APPENDIX E-2:

SLENDER-HORNED SPINEFLOWER ENHANCEMENT AND RELOCATION PLAN

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Slender-horned Spineflower Enhancement and Relocation Plan
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For: Upper Santa Ana Wash Task Force
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Introduction

Management for the federally and State endangered slender-horned spineflower (*Dodecahema leptoceras*) is part of the Upper Santa Ana River Habitat Conservation Plan (USAR HCP). To date, no attempts to enhance or improve the status of known occurrences of this spineflower or to establish novel occurrences have been made. The mitigation strategy of the USAR HCP includes attempting to improve the status and/or distribution of slender-horned spineflower within the Plan Area prior to mining certain occupied habitat areas.

Purpose of Study

The ability to reproduce successfully is primary to the persistence of annual plants and is a result of the number of plants that germinate, survive to flower, and then produce potentially viable seed. This program is proposed to enhance successful reproduction through habitat manipulation.

Study Goals and Objectives

The goals of this proposal are two-fold: 1) enhance or improve the status of known occurrences of spineflower within the Plan Area and 2) successfully establish occurrences of spineflower within the Conservation Area of the USAR HCP.

Enhancement

For the purposes of this management aspect of the USAR HCP, the status of existing occurrences of spineflower is defined as the relative germination, survivorship to reproduction and/or seed production in treated versus untreated test areas. Enhancement of the status of spineflower occurrences will be done through habitat manipulations and the initial focus of these manipulations will be the removal and control of exotic annual grasses. Depending upon the success of grass control efforts and/or an evaluation of new information, other habitat manipulations may be attempted. Fire is not considered a viable option of habitat manipulation given the proximity of urban development to the HCP Plan Area and because wash vegetation is infrequently subjected to fire; the primary habitat disturbance being flooding.

Relocation

A relocated or novel occurrence is defined as an occurrence established through the introduction of seed and/or plants into unoccupied habitat and that demonstrates recurrent germination, survivorship to reproduction and seed production over a multi-year period. The relocation of spineflower within the Conservation Area will be undertaken through

various trial methods of seed and/or plant relocation. Although spineflower is an annual plant, plants of the related annual spineflower, the San Fernando Valley Spineflower (*Chorizanthe parryi* var. *fernandina*), have been successful (Sapphos Environmental Inc. 2001, 2003).

Distribution of Spineflower within the HCP Plan Area

Slender-horned spineflower is considered to be a naturally rare plant (CNPS 2001). These plants are typically found on alluvial benches and terraces away from the active channel in areas receiving little surface disturbance from flooding, but that are subject to sheet flood flows (USFWS 1987).

In the Santa Ana River floodplain, slender-horned spineflower is largely restricted to the Plan Area. A single occurrence is known from outside of the Plan Area within the Woolly-Star Preserve Area that was established as a part of the U.S. Army Corps of Engineers' Seven Oaks Dam Mainstem Project. Slender-horned spineflower occurs in multiple, spatially discrete locations, or patches, within the upper Santa Ana River wash (use Dudek HCP figure here?). All patches of spineflower within the wash are considered "occurrences" as genetic data do not suggest that they are distinct populations (Ferguson 1999).

Biology of the Slender-horned Spineflower

Taxonomy

At the time of listing, the species was classified as *Centrostegia leptoceras* (Gray) Wats. [*Centrostegia l.* Gray. *Eriogonella l.* Goodm.]. Cytological studies (Hardham 1989) and the distinct morphology of the involucre resulted in another taxonomic revision, and this spineflower is now considered to be a monospecific genus; *Dodecahema* (A. Gray) (Reveal and Hardham).

General Distribution and Habitat Characteristics

This species is sparsely distributed over a wide geographic area within the Transverse and Peninsular mountain ranges (*e.g.,* the San Gabriel, San Bernardino, and San Jacinto mountain ranges) (Stephenson and Calcarone 1999). Based on collection data, the historic distribution of this spineflower appears to have been much wider than the current known distribution of this species (CNDDB 2007, Consortium of California Herbaria 2007).

