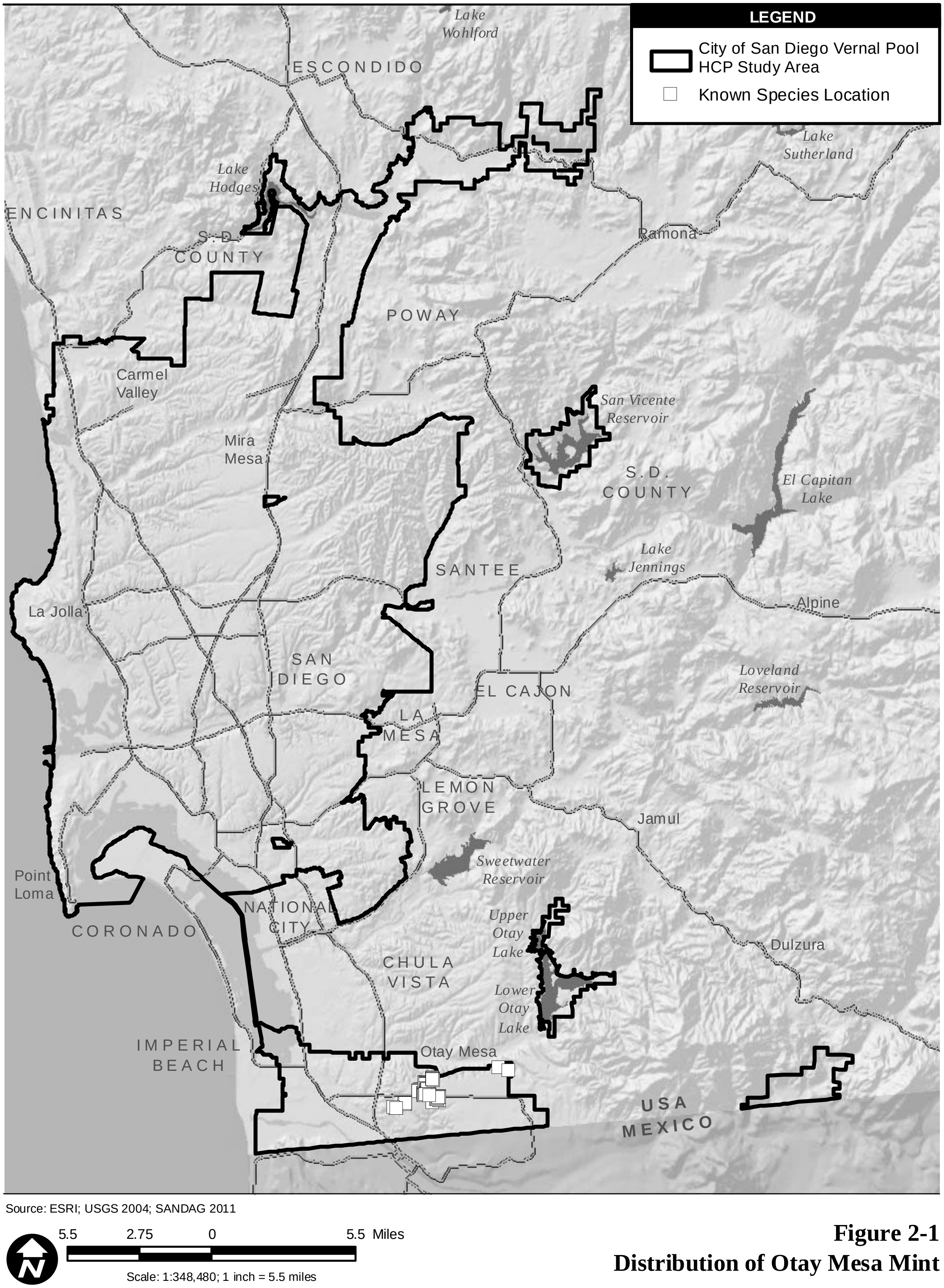

Figure 2-1
Distribution of Otay Mesa Mint

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\OtayMesaMint.mxd, 9/13/2011, augellop

A. As shown, Otay Mesa mint occurs in 398 (12.7%) vernal pools located within 7 vernal pool complexes, all of which are located on Otay Mesa. All but one of the 398 vernal pools are pools that have had some habitat restoration: the single pool at J29-30 complex.

It has been documented that soil type may play an important role in the distribution of vernal pool species in Southern California. Certain species may only occur on the hardpan-type vernal pool, while other species are only found in claypan pools. In addition to these major differences in substrate, other factors such as soil texture, depth, pH, and soil origin may influence the distribution of these species (Bauder and McMillan 1998). The soil types that underlie the seven Otay Mesa mint complexes within the study area are Stockpen, Olivenhain, Linne, and Huerhuero. These are all claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH. AECOM senior restoration ecologist Scott McMillan believes that these factors could be important to the distribution of Otay Mesa mint.

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CHAPTER 3
SAN DIEGO MESA MINT

3.1 LISTING STATUS

San Diego Mesa mint was federally listed as endangered in September 1978. The USFWS 5-year review was completed on September 1, 2010 (USFWS 2010b). No critical habitat has been designated for San Diego Mesa mint, but the Recovery Plan calls for essentially all populations of San Diego Mesa mint to be conserved and protected. Much of the range and distribution for the species is found on MCAS Miramar with remaining populations outside the MCAS Miramar found on City of San Diego MSCP lands. The MCAS Miramar is an active military installation and cannot be designated as critical habitat, for preservation, or for non-military habitat mitigation. While the MCAS Miramar has an approved management plan for vernal pools and San Diego Mesa mint, it is not required to maintain all existing populations of San Diego Mesa mint within the MCAS Miramar boundary (U.S. Marine Corps 2006). Because of this less-than-certain protection for San Diego Mesa mint on the MCAS Miramar, the Recovery Plan considers all populations within the VPHCP Planning Area to be critical to the stability and conservation of the species (USFWS 1998). An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

3.2 SPECIES DESCRIPTION

San Diego Mesa mint is an annual herb in the mint family (Lamiaceae). Howell (1931) considered San Diego Mesa mint to be diagnosable from Otay Mesa mint (*Pogogyne nudiuscula*) by having a hairy calyx and bract with a different morphology. This distinction is supported by Jokerst (1993). San Diego Mesa mint is also diagnosable by usually having only two flowers per node on the stem, whereas Otay Mesa mint has at least six flowers per node.

San Diego Mesa mint can reach 30 centimeters (1 foot) or more in height and typically blooms from May or June through early July. The plants usually give off a strong, sweet mint odor. San Diego Mesa mint usually has two flowers per node, which are arranged in whorls. The vegetative portions of the plant develop a reddish tinge during maturation. The plant has a hairy calyx, rather than the smooth calyx of the Otay Mesa mint, and bracts and leaves that are narrower than Otay Mesa mint.

3.3 HABITAT

San Diego Mesa mint is found in vernal pool habitat in San Diego County. Vernal pools that support San Diego Mesa mint are typically found on Redding soils, historically the second most common of the five pool-supporting soils in San Diego County, and currently the most common (Beauchamp and Cass 1979:26; Bauder and McMillan 1998:61–62). All San Diego Mesa mint populations are known from hard-pan-type vernal pools.

3.4 LIFE CYCLE

The life cycle of San Diego Mesa mint is dependent on soil saturation in vernal pools. The link between the onset of germination, temporal conditions associated with vernal pool inundation and soil moisture are critical to the germination, maturation, flowering, and fruiting of San Diego Mesa mint. The interaction of these factors provides the plants favorable conditions in the spring rather than in the summer, autumn, or winter. Natural differences in the precipitation and the soil saturation/drying time of vernal pools from year to year may influence the distribution and abundance of San Diego Mesa mint. These environmental factors make it difficult to obtain an accurate measure of the population. Additionally, a portion of the population is represented by seeds remaining in the seed bank that are not accounted for each year.

San Diego Mesa mint usually blooms in May and June when water is absent from the vernal pool (Munz 1974:531). The plants produce fruit, dry out, and senesce in the hot, dry summer months. Pollination of San Diego Mesa mint was described by Schiller et al. (2000:392) by monitoring insect visitors to individual plants on Del Mar Mesa. They found the Eurasian honey bee (*Apis mellifera*), two anthophorid bees (*Exomalopsis nitens* and *E. torticornis*), and bee flies (*Bombylids*) to be the most common and likely pollinators of San Diego Mesa mint at the Del Mar Mesa locality. Most of the insect visitors (76%) in this study were Bombylids; anthophorid bees were the next most common (17%). AECOM senior restoration ecologist Scott McMillan has observed other potential pollinators on San Diego Mesa mint, including hover flies (Syrphids). Schiller et al. documented that San Diego Mesa mint is self-fertile, but has significantly greater seed set when cross-pollinated (2000:393).

Pollinator studies specific to vernal pool species have been conducted in the California Central Valley where the upland habitat may play a crucial role in supporting native bee populations (Thorp and Leong 1998). While native bee species may visit and pollinate vernal pool plants, they often nest in upland areas and are directly affected by changes in the quality of the upland habitats. None of the VPHCP focal species or their genera were monitored during these referenced studies, but it is assumed that upland areas for the vernal pools in Southern California play a similar role for pollinators.

Gene dispersal may occur via pollen or seed. San Diego Mesa mint does not have seed morphology associated with animal or wind dispersal, although scattered occurrences of pool plants along well-worn trails that link individual pools over wide areas suggest that large animals may contribute to seed dispersal (Cole 1995). Waterfowl use pools, especially the larger ponds or vernal lakes, and they are presumed to carry seeds and invertebrate eggs from pool to pool (Proctor et al. 1967; Zedler 1987). While the seed does not have any apparent special adaptations for dispersal, it can be readily dispersed when it is retained in the heavy clay soils common to vernal pools. The seed can stick to the heavy clay and then be transferred, along with other inoculums, via wildlife movement or other means of dispersal.

Zedler and Black (1992:4) found that San Diego Mesa mint seeds germinated and grow from pellets of brush rabbits and Audubon's cottontail rabbits, which were collected from vernal pools on Del Mar Mesa and Miramar Mesa. They postulated that rabbit movement might be a potential mechanism for dispersal and genetic mixing of vernal pool obligate species. In addition, San Diego Mesa mint seeds can sometimes float, which may result in limited dispersal opportunities when pools interconnect or lakes fill their basins in years of greater than average precipitation (Scheidlinger 1981:54).

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2010b).

3.5 STATUS AND DISTRIBUTION

San Diego Mesa mint is found in vernal pools on mesas of western San Diego County; however, specific occurrence and range information was not included in the official listing (USFWS 1978, p. 44810). The Recovery Plan (USFWS 1998) identifies the northern distribution for San Diego Mesa mint as Del Mar mesa. It occurs south on Mira Mesa, MCAS Miramar, and Kearny Mesa, with a few scattered populations in western Tierrasanta. Examination of occurrence data from the time of listing (Bauder 1986; CDFG 2010) suggests that the distribution of San Diego Mesa mint has decreased since its listing in 1978. San Diego Mesa mint was extirpated from pool complexes in the most southern and northern extremities of its range (Element Occurrences 49, 56); San Diego Mesa mint was extirpated from at least one pool complex in 12 of the 13 geographic areas where it was known to occur since listing (refer to Appendix 1 of the USFWS 5-year review). No new extant occurrences have been detected since the time of listing; however, San Diego Mesa mint has been restored at multiple mitigation sites (refer to Appendix 1 of the USFWS 5-year review).

Historically, outside of San Diego Mesa mint's current range, the species is thought to have occurred around Linda Vista, the vicinity of Balboa Park, Normal Heights, and the area surrounding San Diego State University (USFWS 1998; Zedler et al. 1979). Some confusion has existed regarding San Diego Mesa mint's historical range due to misidentified herbarium specimens (identified as *Pogogyne nudiuscula*) and vague references regarding collection sites. Upon review of these historical herbarium collections from the central part of San Diego County, it was determined that these historical occurrences were, in fact, San Diego Mesa mint (Bauder and McMillan 1998; Howell 1931).

No estimate of numbers of San Diego Mesa mint plants at specific sites is currently available. This is likely due to the difficulty of measuring temporal abundance at each occurrence. Local site conditions, rainfall, and fresh water pooling likely influence numbers of standing plants and their local distribution (Schiller et al. 2000). Like most annual plants, the germination success of San Diego Mesa mint differs annually depending, in part, on timing and amount of rainfall. Yearly variability in rainfall will result in variability in water depth and duration of vernal pools, which can alter the proportion of each pool experiencing particular moisture conditions in a given year. This can have implications for species distribution within and among pools, given the narrow habitat preferences and tolerances of many vernal pool plant species (Bauder 2005). The number of individuals may differ at any site for any year because numbers also depend, in part, on reproductive success of previous cohorts, the number of seeds deposited in the seed bank, and the survivorship of the annual seedling cohort in the year the survey was conducted. In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed with sensitive plant species, San Diego Mesa mint was found in 373 pools, with a mean percent cover per pool of 6% (City of San Diego 2004).

3.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model found in Attachment B. Specific threats to San Diego Mesa mint can be divided into three major categories:

1. direct destruction of San Diego Mesa mint from construction, grazing, dumping, fire, military development and training, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego Mesa mint, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, and habitat fragmentation; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

At the time of listing in 1978, the major threats to San Diego Mesa mint and its habitat were road-widening projects (such as Miramar Road, State Route 163, and State Route 52), housing development, off-highway vehicle (OHV) use, and illegal dumping. Impacts from development include more than building of homes, and are discussed here under the broader term "urban development." Military activities, altered hydrology, and nonnative plants are new threats identified since its listing, which all continue to pressure San Diego Mesa mint habitat.

While impacts from urban development and altered hydrology have decreased, indirect impacts from these continue to threaten San Diego Mesa mint. Military activities remain a threat to most occurrences on MCAS Miramar due to training and development. In general, urbanization is not expected to expand, but in the limited areas where this is still a possibility, destruction, modification, and curtailment of San Diego Mesa mint habitat may continue.

Impact from invasive species is the prominent range-wide threat to San Diego Mesa mint populations, and is exacerbated by disturbance associated with other threats (e.g., urban development, OHV use). The Cedar Fire in 2003 burned large expanses of MCAS Miramar, including many vernal pools that support San Diego Mesa mint and other listed vernal pool species. For many of these areas, the fire facilitated a dramatic increase in the weed populations. Since the fire, AECOM senior restoration ecologist Scott McMillan has observed an increase in weed invasion, which is impacting populations of San Diego Mesa mint.

Another possible threat to this species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. The narrow range of San Diego Mesa mint makes it particularly vulnerable to all threats. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support San Diego Mesa mint could become filled with upland native and nonnative species that outcompete San Diego Mesa mint in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could out-compete San Diego Mesa mint in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact soil moisture, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which San Diego Mesa mint currently grows more vulnerable to the threats of subsequent erosion and especially nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003). San Diego Mesa mint is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators.

3.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had success restoring San Diego Mesa mint populations and the habitat that supports them (EDAW 2002, 2009; RECON 2007). These successfully restoration efforts have been achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvements to provide watershed protection and to attract pollinators. Effective weed control in vernal pools with San Diego Mesa mint has been achieved through the use of hand weeding and herbicide applications, while seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for San Diego Mesa mint was collected from genetically and geographically local populations. These methods have resulted in the addition of San Diego Mesa mint to more than 50 pools.

