WEED CONTROL ON THE VERNAL POOL RESTORATION AREAS OF THE SAN DIEGO NATIONAL WILDLIFE REFUGE JAMUL, CALIFORNIA

Prepared for:

U.S. Fish and Wildlife Service
San Diego National Wildlife Refuge
14715 Highway 94
P.O. Box 746
Jamul, California 91935

Prepared by:

AECOM
1420 Kettner Boulevard, Suite 500
San Diego, California 92101
Phone: (619) 233-1454
Fax: (619) 233-0952

July 2013

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

This page intentionally left blank.

SITE BACKGROUND AND LOCATION

The Otay-Sweetwater Unit of the San Diego National Wildlife Refuge (Refuge) is operated by the U.S. Fish and Wildlife Service (USFWS). The Refuge includes a vernal pool restoration site that USFWS has been working to restore for several years. The vernal pool restoration site totals approximately 31 acres and is located south of Sweetwater Reservoir and north of San Miguel Road in San Diego County, California (Figures 1 and 2). In April 2007, the restoration site was dethatched and more than 60 degraded vernal pool basins were deepened. In August 2007, a few late-season weeds were treated with herbicide. Weed control has been conducted annually in the growing seasons of 2007/2008, 2008/2009, and 2009/2010. One herbicide treatment was completed late in the 2011/2012 growing season. Where native flora was present in vernal pool basins, the basins were hand-weeded; otherwise, weeds were controlled with glyphosate herbicide.

Sensitive resources on the restoration site include vernal pool flora and fauna such as the federally listed San Diego fairy shrimp (*Branchinecta sandiegonensis*), Otay Mesa mint *(Pogogyne nudiuscula)*, San Diego button celery (*Eryngium aristulatum*), and spreading navarretia (*Navarretia fossalis*). Vernal pool plant seed was broadcast in select pools in November 2010, and native upland shrubs were planted on-site in 2011. As a result, several pools on the restoration site supported populations of these species in the 2010/2011 and 2011/2012 growing seasons. In addition, 10 subterranean nest boxes on the restoration site have been used by burrowing owls (*Athene cunicularia*).

The overall goal of the vernal pool restoration project is to establish healthy vernal pool habitat and associated coastal sage scrub/native grassland where vernal pool and other native flora and fauna are likely to persist.

In fall 2012, AECOM was contracted by USFWS to continue the control of nonnative weeds in the vernal pool restoration site via two sitewide herbicide treatments. The purpose of the herbicide treatments was to kill the 2012/2013 weed crop prior to seed set, thereby removing sources of competition from the vernal pool restoration site and promoting the recovery of native vegetation. Herbicide treatments were conducted in the upland areas of the restoration site and the vernal pool basins that were not occupied by or inoculated with native vernal pool flora or fauna. . This report discusses weed treatments of the vernal pool restoration site undertaken by AECOM between January and June 2013.