Comparisons of historic aerial photographs suggest that the current distribution pattern of slender-horned spineflower is primarily confined to older upland alluvial benches (*i.e.,* 50 years or older). This is supported by empirical observations (CNDDB 2007) and research that determined that the studied terraces supporting this genus are from 100 to over 500 years in age (Wood and Wells 1997).

The slender-horned spineflower and other closely-related species of spineflower typically occur in open, sandy habitat in a mosaic of perennial vegetation (CNDDB 2007, Kluse and Doak 1999, Sapphos Environmental Inc. 2003). The localized distribution of rare

and endemic plants could be explained by herbivory, soil pathogens, intolerance of habitat conditions, or lack of seed dispersal (Baskin and Baskin 1998; Kunin and Gaston 1993). Studies have shown that slender-horned spineflower distribution does not appear to be limited by herbivory or seed predation (Ferguson 1999), or soil pathogens (Young and Allen 2000). The soils occupied by this spineflower appear to have distinctive edaphic characteristics (Allen 1996).

For reasons that are not clear, a noticeable increase in the distribution and density of exotic annual grasses has been noted by many botanists familiar with local slender-horned spineflower habitats; most of the populations that have been in observable decline are also colonized by exotic annual grasses (CNDDB 2007; MEC Analytical Systems 2002). The biological invasion of native plant communities in California has severely reduce the quality of habitat for native forb systems with both live grasses (Coleman and Levine 2006) and thatch negatively impact these forbs (Bergelson 1990).

Demography
Spineflower typically germinates concurrently with other winter-germinating annual forb species following winter rains; but, where they are co-located, it is preceded in germination by exotic annual grass species; primarily rattail fescue (*Vulpia myuros*) and red brome (*Bromus rubens* ssp. *madritensis*) (Ferguson 1999). As is typical of other annual forbs, the yearly abundance of spineflower varies tremendously (Ferguson 1999). The number of plants that survive long enough to flower is highly variable with more plants flowering during cool and wet seasonal conditions and far fewer surviving to flower during drought conditions (Ferguson *et. al.* 1996).

Weather conditions appear to govern seed production more than any other factor such as ovule abortion or seed predation (Ferguson 1999). Slender-horned spineflower plants exhibited a complex phenotypic response to environmental conditions such as total precipitation such that seed production is limited by two environmental extremes: the hot, dry, windy weather condition known as a "Santa Ana" and cool, rainy spring weather. Under hot and dry conditions, plants die before many flowers are produced and seed can be set. Under unseasonably cool or damp conditions, plants favor vegetative growth over reproductive growth and hence, produce far fewer seeds (Ferguson 1999). Comparison of the levels of observed seed production in slender-horned spineflower to that reported for other annual plants growing in drought-prone habitats suggests that seed production for this species may be low (Kemow and Raynal 1993 and Jeffries *et. al.* 1981 in Ferguson 1999), but further investigation is necessary. Only one insect, a native wasp, has been identified as a potential pollinator (Ferguson *et. al.* 1996). No rigorous investigation to identify pollinators has been undertaken.

Although nothing is known about the length of time that seeds can remain viable in the ground (*i.e.*, in the soil seed bank), both demographic and genetic diversity studies indicate that the seed bank is long-lived (Ferguson and Ellstrand 1999). Field observations indicate that some level of surface disturbance, such as sheet flows (Ferguson *et. al.* 1996) and soil disturbances enhance germination in years following the disturbance (CNDDB 2007). Without disturbance, seeds may reside too deeply in the

soil layer to germinate; however, no studies to determine the depth or spatial extent of the seed bank have been undertaken. Seeds collected from plants in the field germinated easily in the laboratory when wetted and pre-germination treatments, such as scarification or cold treatments, have not been found to enhance this process in slender-horned spineflower (Ferguson *et. al.* 1996) or the closely related San Fernando Valley Spineflower (Jones *et. al.* 2002); hence, endogenous dormancy was not detected in seeds of either of these species collected prior to natural dispersal.