3.8 CURRENT STATUS IN STUDY AREA

Figure 3-1 shows the distribution of San Diego Mesa mint within the City. The locations of San Diego Mesa mint within the various vernal pool complexes in the City are included in Attachment A. As shown, there are 368 vernal pools (11.7%) with San Diego Mesa mint within 17 vernal pool complexes. While the exact number of restored vernal pool with San Diego Mesa mint is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that approximately 10% or less of these pools have had some habitat restoration or enhancement.

While the primary soil type that underlies San Diego Mesa mint is Redding in most complexes, Olivenhain was also identified from several complexes. One location, the J30 complex (Lone Star), also had Linne soils underlying the complex. Redding is a hardpan-type soil that is associated with alluvial deposits and typically has subsurface layers that are acidic in pH may be important to the distribution of San Diego Mesa mint.

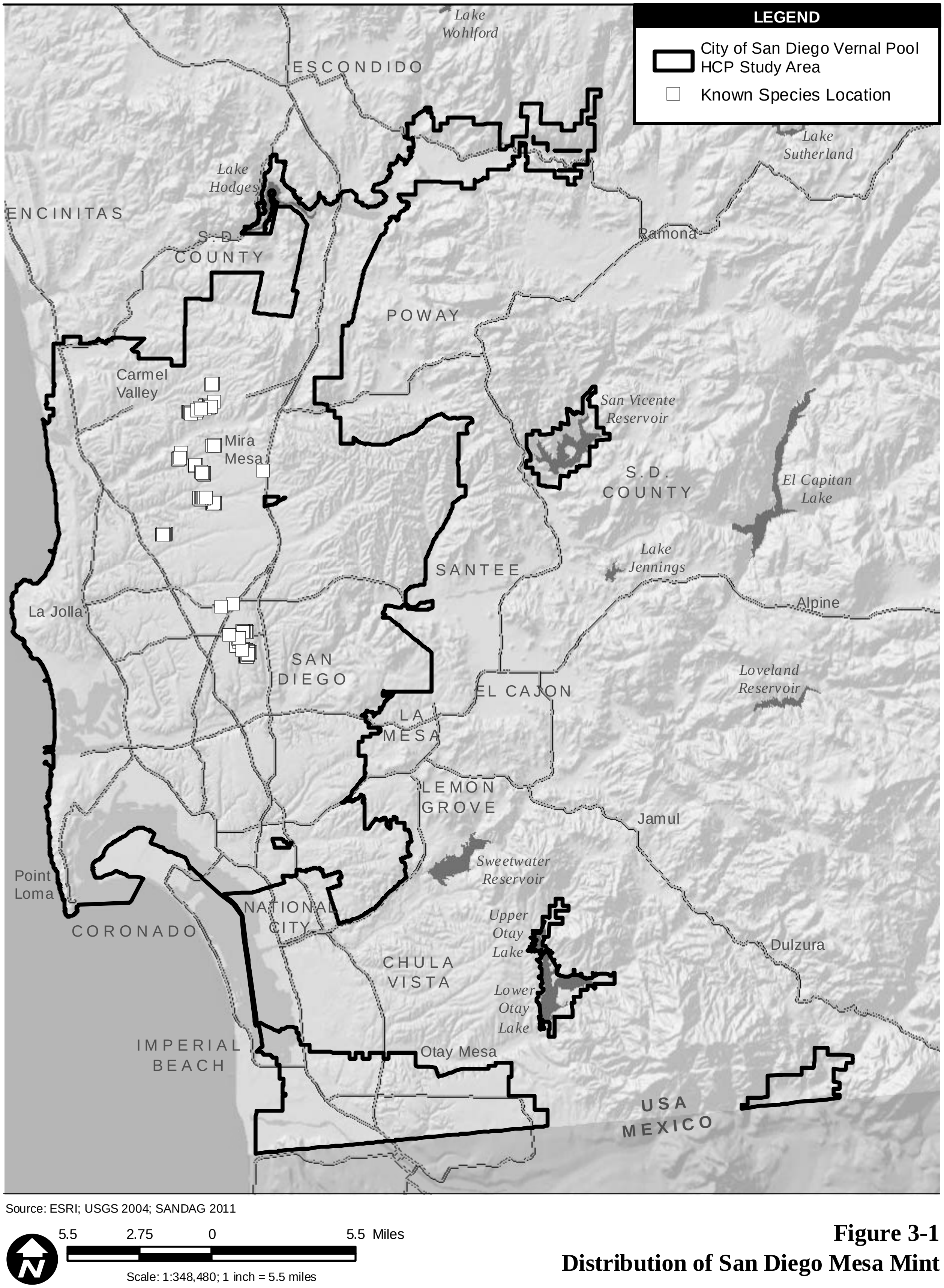

Figure 3-1
Distribution of San Diego Mesa Mint

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CHAPTER 4
SPREADING NAVARRETIA

4.1 LISTING STATUS

Spreading navarretia was federally listed as threatened on October 13, 1998. The USFWS 5-year review was completed on August 10, 2009 (USFWS 2009). Approximately 6,725 acres of habitat in Los Angeles, Riverside, and San Diego Counties, California, fall within the boundaries of the critical habitat designation for spreading navarretia (USFWS 2010d). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

4.2 SPECIES DESCRIPTION

Spreading navarretia is an annual herb in the phlox family (*Polemoniaceae*). It is a low, mostly spreading or ascending plant, 10 to 15 centimeters (4 to 6 inches) tall. The leaves are 1 to 5 centimeters (0.4 to 2 inches) long and finely divided into slender spine-tipped lobes. The lower portions of stems are mostly hairless (glabrous). The flowers are arranged in flat-topped, compact, leafy heads. The white to lavender-white petals (corolla) are joined at their bases to form a tube, although the tips (lobes) are free. The fruit is an ovoid, two-chambered capsule. Each seed is covered by a layer that becomes sticky and viscous when the capsule is moistened. The range of spreading navarretia overlaps with two other species in the genus *Navarretia*:

needle-leaved navarretia (*N. intertexta*) and prostrate navarretia (*N. prostrata*). Spreading navarretia is distinguished from the other two species by its linear corolla lobes, spreading or ascending habit, flat-topped inflorescences, calyx size and shape (sepals collectively), and the position of the corolla relative to the calyx (Day 1993).

4.3 HABITAT

Spreading navarretia occurs on a number of vernal pool soil types, including Huerhuero, Stockpen, Redding, and Chesterton, and is known from hardpan, claypan, alkali playas, and alluvial terrace pool complexes.

The hydrologic regime in the western Riverside County populations of spreading navarretia is unique. These populations are usually associated with the alkali soils series, which facilitate habitat that has sporadic flooding in combination with slow drainage of the alkaline soils. This habitat floods locally on a seasonal basin, while large-scale flooding occurs less frequently (possibly every 20 to 50 years). During the normal seasonal flooding regime, the alkali scrub vegetation expands in distribution and out-competes other native and nonnative species. When large-scale flooding occurs, standing and slow draining water is present for weeks or months and results in the death of submerged alkali scrub. These conditions during large-scale flooding allow adapted annual species, like spreading navarretia, to regain and locally expand their range (Bramlet 1993, 2004; Roberts 2004).

4.4 LIFE CYCLE

The life cycle of spreading navarretia is dependent on the function of the vernal pool ecosystem. This annual species germinates from seeds left in the seed bank. For many vernal pool plant species , soil moisture affects the timing of plant germination (Myers 1975). Although not proven, it is likely that spreading navarretia uses these same cues for germination. Most navarretia species have indehiscent fruit, or fruit with fibers that absorb water and expand to break open the fruit after a substantial rain (Spenser and Rieseberg 1998). The timing of germination is important so that the plant germinates under favorable conditions in the spring rather than the summer, autumn, or winter.

Spreading navarretia abundance also varies from year to year depending on precipitation and the soil saturation/drying time of the vernal pool. This annual variation makes it impossible to obtain an accurate count of the number of individuals in the population because the proportion of standing plants to remaining seeds in the seed bank that makes up the population cannot be measured. Additionally, the occurrences can vary spatially in alkali playa habitat where pools are not in the same place from year to year.

Pollination and dispersal mechanisms are not well known for spreading navarretia. The plant has the ability to self-pollinate, but is not an obligate self-pollinator. Outcrossing, rather than self-pollination, could be advantageous for many vernal pool specialists because it provides a way to better adapt and evolve to the changing conditions of vernal pool habitat through the recombination of beneficial genes. Outcrossing requires annual plants to flower for longer periods of time to attract pollinators (Spenser and Rieseberg 1998). Information on the pollinators of spreading navarretia is not available. Hypothetically, insects would be the main pollinators of the flowers. For example, the Hymenopteran insect *Perdita navarretiae* (a type of mining bee in the Andrenidae family) has been documented to make repeated visits to spreading navarretia, possibly for pollination (Krombein 1979).

Pollinator studies specific to vernal pool species have been conducted in the California Central Valley where the upland habitat may play a crucial role in supporting native bee populations (Thorp and Leong 1998). While native bee species may visit and pollinate vernal pool plants, they often nest in upland areas and are directly affected by changes in the quality of the upland habitats. None of the VPHCP focal species or their genera were monitored during these referenced studies, but it is assumed that upland areas for the vernal pools in Southern California play a similar role for pollinators.

After germination, the plant usually flowers in May and June when the vernal pool is devoid of water (Glenn Lukos 2005). The plant then produces fruit, dries out, and senesces in the hot, dry summer months.

Minimal information exists on the dispersal of spreading navarretia seeds. Individual seeds can often be glued in clusters of five to 20 seeds, and the glued layer becomes viscous and sticky when wet. The seed could stick to an animal or bird passing through the vernal pool, providing a method of dispersal. On the other hand, theories also suggest that the layer helps secure the seed during seed establishment (Sorenson 1986). More research is needed to discover the actual methods of pollination and dispersal for spreading navarretia.

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2009).

4.5 STATUS AND DISTRIBUTION

Spreading navarretia is found in widely disjointed and restricted vernal pool complexes extending from the Santa Clarita region of Los Angeles County, east to the western lowlands of Riverside County, south through coastal and foothill San Diego County, and south to San Quintin, Baja California, Mexico. Nearly 60% of populations in the official listing (USFWS 1998) and in the Recovery Plan (USFWS 1998) were concentrated at three locations: Otay Mesa in southern San Diego County, alongside the San Jacinto River in western Riverside County, and near Hemet in western Riverside County (Bauder 1986; Bramlet 1993). At the time of listing, spreading navarretia occupied less than 300 acres (120 hectares) of habitat in the United States (USFWS 1998).

Range-wide, comprehensive surveys for spreading navarretia have not occurred since listing. The distribution of spreading navarretia presented in the USFWS 5-year review is based on a variety of sources. Surveys are disjointed across space and time, and lack uniform variables that quantify the extent and precise location of occurrences, thus making it difficult to comprehensively evaluate the status and trend of the species. There were 34 extant, documented occurrences of spreading navarretia at the time of listing. Seventeen additional occurrences have been identified since listing. Three of these recently detected occurrences have since been extirpated by urban development. Currently, there are 48 extant occurrences of spreading navarretia in Riverside and San Diego Counties. It is probable that these 17 new occurrences existed at the time of listing, but had not been detected and, therefore, were not analyzed in the final listing rule. Surveys have failed to locate spreading navarretia at 12 occurrences known at listing; however, spreading navarretia does not express itself every year. This natural phenomenon, where not all of the seeds in the soil germinate in a given year even when conditions are suitable, is a form of reserve termed a "seed bank." Because suitable habitat is still considered present at these 12 occurrences, they are considered extant. It is possible that spreading navarretia was present only in the seed bank and, therefore, not observed as standing plants when surveys were conducted. During drier years, the species is not as abundant and is more difficult to find, especially during casual surveys. Also presumed extant are seven occurrences known at listing that have not been resurveyed since then.

Restoration of vernal pools with spreading navarretia has included enhancement of existing and historical occurrences, as well as expansion of the species into restored pools on Otay Mesa.

4.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model provided in Attachment B. Specific threats to spreading navarretia can be divided into three major categories:

1. direct destruction of spreading navarretia from construction, grazing, dumping, fire, military development and training, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy spreading navarretia, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, and habitat fragmentation; and

3. potential long-term, cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat is the primary threat to spreading navarretia, especially where urbanization exists. Urbanization of surrounding lands results in fragmentation of spreading navarretia habitat, including protected areas. Lands that are not preserved in perpetuity are subject to significant habitat modification. Acquisition of land and conservation easements have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss and degradation continues. Restoration activities and associated conservation measures for spreading navarretia habitat have been implemented and improved over time, although many areas are still subject to impacts such as nonnative plant invasion, OHV use, trespassing, manure dumping, and alteration of hydrology, which all contribute to lowering the quality of habitat for spreading navarretia.

Impacts associated with competition from invasive nonnative plants, trash dumping, trampling, and climate change (drier conditions and drought) were identified at the time of listing and continue to threaten spreading navarretia. Since listing, human access and disturbance effects associated with adjacent development have been documented to occur at 71% of the spreading navarretia occurrences. Impact from invasive species is the prominent range-wide threat to spreading navarretia populations and is exacerbated by disturbances associated with other threats (e.g., urban development, OHV use). Certain invasive nonnative plants (i.e., *Lolium perenne*) may replace spreading navarretia if conditions are appropriate (USFWS 2009).

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support spreading navarretia could become filled with upland native and nonnative species that outcompete spreading navarretia in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could outcompete spreading navarretia in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact soil moisture, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which spreading navarretia currently grows more vulnerable to the threats of subsequent erosion and especially nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003). Spreading navarretia is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators.

4.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring spreading navarretia populations and the habitat that supports them (AECOM 2006, 2010b, 2010c, 2011). These successful restoration efforts were achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvements to protect the watershed and attract pollinators. Effective weed control in vernal pools that have spreading navarretia has been achieved through hand weeding and herbicide applications, while seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for spreading navarretia was collected from genetically and geographically local populations. These methods resulted in the addition of spreading navarretia to more than 25 pools.