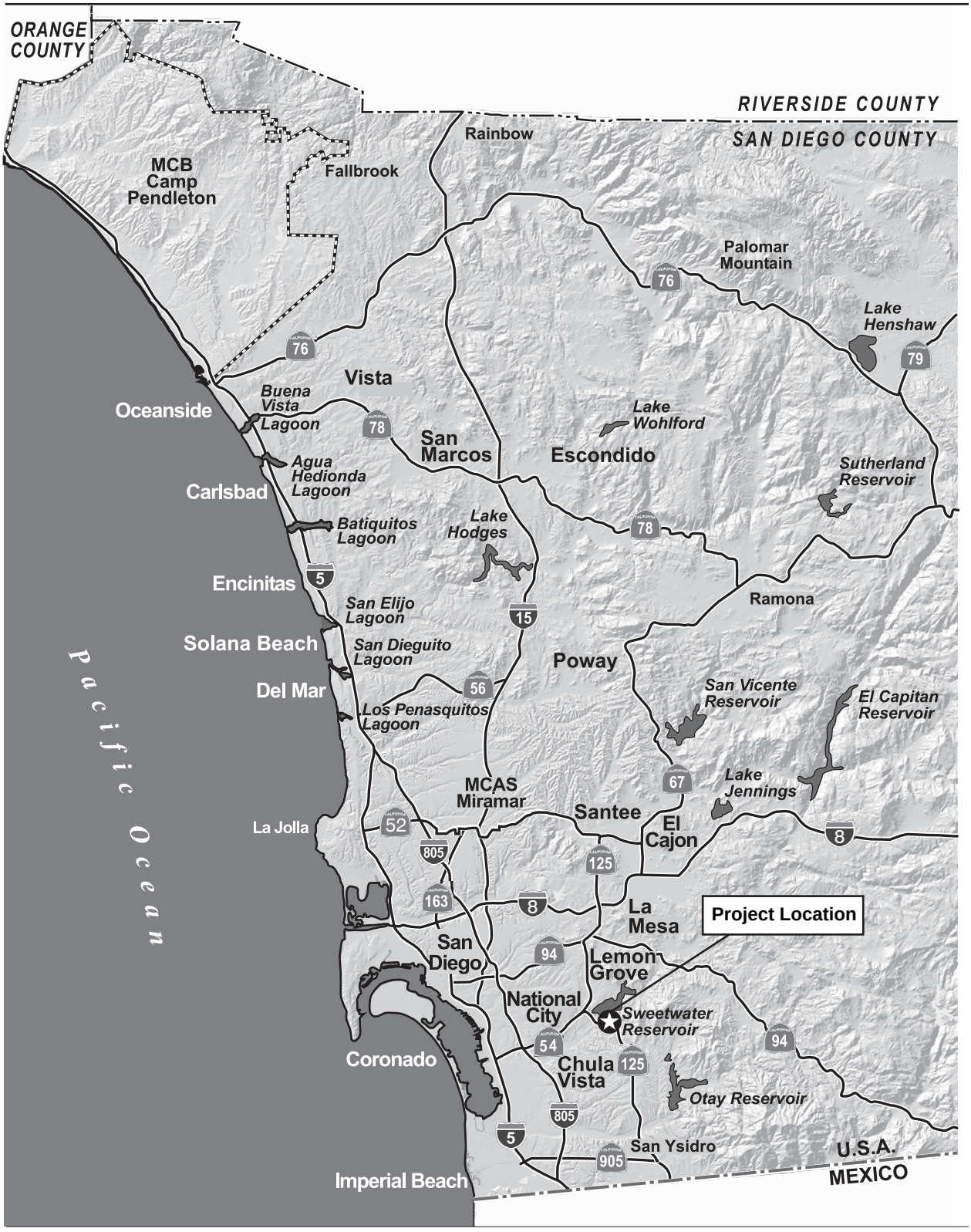