Seed-dispersal could occur via animals (*e.g.*, carried by hooking onto fur or feathers) or insects (*e.g.*, collected and cached by ants), however this has not been determined and seeds lack eliasomes, a specialized dispersal mechanisms attractive to ants (N. Ferguson, USFWS, personal observations).

Genetics
The average level of genetic diversity found in this species is high relative to other rare and endemic annual plant species indicating that the genetic effects of small population sizes and isolation such as inbreeding and a low level of gene diversity are not apparent in this species (Ferguson 1999). The level of gene similarity (or homozgosity) detected in this species indicates that it has a mixed mating system (*e.g.*, seed is produced both through pollination between flowers on a single plant and between flowers on different plants) and that self-pollination occurs more frequently than pollination between plants (Ferguson *et. al.* 1996).

Further experiments were done to compare the genetic diversity in germinating plants and seed produced over a 3-year period (Ferguson 1999). Ferguson's multi-year study found that germinated plants within study populations in Riverside and San Bernardino counties had significantly greater levels of gene diversity than did the seeds they produced. Therefore, plants germinate from seeds deposited in the soil at least one year and probably several years prior to their germination. This finding supports the empirical observation that plants germinate abundantly following years in which few plants were observed (CNDDB 2007, Ferguson 1999).

Experimental Methodology

A. Establishment of Baseline Conditions

Purpose: To locate and mark study plots according to study design.
Objective: To establish control- and treatment-plot conditions prior to treatment applications.

Possible Treatments:

i. GPS mapping of spatial extent of study occurrences will be undertaken once plants can be identifiable in the field.
ii. Establish baseline conditions within study-designed plots and record, at a minimum, the relative abundance of spineflower and annual forbs and grasses in treatment and control plots.

B. Spineflower Germination
Purpose: To increase germination from the seed bank in any given year under natural conditions.
Objectives: Implement treatments to control exotic annual grasses in occupied areas and/or to conduct habitat manipulations to expose a greater proportion of the soil seed bank.

Possible Treatments:

i. Application of a pre-emergent, grass-specific herbicide(s) as recommended by manufacturer.
ii. Hand-pulling of exotic annual grasses following adequate germination.
iii. Removal of dead grass thatch.
iv. Habitat manipulation to expose deeper layers of the soil seed bank.

B. Relocation
Purpose: To establish novel, self-sustaining occurrences of spineflower within protected habitat.
Objective: Relocation of soils containing spineflower seeds and/or plants to areas not known to be occupied by the species.

Possible Treatments:

i. Select relocation sites using edaphic soils characteristics as identified by Allen 1996.
ii. Collect soils from known occupied spineflower habitat for relocation. Experimental collection methods could include use of a hand-held vacuum, raking, or using heavy-equipment to move soils.
iii. Deposit collected material seed bank into relocation sites. Experimental pre-treatments of relocation sites could include habitat manipulations such as soils removal or weeding.
iv. Record relative abundance of spineflower and annual forbs and grasses following methodology established in baseline.
v. Estimate seed production by collecting infloresences from senesced plants within treated and untreated plots. Reproductive output will be measured as the number of developed seeds per involucre.

Data Acquisition and Management
The spatial extent of selected occurrences and sites selected for seed relocation will be delineated using Global Positioning Systems (GPS) technology. The data set for this information will be maintained by the Permitee's and/or their designated habitat management entity and provided to the Carlsbad Fish and Wildlife Office (CFWO) according to an agreed-upon protocol as yet to be developed.

Success criteria and reporting requirements will be developed in cooperation with the USFWS and the CDFG and will be included in the Habitat Management Plan for the USAR HCP.

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