4.8 CURRENT STATUS IN STUDY AREA

Figure 4-1 shows the distribution of spreading navarretia within the study area. The locations of spreading navarretia within the various vernal pool complexes in the study area are included in Attachment A. As shown, spreading navarretia occurs in 112 vernal pools (3.6%) within 10

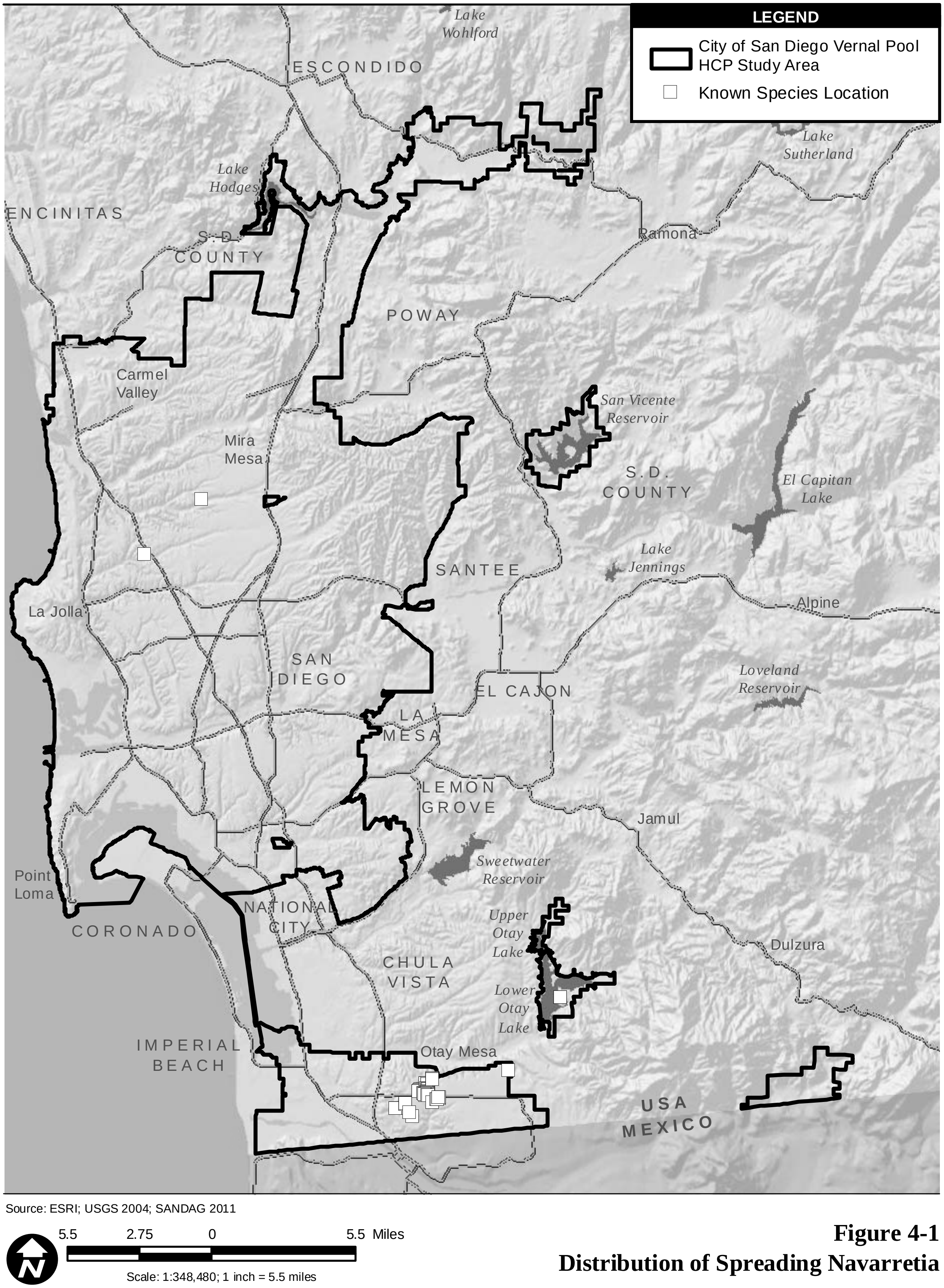

Figure 4-1
Distribution of Spreading Navarretia

complexes. While the exact number of restored vernal pools with spreading navarretia is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 80% of these pools have had some habitat restoration or enhancement.

The soil types that underlie the 10 complexes with spreading navarretia are Redding, Huerhuero, Stockpen, Olivenhain, and Linne. With the exception of one complex (D5-8, also known as Carroll Canyon), all of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH; these specific types of soils may be important to the distribution of spreading navarretia.

CHAPTER 5
SAN DIEGO BUTTON-CELERY

5.1 LISTING STATUS

San Diego button-celery was federally listed as endangered on August 3, 1993 (USFWS 1993). The USFWS 5-year review was completed on September 1, 2010 (USFWS 2010c). No critical habitat has been designated for San Diego button-celery, but the Recovery Plan calls for essentially all populations of San Diego button-celery within the VPHCP Planning Area to be conserved. An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

5.2 SPECIES DESCRIPTION

San Diego button-celery is a biennial or longer lived perennial gray-green herb that has a storage tap-root. It has a spreading shape and reaches a height of 40 centimeters (16 inches) (Constance 1993). The stems and lanceolate leaves give the plant a prickly appearance. San Diego button-celery (var. *parishii*) is one of three varieties of *Eryngium aristulatum* (Constance 1993). San Diego button-celery is separated from common button-celery (var. *aristulatum*) by having styles in fruit that are about the same length as the calyx (outerwhorl of protective structures around the flower) and is separated from Hoover's button-celery (var. *hooveri*) by having bractlets (modified leaves) without callused margins (Constance 1993).

5.3 HABITAT

San Diego button-celery is found in almost every type of Southern California vernal pool, including claypan-, hardpan-, and alluvial-terrace-type pools. San Diego button-celery is known to occur on numerous vernal pool soil types.

5.4 LIFE CYCLE

San Diego button-celery is a vernal pool obligate and relies on ephemerally wet conditions to reproduce, blooming from April through June. San Diego button-celery seems more tolerant of a wider range of vernal pool habitat than most obligate vernal pool species, and can tolerate disturbance factors better than most vernal pool endemics. It is specifically adapted to surviving in vernally wet conditions due to the presence of air channels in the roots that facilitate necessary gas exchange in submerged plants (Keeley 1998).

San Diego button-celery is presumably insect-pollinated (Zedler 1987), potentially by bee flies (*Bombyliids*) (Schiller et al. 2000) and solitary bees (*Apoidea*), as are many vernal pool species (Thorpe 2007). Currently, the level of relationships between pollinators and San Diego button-celery is unknown. If a close ecological relationship exists with San Diego button-celery and its pollinators, conservation of the pollinators at all life stages in habitat near vernal pools may be needed to preserve the efficiency of the pollination service (Thorp 2007). Local and widespread insect extirpations and extinctions have not been well monitored, and are only rarely documented (Dunn 2005). Specialist bee pollinators of vernal pool flowering plants have been well documented in California vernal pools (Thorp 1989, 1998, 2007, 2009; Thorp and Leong 1995). Diversity of insects and insect pollinator presence and diversity in and near California vernal pools within the range of San Diego button-celery is relatively unknown.

Pollinator studies specific to vernal pool species have been conducted in the California Central Valley where the upland habitat may play a crucial role in supporting native bee populations (Thorp and Leong 1998). While native bee species may visit and pollinate vernal pool plants, they often nest in upland areas and are directly affected by changes in the quality of the upland habitats. None of the VPHCP focal species or their genera were monitored during these referenced studies, but it is assumed that upland areas for the vernal pools in Southern California play a similar role for pollinators.

Important differences between San Diego button-celery and the other sensitive vernal pool plant species in Southern California is that San Diego button-celery is a perennial species and has been known to occur in the inter-mound areas, outside of vernal pool basins. San Diego Mesa mint, Otay Mesa mint, California Orcutt grass, and spreading navarretia are all annual species and are highly dependent on the health and quality of the existing seed bank for current and future ecological stability. While a healthy seed bank is important for San Diego button-celery as well, the fact that the plants are perennial means that the seed bank can be almost non-existent and the San Diego button-celery will continue to persist for a number of years, in with fluctuating wet and dry years. In addition, it is safer to use button-celery seed in restoration and enhancement projects because there is less concern with impacting existing seed banks when collecting seed.

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2010c).

5.5 STATUS AND DISTRIBUTION

San Diego button-celery is found in vernal pools in San Diego County at Otay Mesa, Kearny Mesa, Del Mar Mesa, MCAS Miramar, and Marine Corps Base (MCB) Camp Pendleton, and in northern Baja California, Mexico (USFWS 1993). Historically, habitat included a coastal swath from Mesa de Colonet and San Quintin in Baja California, Mexico, north to Los Angeles County. Two specimens were collected in Los Angeles County prior to 1902, including one from Redondo Beach; these were mentioned in a regional flora inventory of the time (Davidson and Moxley 1923) and were verified as San Diego button-celery by Sheikh (1978). Another theory indicates that the plant may have ranged into Ventura County or possibly San Luis Obispo County (Munz 1935); however, specimens representing the latter occurrence are now considered likely a different variety (i.e., *E. a.* var. *hooveri*). Likewise, the specimen that likely served as the basis for the Ventura County report was a misidentified herbarium specimen of *E. vaseyi* (coyote thistle) (Wallace 2009). The current extent of the range of San Diego button-celery is, therefore, less than that known from historical records. The northernmost range of the variety on the Pacific coast is at MCB Camp Pendleton (Wire Mountain). San Diego button-celery can be locally abundant in remnant vernal pools; however, the distribution of this variety has been dramatically reduced due to loss of most (95 to 97%) of vernal pool habitat in San Diego County (USFWS 1998).

5.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model provided in Attachment B. Specific threats to San Diego button-celery can be divided into three major categories:

1. direct destruction of San Diego button-celery from construction, grazing, dumping, fire, military development and training, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego button-celery, including altered hydrology, draining, runoff from adjacent operations, competition by introduced species, loss of pollinators, and habitat fragmentation; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

Loss and modification of vernal pool habitat continues to impact San Diego button-celery. Acquisition of land and conservation easements have preserved vernal pool habitat, but some loss of vernal pool habitat has continued. Threats associated with OHVs continue throughout the range of the variety, including on preserve lands (e.g., Santa Rosa Plateau) and conserved lands (e.g., some sites within the jurisdiction of the San Diego MSCP). Threats associated with mowing and trampling associated with humans and cattle have been reduced. Road construction in urbanized Southern California will likely continue to pose some level of threat to vernal pool habitat. Watershed alterations near vernal pool habitat have caused changes in the hydrological structure and function of some vernal pool habitat. While still a threat throughout the range of the variety, impacts of hydrological alterations have decreased in some areas due to development standards that control run-off and water use. Although military activities continue to impact habitat occupied by San Diego button-celery, some vernal pool habitat has been restored through cooperation with MCAS Miramar and MCB Camp Pendleton via provisions in the Integrated Natural Resource Management Plans.

Threats identified at listing and new threats continue to impact San Diego button-celery (USFWS 1993, pp. 41384–41392). Small population size and effects caused by fragmentation have potential to affect genetic continuity and maintenance of remnant populations. Nonnative species have the potential to and are known to be displacing available habitat, causing competition that San Diego button-celery has not evolved with and increasing the risk for wildfire events that may impact San Diego button-celery (USFWS 2010c). Fire and fire suppression activities are some of the most hazardous stochastic risks to the species, with increasing wildfire size and intensity that can impact vernal pool ecosystems. Extended drought and climate change are potentially range-wide threats to all vernal pool taxa; threats may decrease the long-term viability of small to medium-sized vernal pools through loss of rainfall over several to many years.

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support San Diego button-celery could become filled with upland native and nonnative species that outcompete San Diego button-celery in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could out-compete San Diego button-celery in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

Climate change could also potentially result in temperature changes that may impact soil moisture, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which San Diego button-celery currently grow more vulnerable to the threats of subsequent erosion and especially nonnative/native plant invasion (Ackerly 2005; Graham 1997; and Miller et al. 2003). San Diego button-celery is dependent on a maintained hydrology and surrounding watershed, and adjacent uplands to support pollinators.

5.7 PROPAGATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring San Diego button-celery populations and the habitat that supports them (AECOM 2006, 2010b, 2010c, 2011). These successfully restoration efforts were achieved by applying aggressive programs for weed control, seed bank reestablishment, and upland habitat improvement to protect the watershed and attract pollinators. Effective weed control in vernal pools with San Diego button-celery has been achieved through the use of hand weeding and herbicide applications, while seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for Otay Mesa mint was collected from genetically and geographically local populations. These methods resulted the addition of San Diego button-celery to more than 300.

5.8 CURRENT STATUS IN STUDY AREA

Figure 5-1 shows the distribution of San Diego button-celery within the study area. The locations of San Diego button-celery within the various vernal pool complexes in the study area provided in Attachment A. San Diego button-celery occurs in 860 vernal pools (27.4%) within 26 vernal pool complexes. While the exact number of restored vernal pools with San Diego button-celery is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 45% of these pools have had some habitat restoration or enhancement.

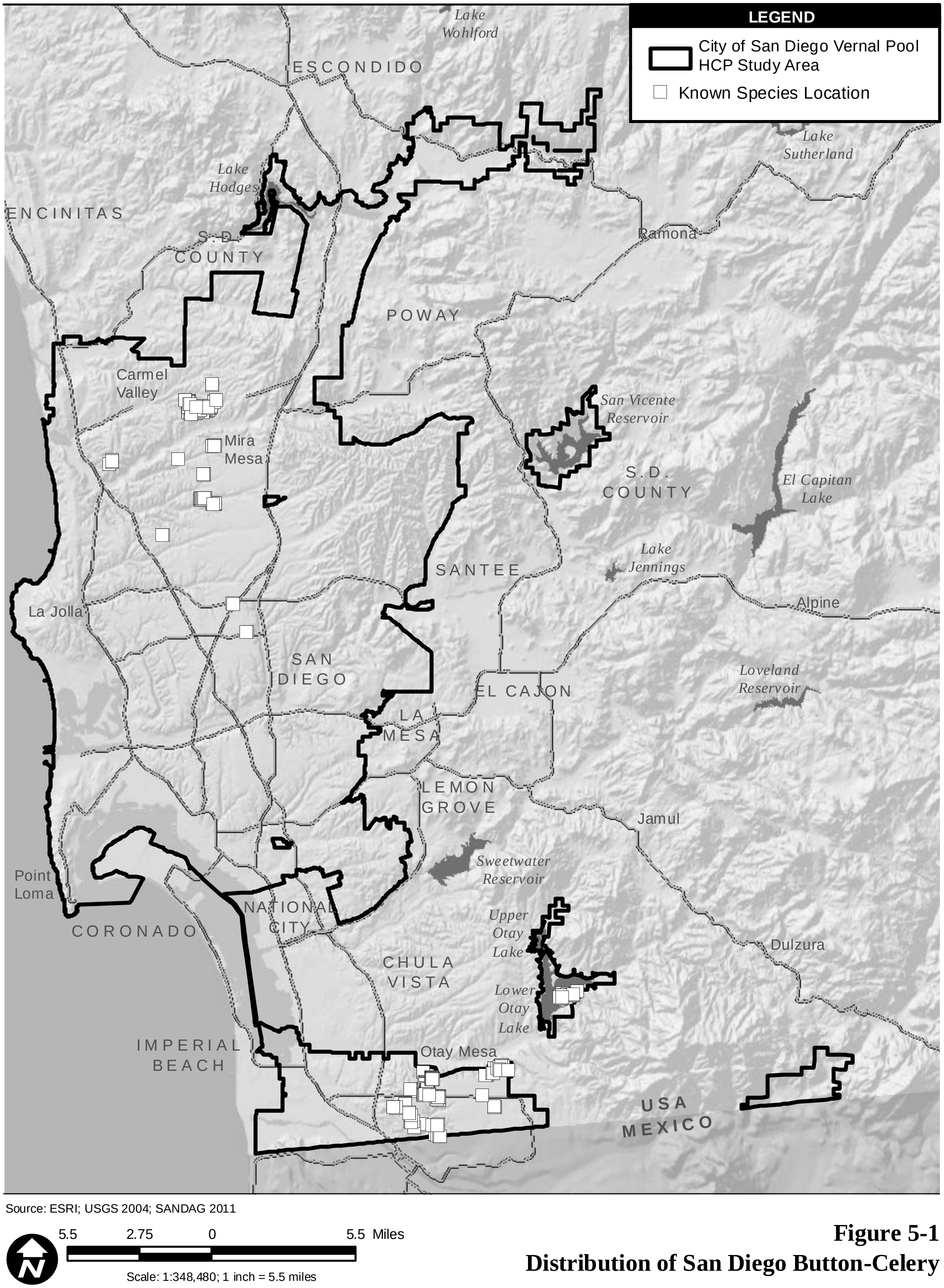

Figure 5-1
Distribution of San Diego Button-Celery

Within the study area, San Diego button-celery occurs across various types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, and Linne. Unlike some of the other sensitive plant species known to occur in Southern California vernal pools, San Diego button-celery does not appear to be restricted to any particular type of soil type. San Diego button-celery can be found on hardpan and claypan pools throughout Southern California, and is found on almost every soil type known to support vernal pools.