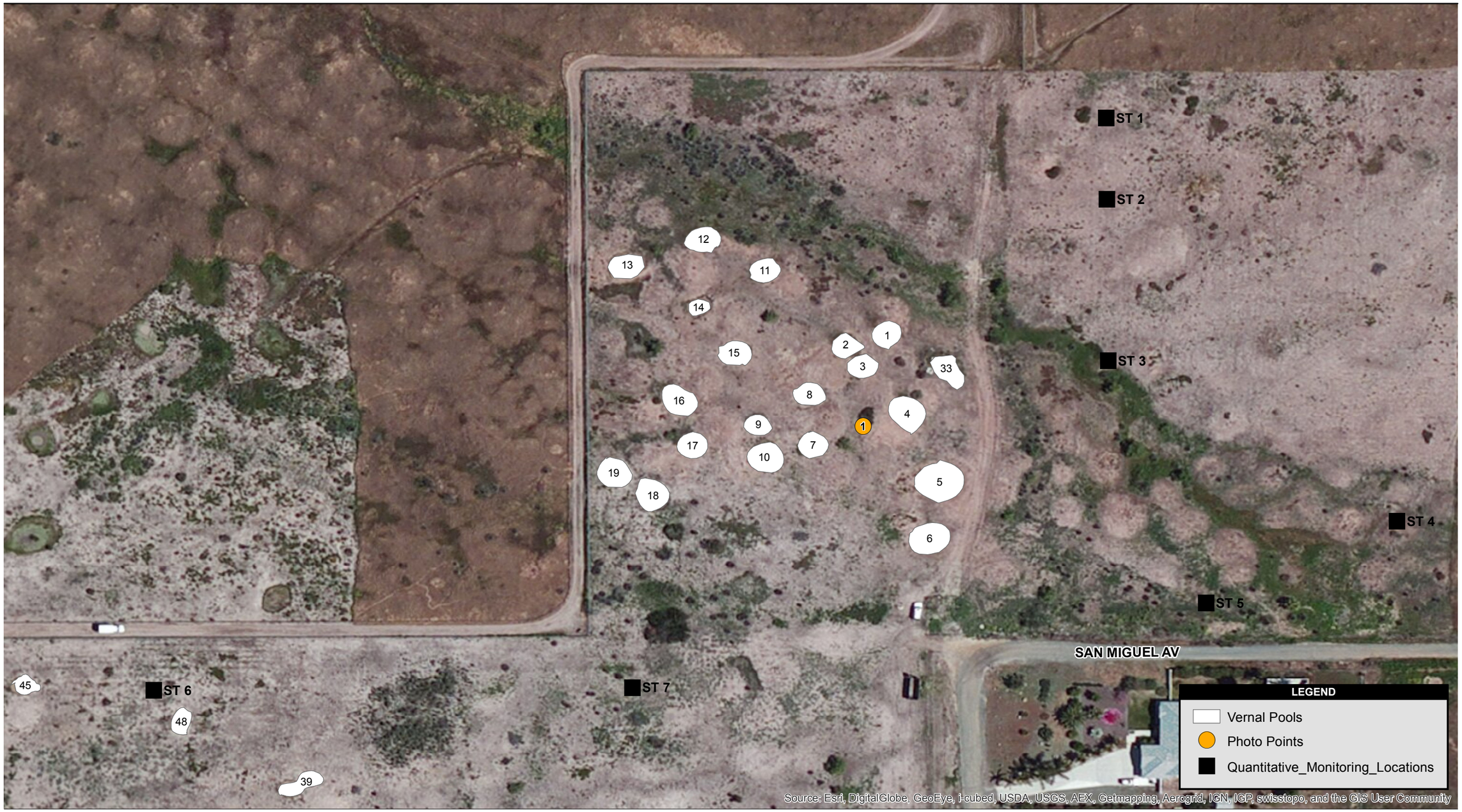