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CHAPTER 6
CALIFORNIA ORCUTT GRASS

6.1 LISTING STATUS

California Orcutt grass was federally listed as endangered on August 3, 1993. The species was listed as endangered by the State of California in September 1979. The USFWS 5-year review was completed on March 11, 2011 (USFWS 2011a). No critical habitat has been designated for California Orcutt grass, but the Recovery Plan calls for all populations of Orcutt grass to be conserved and protected (USFWS 1998). An excerpt from the Recovery Plan detailing the conditions required to stabilize the species can be found in Attachment C.

6.2 SPECIES DESCRIPTION

California Orcutt grass is an annual grass in the grass family (*Poaceae*). This species is inconspicuous and prostrate at first, although it develops more erect glandular pubescent stems that grow to be between 5 and 20 centimeters (2 to 8 inches) tall. The plant is bright gray-green in color and secretes sticky droplets. Inflorescences consist of seven spikelets arranged in two ranks, with the upper spikelets overlapping on a somewhat twisted axis. These spikelets are well separated on the lower part of the axis and crowded toward the tip. California Orcutt grass is sparsely hairy with a prostrate stem (USFWS 1998).

6.3 HABITAT

California Orcutt grass is restricted to vernal pools in Southern California, with several historical occurrences reported from northern Baja California, Mexico.

6.4 LIFE CYCLE

The life cycle of California Orcutt grass is dependent on the function of the vernal pool ecosystem. California Orcutt grass typically flowers from April through July and then sets seed. This species is adapted to conditions in the wettest, longest lasting portion of vernal pools. It is less abundant at the shallow periphery of vernal pools that are subject to more rapid changes in moisture (Munz 1974; Reeder 1993). The first significant fall and winter rains begin the process of vernal pool inundation; with no rain, no significant germination of this species will occur. California Orcutt grass seeds germinate while pools are inundated, and the plant appears prostrate during this period. Orcutt grass typically requires at least 15 to 30 days of inundation before germination will occur, so in low rainfall years, there may not be enough ponding to promote adequate germination and the species may remain dormant in the seed bank until an adequate rainfall season (Griggs 1976, 1981). As the season progresses, temperature increases and rainfall declines result in increased evaporation. This stimulates the plants' stems to become more erect, at which time the plant begins to flower. Flowering generally occurs April through June, and by early to mid-summer, the pools become dry. California Orcutt grass relies on fungi to play a role in stimulating germination (Griggs 1976, 1981; Keeley 1988), but it is unclear if this fungal association is present in all populations.

Like the entire grass family, California Orcutt grass is believed to be wind pollinated, although no studies of wind pollination or vector-assisted pollination in this species are currently known (USFWS 2011a).

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2011a).

6.5 STATUS AND DISTRIBUTION

California Orcutt grass is currently considered to be extant at 28 occurrences in four counties of Southern California: three occurrences in Ventura County, three occurrences in Los Angeles County, nine occurrences in Riverside County, and 13 occurrences in San Diego County. Within San Diego County, this species is currently extant at eight pool complexes in Otay Mesa, three pools in MCAS Miramar, one pool in the City of Carlsbad, and one pool in Warner Valley. Two additional populations of this species known from Otay Mesa are presumed to have been extirpated, and the status of a population at a created pool at the Penasquitos Substation is unknown (USFWS 2011a).

Historically, this species was also found on Mesa de Colonet and in pools at San Quintin in northern Baja California, Mexico. There is no current knowledge confirming the contemporary existence of the species in Baja California, Mexico, but the vernal pool habitat that supported these occurrences still persists (USFWS 2011a).

No estimate of numbers of California Orcutt grass specimens at specific sites is currently available. This is likely due to the difficulty of measuring temporal abundance at each occurrence. Local site conditions, rainfall, and fresh water pooling likely influence numbers of standing plants and their local distribution (Schiller et al. 2000). Like most annual plants, the germination success of California Orcutt grass differs annually depending, in part, on timing and amount of rainfall. Yearly variability in rainfall will result in variability in water depth and duration of vernal pools, which can alter the proportion of each pool experiencing particular moisture conditions in a given year. This can have implications for species distribution within and among pools given the narrow habitat preferences and tolerances of many vernal pool plant species (Bauder 2005).

The number of individuals may differ at any site for any year because numbers also depend, in part, on reproductive success of previous cohorts, the number of seeds deposited in the seed bank, and the survivorship of the annual seedling cohort in the year the survey was conducted.

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, California Orcutt grass was found in 58 pools, with a mean percent cover per pool of 3.8%. This relatively low percent cover is due, in part, to plant physiognomy, as California Orcutt grass is a slender, diminutive species that will yield low cover estimates even in areas of relatively high population density (City of San Diego 2004).

6.6 THREATS AND PRESSURES

Threats to endemic vernal pool plant species are illustrated in a conceptual model provided in Attachment B. Specific threats to California Orcutt grass can be divided into three major categories:

1. direct destruction of California Orcutt grass from construction, grazing, dumping, fire, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy California Orcutt grass habitat, including altered hydrology, draining, competition by introduced species, habitat fragmentation, and alteration of natural fire regimes; and

3. potential long-term cumulative impacts, such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

Loss of habitat due to urban and agricultural development has historically been the predominant threat to California Orcutt grass, and is considered a primary threat to vernal pools in Southern California (Bauder 1986, 1987). Populations of California Orcutt grass that are not directly threatened by development are still subject to indirect impacts caused by habitat fragmentation and urbanization of surrounding lands, including OHV use, other human access and disturbance, changed hydrological conditions, invasion by nonnative plants, dumping, pollution, and altered fire regimes. Additionally, even areas of protected habitat may still be affected by direct and indirect impacts that make the habitat less suitable for California Orcutt grass, including OHV use, unauthorized access, and introduction of nonnative species (USFWS 2011a). Furthermore, California Orcutt grass's small population size makes it more vulnerable to demographic, genetic, and environmental stochastic events and natural catastrophes (Asquith 2001; Caughley 1994).

Another possible threat to the species is potential future climate change. The effects of climate change are uncertain, but could include changes in the hydrological parameters that determine the patterns, durations, and depths of ponding. Negative effects could include both drier and wetter hydrological conditions. If conditions become drier, vernal pools that support Orcutt grass could become filled with upland native and nonnative species that outcompete Orcutt grass in dry conditions. Reversely, wetter conditions could lead to a greater abundance of the more aquatic native and nonnative species, which could outcompete Orcutt grass in wet conditions. With vernal pool habitats, even slight changes in hydrological characteristics can lead to dramatic changes in floral composition (Bauder 2005).

In addition to changes in rainfall patterns, climate change could also result in temperature changes that may impact soil moisture, desiccation of pools, and pollinator interaction. Drier conditions could also result in increased fire frequency, making the ecosystems in which Orcutt grass currently grows more vulnerable to the threats of subsequent erosion and nonnative/native plant invasion (Ackerly 2005; Graham 1997; Miller et al. 2003).

California Orcutt grass is restricted to 13 vernal pool complexes in San Diego County, eight of which occur within the jurisdiction of the City and are located in Otay Mesa. As with other vernal pool species, California Orcutt grass is dependent on a maintained hydrology and surrounding watershed.

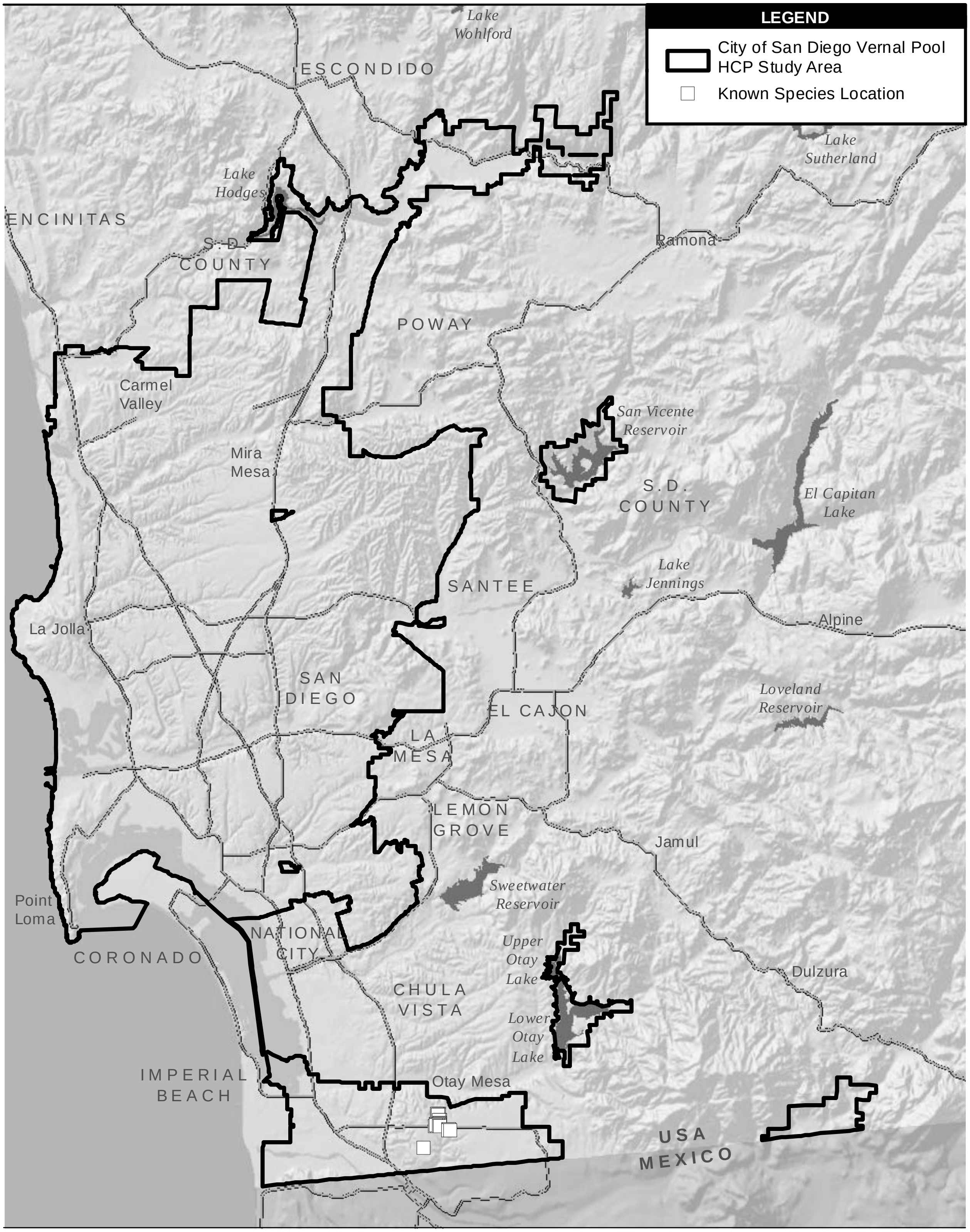
6.7 PROPAGATION AND RESTORATION POTENTIAL

There has been some success in restoring California Orcutt grass populations and the habitat that supports them. These successful restoration efforts have been achieved by applying aggressive programs for weed control, reestablishing the seed bank, and improving upland habitat for watershed protection and pollinators. Effective weed control in vernal pools with California Orcutt grass has been achieved through hand weeding and herbicide applications; seed banks have been rebuilt using a program of seed collection, seed bulking (greenhouse propagation), and seed dispersal. Seed for California Orcutt grass was collected from genetically and geographically local populations. These methods resulted in the addition of California Orcutt grass to more than 25 pools with.

6.8 CURRENT STATUS IN STUDY AREA

Figure 6-1 shows the distribution of California Orcutt grass within the study area. The locations of California Orcutt grass within the various vernal pool complexes in the study area provided in Attachment A. There are 61 vernal pools (1.9%) with California Orcutt grass within 4 vernal pool complexes within the study area. While the exact number of restored vernal pools with California Orcutt grass is not evaluated here, it is estimated that at least 90% of these pools have had some habitat restoration or enhancement.

Within the study area, all of the complexes and pools with California Orcutt grass are on Otay Mesa. The soil types that underlie the complexes with California Orcutt grass are Huerhuero, Olivenhain, Stockpen, and Linne. All of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH; these specific types of soils may be important to the distribution of Orcutt grass.



Source: ESRI; USGS 2004; SANDAG 2011

5.5 2.75 0 5.5 Miles

Scale: 1:348,480; 1 inch = 5.5 miles

Figure 6-1
Distribution of California Orcutt Grass

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\CaliforniaOrcuttGrass.mxd, 9/13/2011, augellop

CHAPTER 7
RIVERSIDE FAIRY SHRIMP

Photograph: C. Brown, USGS

7.1 LISTING STATUS

Riverside fairy shrimp was federally listed as endangered on August 3, 1993. The USFWS 5-year review was completed on September 29, 2008 (USFWS 2008a). A final designation of critical habitat for this species was made on April 12, 2005. The current critical habitat consists of 306 acres of land in four units in Ventura, Orange, and San Diego Counties. USFWS drafted a proposed rule, dated June 1, 2011, to revise the critical habitat for Riverside fairy shrimp. This revision would designate approximately 2,986 acres of land in five units in Ventura, Orange, Riverside, and San Diego Counties, which, if finalized as proposed, would result in an increase of approximately 2,680 acres of critical habitat for this species (USFWS 2011b). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

7.2 SPECIES DESCRIPTION

Riverside fairy shrimp is a small aquatic crustacean in the order Anostraca. Mature males are between 13 and 25 millimeters (0.5 to 1.0 inch) long. The frontal appendage is cylindrical, bibbed at the tip, and extends only part way to the distal end of the basal segment of the antenna. The spur of the thumb is a simple blade-like structure. The finger has two teeth; the proximal tooth is shorter than the distal tooth. The distal tooth has a lateral shoulder that is equal to about half the tooth's total length measured along the proximal edge. The cercopods, which enhance

the rudder-like function of the abdomen, are separate, with plumose setae (feathery bristles) along the medial and lateral borders. Mature females are between about 13 and 22 millimeters (0.5 to 0.87 inch) in length. The brood pouch extends to abdominal segments seven, eight, or nine. The cercopods of females and males are the same (USFWS 1998).

No data is published on the diet of Riverside fairy shrimp. Male Riverside fairy shrimp are distinguished from other fairy shrimp species primarily by the second pair of antennae. The females carry their cysts in an oval or elongate ventral brood sac (Eng et al. 1990; Eriksen and Belk 1999).

7.3 HABITAT

This species is restricted to vernal pools and other non-vegetated ephemeral pools in Riverside, Orange, and San Diego Counties, usually in the elevation range of 30 to 415 meters above sea level. Riverside fairy shrimp is found in warm-water pools that are low to moderate in dissolved solids and are less than predictable in inundation, but are long-lived when inundated. It is the only species in California that has these specific habitat requirements (Eriksen and Belk 1999). Riverside fairy shrimp are usually found in pools that are at least 12 inches deep and can be found in pools that are up to 2 feet deep.

7.4 LIFE CYCLE

The life cycle of Riverside fairy shrimp is dependent on the function of the vernal pool ecosystem. As mentioned above, this species is known from pools that are greater than 30.5 centimeters (12 inches) in depth. The species cannot persist in perennial water bodies because the re-wetting of the dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999). Riverside fairy shrimp are usually observed January through March, although the hatching period may be extended in years with early or late rainfall. Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool, depending on water temperature (Simovich and Hathaway 1996).

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in the same or subsequent rainy seasons. Therefore, cyst "banks" develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the Riverside fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce. If all cysts hatched during an insufficient filling, the species could be extirpated from a pool (Philippi et al. 2001; Simovich 2005; Simovich and Hathaway 1996). The ability of Riverside fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of the species (Ripley et al. 2004; Simovich 2005).

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2008a).

7.5 STATUS AND DISTRIBUTION

Riverside fairy shrimp is currently considered to be extant at 45 known occupied vernal pool complexes (approximately 200 occupied pools), covering an area of approximately 59 acres. Twenty-six of the extant known occupied complexes are in San Diego County, 11 are in Riverside County, and eight are in Orange County. Of the 26 extant occurrences in San Diego County, two are located in MCAS Miramar, one is located in Ramona, one is located in the City of Carlsbad, eight are located in MCB Camp Pendleton, and the remaining 14 are located in Otay Mesa (USFWS 2008a).

Historical occurrences are also reported from the Tierra Rejada Preserve complex in Ventura County, the Los Angeles Airport and Madrona Marsh complexes in Los Angeles County, and from Valle de las Palmas and at Bajamar (north of Ensenada) in Baja California, Mexico. The population formerly present at the Los Angeles Airport complex is known to be extirpated, and there is no current knowledge confirming the contemporary existence of the species in the other locations described above (USFWS 2008a).

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, Riverside fairy shrimp was found in 11.7% (134) of pools (City of San Diego 2004). Due to the small size and life history traits of Riverside fairy shrimp, surveying occurrences for changes in numbers of individuals and demographic trends over time is not feasible. Therefore, population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time (USFWS 2008a).

7.6 THREATS AND PRESSURES

Threats to endangered fairy shrimp species are illustrated in a conceptual model provided in Attachment B. Specific threats to Riverside fairy shrimp can be divided into three major categories:

1. direct destruction of Riverside fairy shrimp from construction, grazing, dumping, trampling, plowing, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy Riverside fairy shrimp habitat, including altered hydrology, exposure to pesticides, invasion by nonnative plant species, habitat fragmentation, and military training activities; and

3. potential long-term cumulative impacts, such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat continues to be a significant threat to the Riverside fairy shrimp, especially in areas where urbanization is expected to expand. Since its listing in 1993, at least nine complexes known to be occupied by Riverside fairy shrimp have been lost to urban development, another 10 complexes have been partially lost to urban development, and eight contain pools that have been damaged, but not lost. Most of these losses and impacts are the result of urban development, international border security, and military-related development and training. Conservation of land and restoration programs have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private lands. Additionally, even preserved lands are often subject to impacts, such as invasion by nonnative plants, OHV use, trespassing, and other conditions and effects that degrade the quality of habitat (USFWS 2008a).

Loss of habitat from grazing was a concern a decade ago; however, currently, grazing is restricted from the vernal pool complexes in San Diego. While some studies have shown that grazing can reduce nonnative thatch accumulation and provide other potential benefits (Marty 2005), these studies have concentrated exclusively on highly disturbed vernal pool habitat in the central and northern portions of California where the habitat is almost entirely nonnative grassland. In San Diego, grazing ultimately converted native upland habitats around vernal pools to nonnative grassland. Grazing is not a viable management tool when the upland habitats are still intact.

Fire is another potential threat to Riverside fairy shrimp. Studies have shown that fire does not directly impact fairy shrimp adults or the cysts in the soils, but can impact the shrimp through habitat destruction (Wells et al. 1997).

Nonnative plants also threaten Riverside fairy shrimp habitat throughout its range by resulting in nonnative thatch accumulation in pools, which can often reduce ponding depth and duration, as well as impact water quality.

Riverside fairy shrimp habitat is also threatened by indirect impacts resulting from the proximity of its habitat to urban development, including OHV use and other human access and disturbance impacts, runoff and altered hydrology, dumping, and water and air pollution. OHV use for recreation, law enforcement (including Border Patrol), and military activities threatens this species throughout much of its range. Riverside fairy shrimp habitat is naturally fragmented, and development projects and other disturbance factors continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species (USFWS 2008a).

Riverside fairy shrimp may also be affected by factors associated with climate change, which has the potential to adversely affect this species through changes in vernal pool inundation patterns and consistency. It is possible that climate warming will cause shifts in the distribution and abundance of species, and the ability of Riverside fairy shrimp to survive will likely depend, in part, on the species' ability to disperse to pools where conditions are suitable (Bohonak and Jenkins 2003; Bonte et al. 2004). However, loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shifts induced by climate change may be more difficult for the species to successfully accommodate. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality, and even modest changes in climate could alter the seasonality and duration of vernal pool hydration (Cayan et al. 2001; Field et al. 1999). These changes could adversely affect Riverside fairy shrimp, as this species is adapted to complete its life cycle within a limited temperature range and requires a minimum length of inundation to reach maturity and reproduce (Pyke and Marty 2005). Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual occurrences, even where occurrences are already known to fluctuate widely (McLaughlin et al. 2002).

Herbicides, specifically glyphosate herbicides, have been used for weed control in upland watershed areas around vernal pools for many years, and specific studies on the effects of common herbicides (malathion and glyphosate) have shown no effects result from herbicide when used at normal rates of application (Ripley et al. 2004).

Riverside fairy shrimp is restricted to 26 vernal pool complexes in San Diego County, 11 of which occur within the jurisdiction of the City and are located on Otay Mesa. As with other vernal pool species, Riverside fairy shrimp is dependent on a maintained hydrology and surrounding watershed.

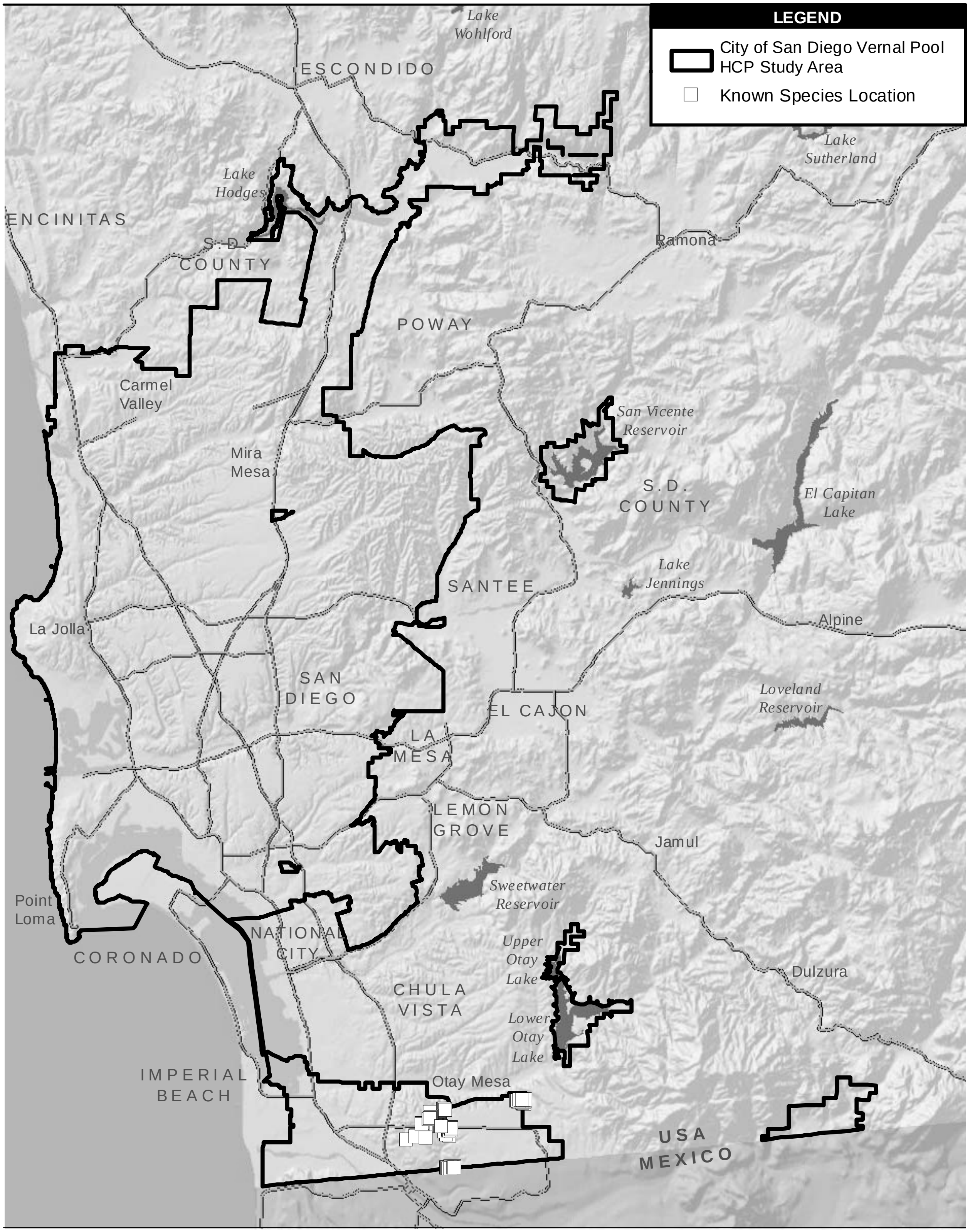
7.7 INNOCULATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring Riverside fairy shrimp populations and the habitat that supports them (AECOM 2006, 2010b, 2010c, 2011). These successful restoration efforts have been achieved by a combination of conducting topographic reconstruction, applying aggressive programs for weed and thatch control, reestablishing cyst banks through inoculation, and improving upland habitat for watershed protection and water quality improvements. Topographic reconstruction has been achieved through a combination of hand and mechanical grading; effective weed and thatch control in vernal pools with San Diego fairy shrimp has been achieved through the use of hand weeding and herbicide applications. Cyst banks have been rebuilt using a program of soil collection and redistribution—cyst soil was collected from genetically and geographically appropriate local populations. These methods resulted in the addition of Riverside fairy shrimp to more than 50 pools.

7.8 CURRENT STATUS IN STUDY AREA

Figure 7-1 shows the distribution of Riverside fairy shrimp within the study area. The locations of Riverside fairy shrimp within the various vernal pool complexes in the study area are included in Attachment A. Riverside fairy shrimp has been identified in 215 vernal pools (6.9%) within 12 vernal pool complexes. While the exact number of restored vernal pool with Riverside fairy shrimp is not evaluated here, AECOM senior restoration ecologist Scott McMillan estimates that at least 95% of these pools have had some habitat restoration or enhancement.

Within the study area, all of the complexes and pools with Riverside fairy shrimp occur on Otay Mesa. The soil types that underlie the 12 complexes with Riverside fairy shrimp are Huerhuero, Stockpen, Olivenhain, Diablo, and Linne**.** All of these complexes are on claypan-type soils that are associated with marine sediments and typically have subsurface layers that are basic in pH, which may be important to the distribution of Riverside fairy shrimp.



Source: ESRI; USGS 2004; SANDAG 2011

5.5 2.75 0 5.5 Miles

Scale: 1:348,480; 1 inch = 5.5 miles

Figure 7-1
Distribution of Riverside Fairy Shrimp

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CHAPTER 8
SAN DIEGO FAIRY SHRIMP

Source: Diolinda Parsick

8.1 LISTING STATUS

San Diego fairy shrimp was federally listed as endangered on February 3, 1997. The USFWS 5-year review was completed on September 30, 2008 (USFWS 2008b). Critical habitat for the San Diego fairy shrimp was designated on October 23, 2000. Critical habitat was remanded but not vacated by the Central District Court of California on June 12, 2002. Critical habitat was re-proposed on April 22, 2003. Revised critical habitat for the San Diego fairy shrimp was designated on December 12, 2007. This final rule designated five critical habitat units (with 29 subunits) for San Diego fairy shrimp on 3,085 acres of land in Orange and San Diego Counties (USFWS 2007). An excerpt from the Recovery Plan (USFWS 1998) detailing the conditions required to stabilize the species can be found in Attachment C.

8.2 SPECIES DESCRIPTION

San Diego fairy shrimp is a small aquatic crustacean in the order Anostraca. San Diego fairy shrimp have large stalked compound eyes, no carapace, and 11 pairs of swimming legs. Mature males attain 16 millimeters (0.6 inch) in length, and females attain 14 millimeters (0.5 inch) in length (USFWS 1998). San Diego fairy shrimp feed on algae, diatoms, and particulate organic matter (Parsick 2002). Male San Diego fairy shrimp are distinguished from other *Branchinecta*

species males by differences in the distal tip of the second antennae. The females carry their cysts in an oval or elongate ventral brood sac (Eriksen and Belk 1999). Females are distinguishable from other *Branchinecta* species females by the shape and length of the brood sac, length of the ovary, and presence of paired dorsolateral spines on five of the abdominal segments. The San Diego fairy shrimp is often misidentified with the versatile fairy shrimp (*Branchinecta lindahli*) (Fugate 1993), which is native to and commonly found throughout western North America (Eng et al. 1990; Simovich 1998).

8.3 HABITAT

This species is restricted to vernal pools and other non-vegetated ephemeral pools in coastal areas of San Diego County, Orange County, and northwestern Baja California, Mexico. San Diego fairy shrimp are restricted to dilute vernal pools, having relatively low sodium concentrations, low alkalinity, and neutral pH (Gonzales et al. 1996). This species is considered a cool-water pool species and is usually found in pools that are less predictable and short lived, usually from 2 to 12 inches in depth, and in the elevation range of 15 to 125 meters above sea level (Eriksen and Belk 1999).

8.4 LIFE CYCLE

The life cycle of San Diego fairy shrimp is dependent on the function of the vernal pool ecosystem. The species cannot persist in perennial water bodies because the re-wetting of the dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999). San Diego fairy shrimp are usually observed January through March when seasonal rainfall fills vernal pools and initiates cyst hatching. Individuals hatch and mature within 7 to 14 days of rainfall filling a pool, depending on water temperature (Simovich and Hathaway 1996). This hatching period may be extended in years with early or late rainfall.

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in the same or subsequent rainy seasons. Therefore, cyst "banks" develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the San Diego fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce. If all cysts hatched during an insufficient filling, the species could be extirpated from a pool (Philippi et al. 2001; Simovich 2005; Simovich and Hathaway 1996). The ability of San Diego fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of the species (Ripley et al. 2004; Simovich 2005).

For more information on the life history of this species and additional references, refer to the USFWS 5-year review (USFWS 2008b).

8.5 STATUS AND DISTRIBUTION

San Diego fairy shrimp is currently considered to be extant at 137 known occupied vernal pool complexes in the United States. One hundred thirty-two of the extant known occupied complexes in the U.S. are in San Diego County and five are in Orange County. The pool complexes in San Diego County are located in Del Mar Mesa, Kearny Mesa, Mira Mesa, Chollas Heights, Mission Trails Regional Park, Marron Valley, Otay Mesa, MCAS Miramar, MCB Camp Pendleton, Poway, Carlsbad, San Marcos, Santee, Ramona, Santa Fe Valley, Naval Base Coronado, Otay Mesa, Sweetwater Reservoir, and Tijuana Slough (USFWS 2008b).

In Baja California, San Diego fairy shrimp have been recorded at two localities: Valle de Palmas, south of Tecate, and Baja Mar, north of Ensenada. The status of these populations is currently unknown. A single isolated female was previously reported from vernal pools in Isla Vista, Santa Barbara County, California; however, directed surveys have not located any additional individuals (USFWS 1998).

In 2003, the City conducted a survey of vernal pools within its jurisdiction. Of the 1,142 vernal pools surveyed, San Diego fairy shrimp was found in 35.7% (408) of pools. *Branchinecta* spp. was identified in an additional 220 pools (City of San Diego 2004). Due to the small size and life history traits of San Diego fairy shrimp, surveying occurrences for changes in numbers of individuals and demographic trends over time is not feasible. Therefore, population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time.

As part of the City's 2003–2004 survey, a study was conducted on the genetic structure of the San Diego fairy shrimp. Past assessments of the genetic structure for this species concentrated on allozyme data and were conducted on a limited number of pools (Davies et al. 1997). The study that was conducted in 2003–2004 looked at mitochondrial DNA (mtDNA), which has a higher degree of precision and allows for a wider range of analyses that can be conducted (Bohonak 2005). This study concluded a number of findings, including:

- San Diego fairy shrimp appears to be a monophyletic lineage, meaning the taxon consists of the species and all its descendants.

- The mtDNA showed significant divergence among hydrologically linked complexes.

- Gene flow between complexes appeared to be much less in areas that are less developed.

- San Diego fairy shrimp may have two separate clades (lineages). With further data, these clades may be considered separate Evolutionarily Significant Units and may warrant separate protection status. These clades do not appear to be linked to any obvious geographic factors.

In 2008, a project was been funded by an Endangered Species Act Section 6 grant to develop a protocol to estimate San Diego fairy shrimp population sizes and conduct population viability analyses in real time to detect a decline preceding the likely extinction of a population (USFWS 2008b).

8.6 THREATS AND PRESSURES

Threats to endangered fairy shrimp species are illustrated in a conceptual model found in Attachment B. Specific threats to San Diego fairy shrimp can be divided into three major categories:

1. direct destruction of San Diego fairy shrimp from construction, grazing, dumping, trampling, plowing, off-road vehicle traffic, and other mechanical disturbances;

2. indirect threats that degrade or destroy San Diego fairy shrimp habitat, including altered hydrology, exposure to pesticides, invasion by nonnative plant species, habitat fragmentation, and military activities; and

3. potential long-term cumulative impacts such as the effects of isolation on genetic diversity and locally adapted genotypes, air and water pollution, drastic climatic variations, competition/hybridization with other species, and changes in nutrient availability (Bauder 1986).

The loss and modification of vernal pool habitat continues to be a significant threat to San Diego fairy shrimp, especially in areas where urbanization is expected to expand. As of 2008, 28 (14 of which are in the City of San Diego VPHCP Planning Area) of the 137 vernal pool complexes occupied by the species had been partially lost to urban development, and about five additional complexes contained pools that had been damaged, but not lost. Most of these losses and impacts are the result of urban development, followed by industrial/commercial development, international border security, and military facilities and training. Acquisition of land and conservation easements have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private land. Additionally, even preserved lands are often subject to impacts, such as invasion by nonnative plants, OHV use, trespassing, and other conditions and effects that degrade the quality of habitat (USFWS 2008b).

Loss of habitat from grazing was a concern a decade ago; however, currently, grazing is restricted from the vernal pool complexes in San Diego. While some studies have shown that grazing can reduce nonnative thatch accumulation and provide other potential benefits (Marty 2005), these studies have concentrated exclusively on highly disturbed vernal pool habitat in the central and northern portions of California where the habitat is almost entirely nonnative grassland. In San Diego, grazing ultimately converted native upland habitats around vernal pools to nonnative grassland. Grazing is not a viable management tool when the upland habitats are still intact.

Fire is another potential threat to San Diego fairy shrimp. Studies have shown that fire does not directly impact fairy shrimp adults or the cysts in the soils, but can impact the shrimp through habitat destruction (Wells et al. 1997).

Nonnative plants also threaten San Diego fairy shrimp habitat throughout its range by resulting in nonnative thatch accumulation in pools, which can often reduce ponding depth and duration, as well as impact water quality.

Indirect impacts to San Diego fairy shrimp result from the proximity of the species' habitat to urban development. These include OHV use and other human access and disturbance impacts, runoff and altered hydrology, dumping, and water and air pollution. OHV use for recreation, law enforcement (including Border Patrol), and military activities threatens this species throughout much of its range. San Diego fairy shrimp habitat is naturally fragmented, but development projects and other disturbance factors continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species (USFWS 2008b).

San Diego fairy shrimp may also be affected by factors associated with climate change, which has the potential to adversely affect this species through changes in vernal pool inundation patterns and consistency. It is possible that climate warming will cause shifts in the distribution and abundance of species, and the ability of San Diego fairy shrimp to survive will likely depend, in part, on the species' ability to disperse to pools where conditions are suitable (Bohonak and Jenkins 2003; Bonte et al. 2004). In addition, loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shifts induced by climate change may be more difficult for the species to successfully accommodate. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality, and even modest changes in climate could alter the seasonality and duration of vernal pool hydration (Cayan et al. 2005; Field et al. 1999). These changes could adversely affect San Diego fairy shrimp, as this species is adapted to complete its life cycle within a limited temperature range and requires a minimum length of inundation to reach maturity and reproduce. (Pyke and Marty 2005) Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual occurrences, even where occurrences are already known to fluctuate widely (McLaughlin et al. 2002).

Another potential threat to San Diego fairy shrimp is artificial dispersal of crustacean species found in vernal pools. A number of natural dispersal agents exist, including wind, animals (rodents and birds), and above-ground water flow. A number of artificial dispersal agents also exist, including mechanized equipment, biological monitoring, and habitat maintenance efforts. These artificial dispersal agents have the potential to increase the amount and degree of natural genetic flow between pools and between pool complexes. This could potentially lead to a homogenization of habitat and the gene pools that are supported by that habitat. Genetically unique populations could be blended into the greater gene pool and permanently lost (Bohonak and Jenkins 2003; Bohonak 2005).

Other potential threats to San Diego fairy shrimp are hybridization and direct competition with the versatile fairy shrimp. The versatile fairy shrimp is common throughout western North America, is found in a wide variety of habitats, and tends to inhabit disturbed sites (Gonzalez et al. 1996). The versatile fairy shrimp has been documented within the range of the San Diego fairy shrimp in relatively disturbed pools at Otay Mesa, MCAS Miramar, Carmel Mountain, and MCB Camp Pendleton. The two species are known to hybridize in the laboratory (Fugate 1998) and in the field (Simovitch et al. in press). If hybridization becomes too frequent in the natural environment, the unique genetics of San Diego fairy shrimp could be lost. The disturbance of vernal pool habitat by vehicles used in military training may increase the distribution of the versatile fairy shrimp on MCB Camp Pendleton. Although the known distribution of versatile fairy shrimp is still fairly limited within the range of the San Diego fairy shrimp, hybridization and competition could threaten the San Diego fairy shrimp in the future should the range of the versatile fairy shrimp expand (USFWS 2008b). While documented nonnative crustaceans use in the vernal pools of Southern California is scarce, future invasion by nonnative crustacean species or other aquatic invertebrate could seriously threaten populations of native crustacean species through direct or indirect competition (Wilcove et al. 1998).

Another recent issue of concern for San Diego fairy shrimp reproduction and genetics is the cytoplasmic incompatibility induced by *Wolbachia* (or similar) bacteria. These bacteria reside in the intracellular space of reproductive tissue of many invertebrates and are maternally inherited from generation to generation. If males and females are infected with different strains of the bacteria, they are usually not reproductively compatible. Because of this, the bacteria can initiate lineage isolation and speciation (Werren et al. 2008). In addition to incompatibility, the bacteria can also lead to biased sex ratios, parthenogenesis (female asexual reproduction), feminization of males, and a high juvenile male mortality. There is substantial evidence that the versatile fairy shrimp harbors feminizing endoparasitic bacteria (Krumm 2006). While there is no evidence of the bacteria in San Diego fairy shrimp, the potential hybridization of the two species suggests that this could be a concern for the genetics and reproduction of the San Diego fairy shrimp.

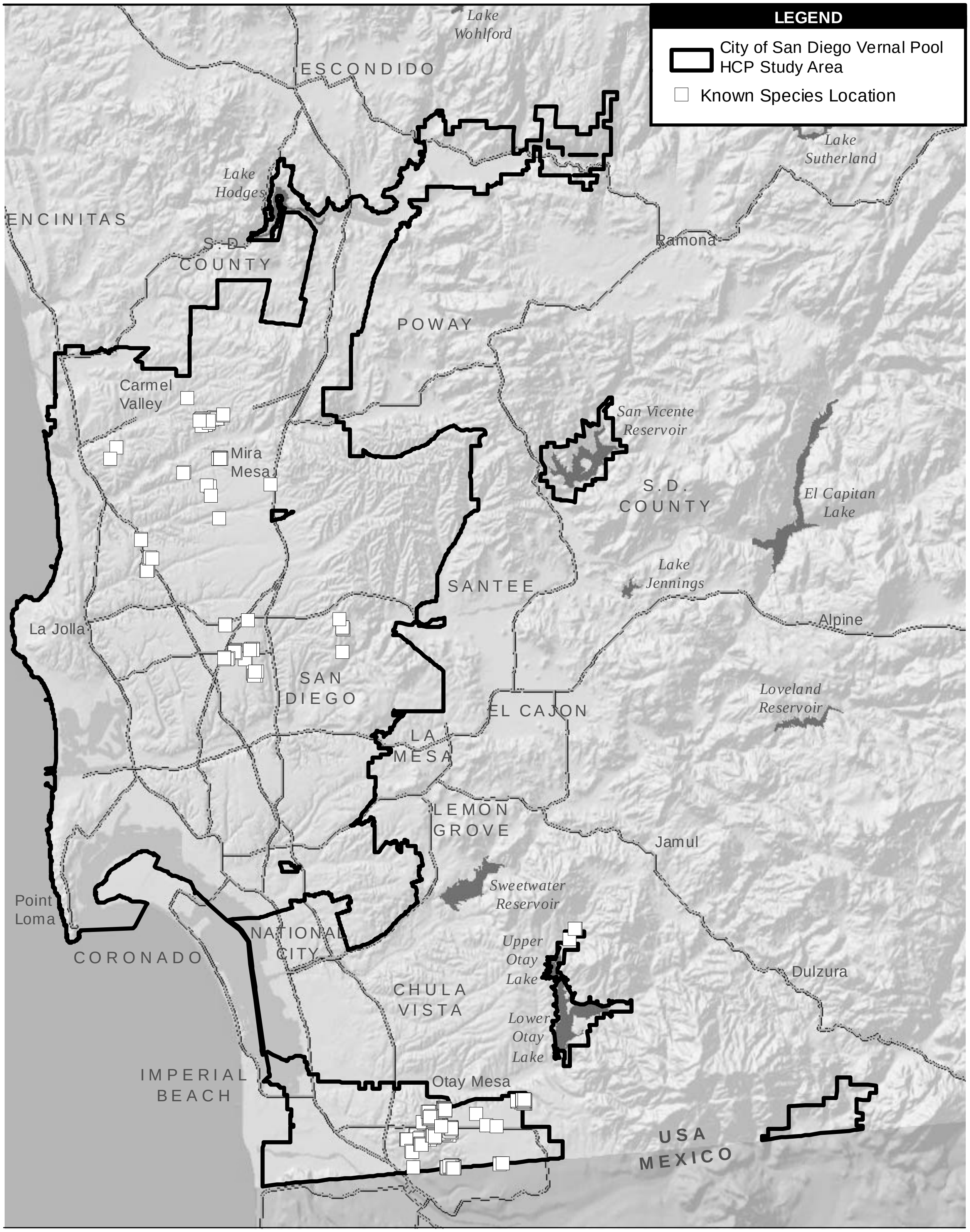
Herbicides, specifically glyphosate herbicides, have been used for weed control in upland watershed areas around vernal pools for many years and specific studies on the effects of common herbicides (malathion and glyphosate) have shown no effects result from herbicide when used at normal rates of application (Ripley et al. 2004).

8.7 INNOCULATION AND RESTORATION POTENTIAL

AECOM and others have had significant success restoring San Diego fairy shrimp populations and the habitat that supports them (AECOM 2006, 2010b, 2010c, 2011). These successful restoration efforts were achieved through a combination of conducting topographic reconstruction, applying aggressive programs for weed and thatch control, reestablishing cyst banks through inoculation, and improving upland habitat for watershed protection and water quality improvements. Topographic reconstruction has been achieved through a combination of hand and mechanical grading; effective weed and thatch control in vernal pools with San Diego fairy shrimp has been achieved through hand weeding and herbicide application. Cyst banks have been rebuilt using a program of soil collection and redistribution. Cyst soil was collected from genetically and geographically appropriate local populations. These methods have resulted in the addition of San Diego fairy shrimp to more than 300 pools.

8.8 CURRENT STATUS IN STUDY AREA

Figure 8-1 shows the distribution of San Diego fairy shrimp within the study area. The locations of San Diego fairy shrimp within the various vernal pool complexes in the study area are included in Attachment A. San Diego fairy shrimp has been identified in 678 vernal pools



Source: ESRI; USGS 2004; SANDAG 2011

5.5 2.75 0 5.5 Miles

Scale: 1:348,480; 1 inch = 5.5 miles

Figure 8-1
Distribution of San Diego Fairy Shrimp

Path: P:\2011\60218732\06GIS\6.3_Layout\SpeciesMaps\SanDiegoFairyShrimp.mxd, 9/13/2011, augellop

(21.6%) within 42 vernal pool complexes. While the exact number of restored vernal pool with San Diego fairy shrimp is not evaluated here, it is estimated that at least 60% of these pools have had some habitat restoration or enhancement.

San Diego fairy shrimp occurs across all types of vernal pool soils, including Redding, Olivenhain, Huerhuero, Stockpen, Diablo, Linne, and Chesterton. These complexes occur on both claypan- and hardpan-type soils, and include every soil type that has been identified to support vernal pools.

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CHAPTER 9
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ATTACHMENT A
VERNAL POOL AND
FOCAL SPECIES DATA

Attachment A
Vernal Pool Complex Data for the City of San Diego Vernal Pool Habitat Conservation Plan Planning Area

Complex ID	Complex Name	Geographic Area	Subject or NOT Subject to City Jurisdiction	Number of Pools per Complex by Ownership			Total Surface Area of Pools	Soils within Complex	Inside or Outside MHPA	Proximity to Other Complexes (Mile)	Focal Species Critical Habitat Present*	Number of Pools Occupied by Focal Species						
				Total	City Controlled	Other Ownership						PONU	POAB	NAFO	ERAR	ORCA	RFS	SDFS
B 11	Mesa Norte	North	Subject	44	0	44	0.60	RdC, TeF	Outside	0.9	None		12		10			24
B 5	Tierra Alta	North	Subject	1	0	1	0.01	RdC, TeF	Within	0.1	None							
B 6	***Lopez Ridge (CDFG)***	***North***	***NOT Subject***	***1***	***0***	***1***	***0.22***	***RdC, TeF***	***Within***	***0.1***	***SDFS***		***1***					
B 7-8	Crescent Heights	North	Subject	7	7	0	0.04	RdC, TeF	Within	0.1	SDFS							1
	Lopez Ridge (City)	North	Subject	10	10	0	0.38	RdC, TeF	Within	0.1	SDFS		10		1			2
C 10-16	***Winterwood***	***North***	***NOT Subject***	***61***	***0***	***61***	***0.81***	***RdC, TeF***	***Within***	***0.2***	***SDFS***		***27***		***7***			***2***
C 17-18	Fieldstone	North	Subject	9	0	9	0.32	RdC	Within	0.2	None		8					
C 27	Mira Mesa Market Center	North	Subject	1	0	1	0.06	RdC	Outside	2	None		1					1
C28	***Jonas Salk Elementary School***	***North***	***NOT Subject***	***81***	***0***	***81***	***0.97***	***RdC***	***Within***	***0.2***	***None***							***1***
D 5-8	Parkdale Carroll Canyon	North	Subject	4	4	0	0.02	RdC, ReE, TeF	Within	0.2	SDFS, NAFO							
	Carroll Canyon	North	Subject	119	119	0	1.19	RdC, ReE, TeF	Within	0.2	SDFS, NAFO		42	1	65			5
F 16-17	***MCAS Miramar***	***Central***	***NOT Subject***	***34***	***0***	***34***	***0.74***	***RdC, ReE***	***Outside***	***0.1***	***None***							
	Menlo KM Parcel	Central	Subject	14	0	14	0.19	RdC, ReE	Outside	0.1	None							1
H 1-10, 13-15,18-23, 24-26	***Del Mar Mesa (State/Federal)***	***North***	***NOT Subject***	***246***	***0***	***246***	***4.68***	***OhF, RdC, RfF, TeF***	***Within***	***0.3***	***SDFS***		***58***		***124***			***16***
	Del Mar Mesa (Private)	North	Subject	5	0	5	0.26	OhF, RdC, RfF, TeF	Within	0.3	SDFS				*2*			*1*
	Del Mar Mesa (City/County)	North	Subject (92)/ ***Not Subject (17)***	109	92	17	0.81	OhF, RdC, RfF, TeF	Within	0.3	SDFS		5		61			8
	Rhodes	North	Subject	156	0	156	0.77	OhF, RdC, RfF, TeF	Within	0.3	SDFS		7		6			4
H 17	Shaw Lorenz	North	Subject	28	0	28	0.24	RdC, RfF, TeF	Within	0.9	None							8
H 33	East Ocean Air Drive	North	Subject	2	0	2	0.03	GaF, RdC	Outside	0.2	None				2			
	SDG&E Substation	***North***	***NOT Subject***	***12***	***0***	***12***	***0.35***	***GaF, RdC***	***Outside***	***0.2***	***None***				***4***			
H 38	Carmel Mountain	North	Subject	64	64	0	0.61	CvC, LvF3, RdC	Within	0.2	SDFS							2
H 39	Greystone Torrey Highlands	North	Subject	19	19	0	0.68	OhC, OhE	Outside	0.3	None		5		3			
I 1	Arjons	North	Subject	34	0	34	0.73	RdC, TeF	Outside	0.2	None		22		15			1
I 12	Pueblo Lands	North	Subject	2	2	0	0.04	RdC, TeF	Within	0.2	None							2
	Pueblo Lands	***North***	***NOT Subject***	***5***	***0***	***5***	***0.05***	***RdC, TeF***	***Within***	***0.2***	***None***							***4***
I 6 B	Ford Leasing (Bob Baker)	North	Subject	8	0	8	0.08	RdC, TeF	Outside	Adjacent	None		7					3
I 6 C	Facilities Development (Eastgate Miramar Associates)	North	Subject	15	0	15	0.24	OhE, OhF	Outside	Adjacent	None		11		2			6
J 11 E	Slump Block Pools	South	Subject	2	0	2	0.63	OhE	Within	0.2	RFS							
J 11 W	J 11 West	South	Subject	5	0	5	0.49	OhE, OhF	Within	0.4	RFS						1	1
J 12	J 12	South	Subject	5	0	5	0.28	OhE, OhF	Within	0.1	SDFS, RFS							
J 13 E	South Otay J 13 East	South	Subject	8	0	8	0.06	HrC, OhF	Within	0.1	SDFS, RFS				1			
J 13 N	South Otay 1 acre (Private)	South	Subject	7	0	7	0.02	HrC	Outside	0.1	None							
	South Otay 1 acre (City)	South	Subject	17	17	0	0.22	HrC	Outside	0.1	None			1	1	1		
	NDU 1 & 2	South	Subject	13	0	13	0.07	HrC	Outside	0.1	None	0	0	1	2	0	0	13
J 13 S	South Otay J 13 South	South	Subject	39	0	39	0.58	HrC	Outside	Adjacent	SDFS, NAFO				7			
	NDU 1 & 2	South	Subject	4	0	4	0.21	HrC	Outside	Adjacent	None							2
	Bachman	South	Subject	2	0	2	0.01	HrC	Outside	Adjacent	SDFS, NAFO							
J 14	***Anderprises (Caltrans)***	South	***NOT Subject***	***30***	***0***	***30***	***0.50***	***GP, OhF, SuB***	***Within***	***Adjacent***	***None***	***1***		***1***			***3***	***4***
	Anderprises (City)	South	Subject	2	2	0	0.01	GP, OhF, SuB	Within	Adjacent	None							
	Cal Terraces (South)	South	Subject	73	73		1.45	GP, OhF, SuB	Within	Adjacent	RSF, SDFS, NAFO	63	0	6	55	5	26	32
	Handler	South	Subject	24	0	24	0.07	GP, OhF, SuB	Within	Adjacent	RSF, SDFS							
	Bachman	South	Subject	2	0	2	0.02	GP, OhF, SuB	Within	Adjacent	RSF, SDFS							
	Brown Field Basins	South	Subject	4	0	4	0.83	GP, OhF, SuB	Within	Adjacent	RSF, SDFS							
J 15	***Arnie's Point***	***South***	***NOT Subject***	***69***	***0***	***69***	***2.79***	***DaF, OhF, SuA, SuB***	***Within***	***0.1***	***RFS***	***15***		***10***	***61***	***3***	***30***	***56***
J 16-18	***Goat Mesa (Federal)***	***South***	***NOT Subject***	***2***	***0***	***2***	***0.15***	***DaF, LsF, OhF, SuA, SuB***	***Within***	***0.1***	***RFS, SDFS***							
	Goat Mesa (Private)	South	Subject	2	0	2	0.01	DaF, LsF, OhF, SuA, SuB	Within	0.1	RFS, SDFS							
	Goat Mesa (City)	South	Subject	15	15	0	0.34	DaF, LsF, OhF, SuA, SuB	Within	0.1	RFS, SDFS				4		1	
	Wruck Canyon	South	Subject	6	6	0	0.02	DaF, LsF, OhF, SuA, SuB	Within	0.1	RFS, SDFS							
J 2	Cal Terraces (North), Otay Mesa Road Parcels	South	Subject	304	304	0	3.53	OhF, SuB	Within	Adjacent	RFS, SDFS, NAFO	286		79	275	52	93	209
	Clayton Parcel	South	Subject	35	35	0	0.27	OhC, OhF, SuB	Within	Adjacent	RFS, SDFS, NAFO				1			2
	St. Jerome's	South	Subject	24	0	24	0.41	OhC, OhF, SuB	Within	Adjacent	RFS, SDFS, NAFO						3	1
J 20-21	La Media ITS	South	Subject	33	0	33	1.43	SuA, SuB	Outside	0.1	None							6
J 21	La Media Swale South	South	Subject	7	0	7	0.21	HrC	Outside	0.1	None							
J 27	Empire Center	South	Subject	10	0	10	0.23	HrC, SuB	Outside	0.2	None				9			
J 28 E	La Media Swale North	South	Subject	5	0	5	0.16	HrC, SuB	Within	0.2	None							

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Vernal Pool Complex Data for the City of San Diego Vernal Pool Habitat Conservation Plan Planning Area

Complex ID	Complex Name	Geographic Area	Subject or NOT Subject to City Jurisdiction	Number of Pools per Complex by Ownership			Total Surface Area of Pools	Soils within Complex	Inside or Outside MHPA	Proximity to Other Complexes (Mile)	Focal Species Critical Habitat Present*	Number of Pools Occupied by Focal Species						
				Total	City Controlled	Other Ownership						PONU	POAB	NAFO	ERAR	ORCA	RFS	SDFS
J 29	***Lonestar W (Caltrans)***	***South***	***NOT Subject***	***10***	***0***	***10***	***0.15***	***OhF, SuA***	***Within***	***Adjacent***	***RFS, SDFS, NAFO***				7		1	4
J3	***J3***	***South***	***NOT Subject***	***1***	***0***	***1***	***0.01***	***OhC, OhE***	***Outside***	***0.1***	***RFS, SDFS, NAFO***							
J 30	***Lonestar E (Caltrans)***	***South***	***NOT Subject***	***103***	***0***	***103***	***4.81***	***LsE, SuA***	***Within***	***Adjacent***	***RFS, SDFS, NAFO***						35	50
	Lonestar E (Private)	South	NOT Subject	62	0	62	0.80	LsE, SuA	Within	Adjacent	RFS, SDFS, NAFO	1			32			
J 31	***Dennery West***	***South***	***NOT Subject***	***47***	***0***	***47***	***0.97***	***OhC, OhF, SuB***	***Within***	***0.1***	***RSF, SDFS***						10	38
	Hidden Trails	South	Subject	66		66	0.66	OhC, OhF, SuB	Within	0.1	RFS, SDFS							1
J 32	***West Otay A***	***South***	***NOT Subject***	***22***	***0***	***22***	***0.24***	***HrC***	***Within***	***0.2***	***NAFO***	***8***		***3***	***3***		***1***	***8***
	West Otay B	South	Subject	15	15	0	0.06	HrC	Within	0.2	NAFO							
	West Otay C	South	Subject	7	7	0	0.04	HrC	Within	0.2	NAFO				1			
J 33	***Sweetwater High School***	***South***	***NOT Subject***	***8***	***0***	***8***	***0.07***	***OhC, OhF***	***Outside***	***Adjacent***	***RFS, NAFO***	***5***		***3***	***2***		***3***	***8***
J 34	Bachman	South	Subject	15	0	15	0.09	HrC, OhC, OhF, SuB	Within	Adjacent	RFS, SDFS							1
	Candlelight	South	Subject	27	0	27	0.41	HrC, OhC, OhF, SuB	Within	Adjacent	RFS, SDFS						2	15
J 35	Brown Field	South	Subject	28	28	0	3.03	DaF, GP, OhF, SuA, SuB	Within	Adjacent	None	0	0	0	1	0	0	3
J 36	Southview	South	Subject	17	0	17	0.11	OhC, OhF, SuB	Within	Adjacent	RFS, SDFS							12
J 4-5	Robinhood Ridge	South	Subject	83	83	0	0.56	OhF, SuB	Within	0.1	RFS, SDFS, NAFO	19		4	46		6	41
	California Crossing	South	Subject	11	0	11	0.09	OhF, SuB	Within	0.1	RFS, SDFS							5
K 5	Otay Lakes	Central	Subject	85	85	0	3.20	OhE, OhF, ReE, SmE, SnG, TuB	Within	1.6	SDFS, NAFO			2	46			6
KK1	Lake Murray	Central	Subject	1	1	0	0.02	TuB	Within	0.5	None							
KK 2	Pasatiempo	Central	Subject	10	10	0	0.04	BsC, DcD	Outside	0.5	None							
MM 1	Marron Valley	South	Subject	18	18	0	0.18	HrC, HrC2, Rm, SvE, VbB	Within	8.2	SDFS							5
N 1-4	Teledyne Ryan	Central	Subject	43	0	43	0.59	RdC	Outside	0.3	None		1					11
N 5-6	Montgomery Field	Central	Subject	282	282	0	8.35	CfB, CgC, OhE, RdC	Within	Adjacent	SDFS, NAFO		129					17
N 7	Serra Mesa Library	Central	Subject	26	26	0	0.41	RdC, RhC	Within	Adjacent	None							
N 8	General Dynamics	Central	Subject	22	0	22	0.40	RdC	Within	0.2	None		20		2			6
NC	Li Collins	North	Subject	2	0	2	0.04	HrE2, LeE, OhC	Within	1.1	None							
	Kelton	South	Subject	3	3	0	0.02	HrE2, LeE, OhC	Within	1.1	None							
OO	Salk Institute	North	Subject	15	0	15	0.09	CbB, CfB	Within	2.4	None							
Q2	***Mission Trails Regional Park School District***	***Central***	***NOT Subject***	***2***	***0***	***2***	***0.02***	***OhF, RdC, ReE, VbB***	***Within***	***1.6***	***None***							
	Mission Trails Regional Park	Central	Subject	17	17	0	0.25	OhF, RdC, ReE, VbB	Within	1.6	None							6
Q 3	Castlerock	North	Subject	9	0	9	0.05	DoE	Outside	1.6	None	0	0	0	0	0	0	4
QQ	Tecolote Canyon	Central	Subject	9	9	0	0.09	CgC, GaF, HrC, TaF	Within	1.7	None							
R 1	Proctor Valley	South	Subject	124	124	0	1.40	DoE, FxE, OhC, OhE, PfC, Rm, SnG, VbB	Within	2.2	NAFO							3
U 15	SANDER	Central	Subject	39	39	0	0.83	RdC, ReE	Outside	0.3	SDFS		1					2
U 19	Cubic	Central	Subject	29	0	29	0.45	RdC	Outside	0.1	SDFS		1		2			7
X 5	Nobel Drive	North	Subject	11	11	0	0.10	HrE2, RdC	Within	0.1	NAFO			1				6
X 7	Nobel Research	North	Subject	28	0	28	0.10	RdC	Within	0.1	None							1
Subtotal (Pools Included in TWP 1 Study Area)				**3,137**	**1,527**	**1,610**	**58.78**					**398**	**368**	**112**	**860**	**61**	**215**	**678**
N/A	***MCAS Miramar***	***Central***	***NOT Subject***	***7,531***	***0***	***7,531***	***ND***	***ND***	***Outside***	***ND***	***ND***	***0***	***1,112***	***6***	***1,795***	***2***	***0***	***4,051***
Total in VPHCP Planning Area				**10,668**	**1,527**	**9,141**						**398**	**1,480**	**118**	**2,655**	**63**	**215**	**4,729**

ND= No Data

*= Critical habitat is designated by USFWS for San Diego fairy shrimp (SDFS) and spreading navarretia (NAFO), and proposed for Riverside fairy shrimp (RFS).

[shaded] = Land not owned by City of San Diego. ***Bold*** = Land not owned by City of San Diego or under the City of San Diego's land use authority.

Soil Types Legend

MUSYM	Description	Category
BsC	Bosanko clay, 2 to 9% slopes	Bosanko clay
CbB	Carlsbad gravelly loamy sand, 2 to 5% slopes	Carlsbad gravelly loamy sand
CbC	Carlsbad gravelly loamy sand, 5 to 9% slopes	Carlsbad gravelly loamy sand
CfB	Chesterton fine sandy loam, 2 to 5% slopes	Chestern fine sandy loam
CgC	Chesterton-Urban land complex, 2 to 9% slopes	Chestern-Urban land complex
DaF	Diablo clay, 30 to 50% slopes	Diablo clay
DcD	Diablo-Urban land complex, 5 to 15% slopes	Diablo-Urban land complex
DoE	Diablo-Olivenhain complex, 9 to 30% slopes	Diablo-Olivenhain complex
FxE	Friant rocky fine sandy loam, 9 to 30% slopes	Friant rocky fine sandy loam
GaF	Gaviota fine sandy loam, 30 to 50% slopes	Gaviota fine sandy loam
GP	Gravel pits	Gravel pits
HrC	Huerhuero loam, 2 to 9% slopes	Huerhuero loam
HrC2	Huerhuero loam, 5 to 9% slopes, eroded	Huerhuero loam
HrE2	Huerhuero loam, 15 to 30% slopes, eroded	Huerhuero loam
LeE	Las Flores loamy fine sand, 15 to 30% slopes	Las Flores loamy fine sand
LsE	Linne clay loam, 9 to 30% slopes	Linne clay loam
LsF	Linne clay loam, 30 to 50% slopes	Linne clay loam

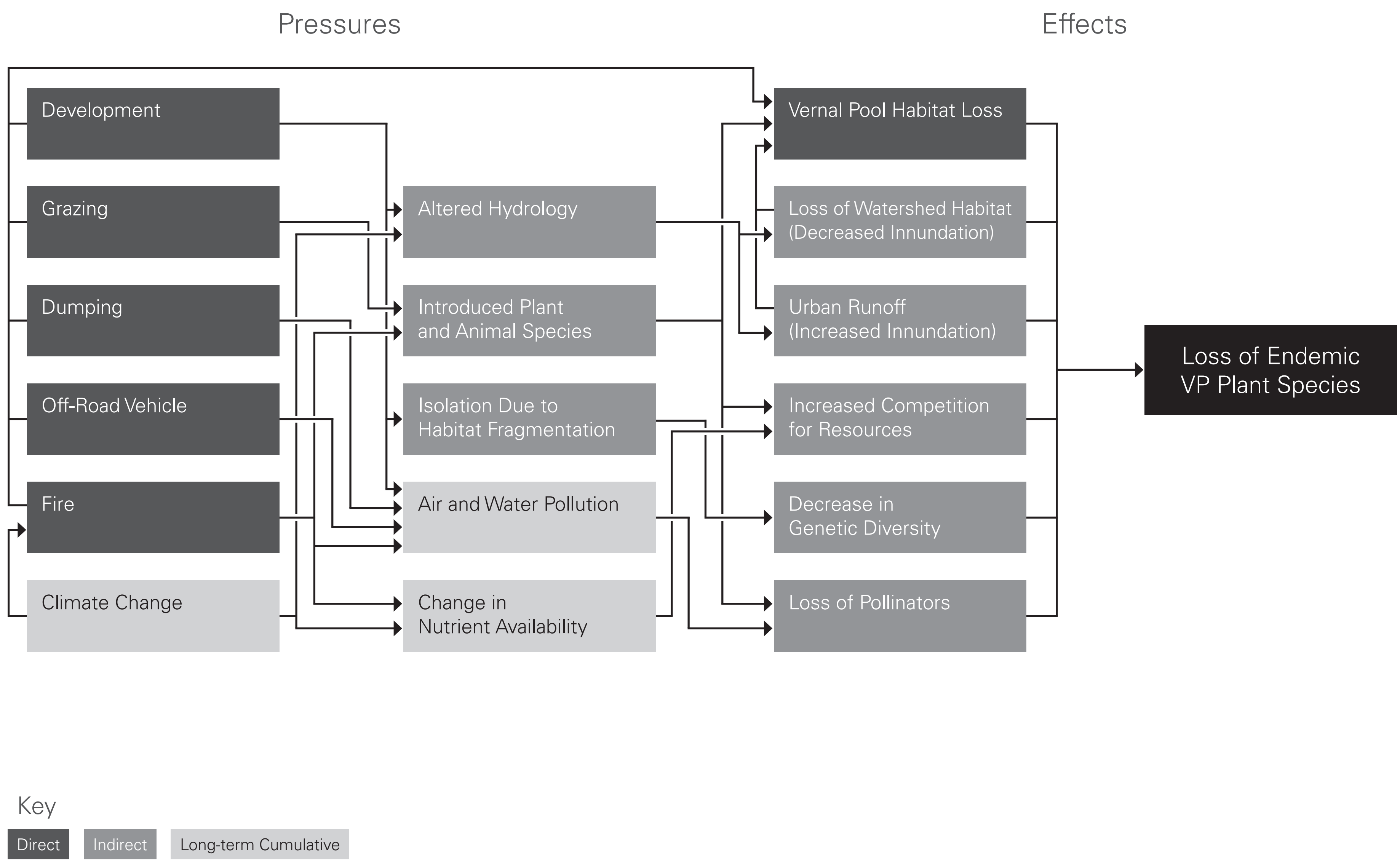
Attachment A
Vernal Pool Complex Data for the City of San Diego Vernal Pool Habitat Conservation Plan Planning Area

LvF3	Loamy alluvial land-Huerhuero complex, 9 to 50% slopes, severely eroded	Loamy alluvial land-Huerhuero complex
MlC	Marina loamy coarse sand, 2 to 9% slopes	Marina loamy coarse sand
OhC	Olivenhain cobbly loam, 2 to 9% slopes	Olivenhain cobbly loam
OhE	Olivenhain cobbly loam, 9 to 30% slopes	Olivenhain cobbly loam
OhF	Olivenhain cobbly loam, 30 to 50% slopes	Olivenhain cobbly loam
PfC	Placentia sandy loam, thick surface, 2 to 9% slopes	Placentia sandy loam
RdC	Redding gravelly loam, 2 to 9% slopes	Redding gravelly loam
ReE	Redding cobbly loam, 9 to 30% slopes	Redding cobbly loam
RfF	Redding cobbly loam, dissected, 15 to 50% slopes	Redding cobbly loam
RhC	Redding-Urban land complex, 2 to 9% slopes	Redding-Urban land complex
RhE	Redding-Urban land complex, 9 to 30% slopes	Redding-Urban land complex
Rm	Riverwash	Riverwash
SmE	San Miguel rocky silt loam, 9 to 30% slopes	San Miguel rocky silt loam
SnG	San Miguel-Exchequer rocky silt loams, 9 to 70% slopes	San Miguel-Exchequer rocky silt loams
SuA	Stockpen gravelly clay loam, 0 to 2% slopes	Stockpen gravelly clay loam
SuB	Stockpen gravelly clay loam, 2 to 5% slopes	Stockpen gravelly clay loam
SvE	Stony land	Stony land
TeF	Terrace escarpments	Terrace escarpments
TuB	Tujunga sand, 0 to 5% slopes	Tujunga sand
VbB	Visalia gravelly sandy loam, 2 to 5% slopes	Visalia gravelly sandy loam
W	Water	Water

ATTACHMENT B
CONCEPTUAL MODELS OF SPECIES PRESSURES

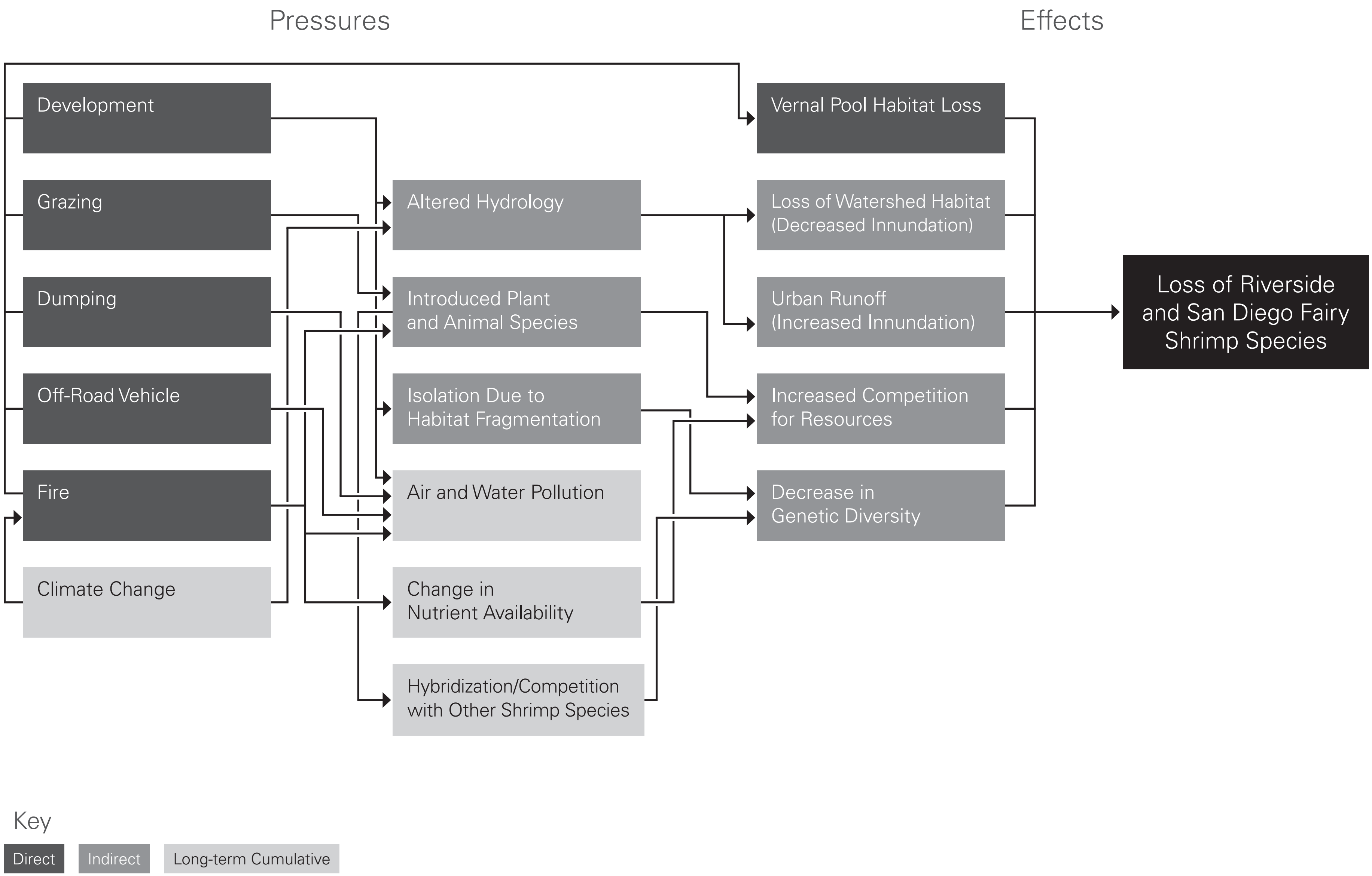
ATTACHMENT B-1

Conceptual Model of Pressures Affecting Endemic Vernal Pool Plant Species in San Diego, CA



ATTACHMENT B-2

Conceptual Model of Pressures Affecting Endangered Fairy Shrimp Species in San Diego, CA



ATTACHMENT C
USFWS VERNAL POOL RECOVERY PLAN EXCERPT

Attachment C
Excerpt from USFWS Vernal Pool Recovery Plan (1998)

Recovery Criteria

Reclassification to threatened status may be considered for *Eryngium aristulatum* var. *parishii, Pogogyne abramsii, Pogogyne nudiuscula, Orcuttia ca/Wornica;* San Diego and Riverside fairy shrimp; and the long-term conservation of *Navarretia fossalis,* a species proposed as threatened, will be assured when the following criteria are met:

1. The following conditions must be met to maintain the current status of *Navarretia fossalis, Eryngium aristulatum* var. *parishii, Pogogyne abramsii, Pogogyne nudiuscula, Orcuttia californica,* and San Diego and Riverside fairy shrimp in order to maintain genetic diversity and population stability of the listed species and other sensitive species:

   Existing vernal pools currently occupied by *Orcuttia californica, Pogogyne nudiuscula,* and Riverside fairy shrimp and their associated watersheds should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

   Existing vernal pools and their associated watersheds within the Transverse and Los Angeles Basin-Orange Management Areas should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

   Existing vernal pools and their associated watersheds within the San Marcos vernal pool complexes that contain *Navarretiafossalis, Eryngium aristulatum* var. *parishii,* or any other vernal pool species, should be secured from further loss and degradation. Habitat functions and species viability for any of the remaining vernal pools and their associated watersheds within the San Marcos complexes must be ensured;

   Existing vernal pools and their associated watersheds within the Ramona complexes that contain *Eryngium aristulatum* var. *parishii, Navarretia fossalis,* San Diego fairy shrimp, or any other vernal pool species, should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability;

   Existing vernal pools and their associated watersheds within the Hemet complexes that contain *Navarretia fossalis,* and *Orcuttia californica,* or any other vernal pool species,

should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability,

Existing vernal pools and their associated watersheds located on Stockpen soils (Otay Mesa) should be secured from further loss and degradation in a configuration that maintains habitat functions and species viability, to provide for the recovery of species restricted to this soil type (i.e., *Pogogyne nudiuscula);* and

Remaining vernal pools and their associated watersheds contained within the complexes identified in Table 4 must be secured in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks).

2. The existing vernal pools and their associated watersheds contained within the complexes identified in Table *5* are secured in a configuration that maintains habitat function and species viability (as determined by recommended research).

3. Secured vernal pools are enhanced or restored such that population levels of existing species are stabilized or increased.

4. Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to consideration for reclassification. Monitoring should continue for a period of at least 10 years following reclassification to ensure population stability.

Delisting of each of the species is conditional on the downlisting criteria shown above, improvement (stabilized or increasing population trends) at all currently known sites; restoration, protection, and management of the minimum habitat area and configuration needed to ensure long-term viability; and establishing historic but locally extirpated species populations when needed to ensure viability.