Figure 1
Regional Map



Source:

100 50 0 100 Feet

Scale: 1:24,000; 1 inch = 2,000 feet

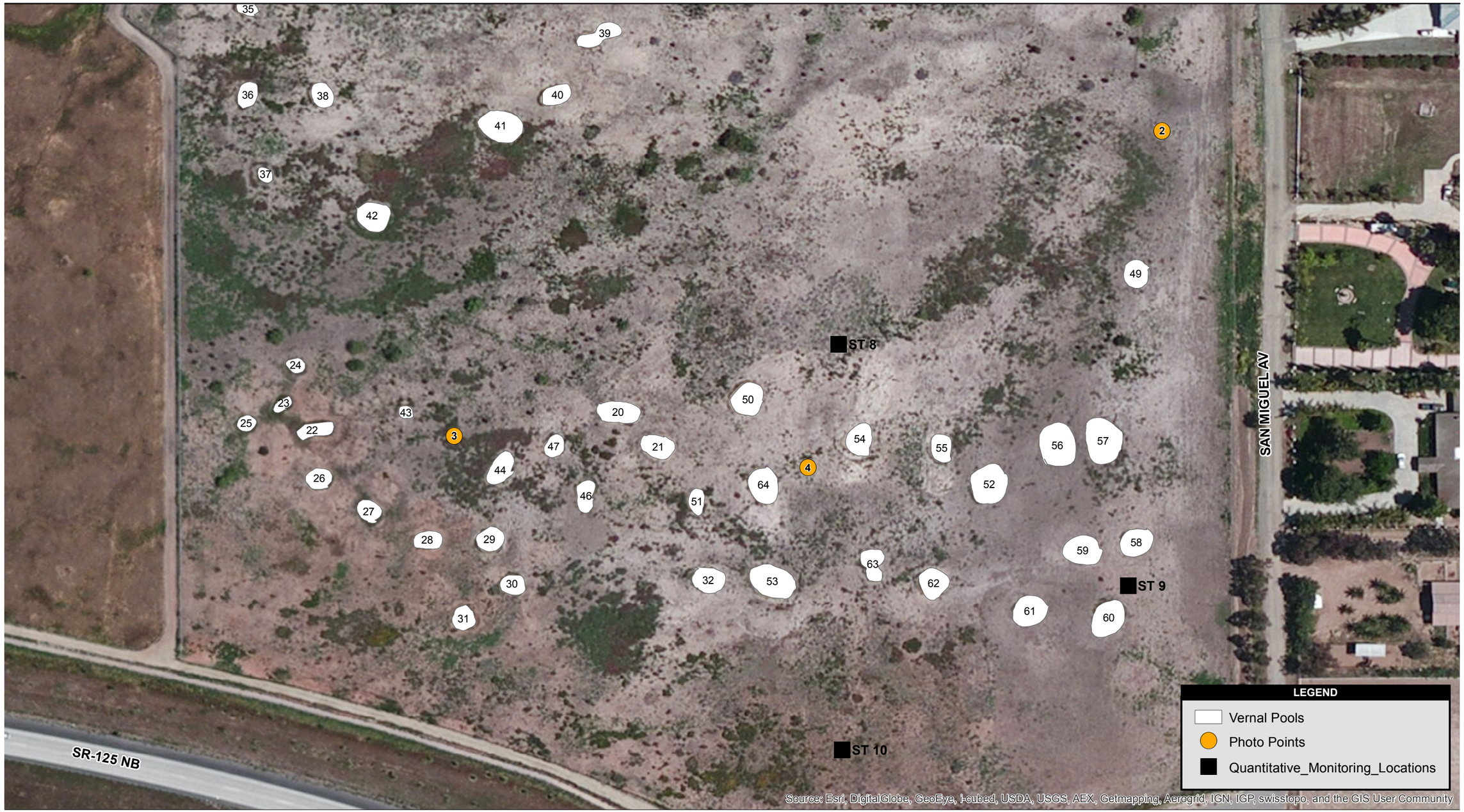
Vernal Pool Restoration Sites

San Diego National Wildlife Refuge

Figure 2a

Path: P:\2012\60278746_SDNWR_Weed\06GIS\6.3_Layout\VP_Fig2_SDNWR_Restoration_Sites.mxd, 7/1/2013, alburyk

This page intentionally left blank.



Source:

100 50 0 100 Feet

Scale: 1:24,000; 1 inch = 2,000 feet

Vernal Pool Restoration Sites

San Diego National Wildlife Refuge

Figure 2b

Path: P:\2012\60278746_SDNWR_Weed\06GIS\6.3_Layout\VP_Fig2_SDNWR_Restoration_Sites.mxd, 7/1/2013, alburyk

This page intentionally left blank.

METHODS

Weeds were treated using application of herbicide, mechanical removal (gas-powered weed trimmers), and hand removal. Treatments for particular regions within the vernal pools complex may have involved one or more of these methods, as directed by the AECOM restoration ecologist. Site-specific treatment prescriptions were defined based on species composition and phenology of target species.

Herbicide applications were performed under the authorization of a California Department of Pesticide Regulations (CADPR) Maintenance Gardener Pest Control Business License (#37064) and under the guidance of Qualified Applicator's Licenses (QAL). All applications were completed when wind speed was less than 5 miles per hour to reduce potential spray drift. Herbicide was not applied if rain was forecasted within 24 hours of the treatment. All crews were trained on the identification of native plants and the proper methods and safety procedures of herbicide application. One person flagged native annuals or perennial shrubs ahead of the herbicide applicators, which reduced the risk of the loss of native plants. Herbicide treatments were completed using a combination of backpack sprayers and a gas-powered reel-spray rig (Figure A.1 in Appendix A).

Applications used aquatic-safe glyphosate according to label-suggested application rates (2% herbicide solution) and safety procedures. Glyphosate is a commonly used systemic, nonselective, foliar-applied herbicide. Application of glyphosate was performed primarily using backpack sprayers (spot application). The reel-spray rigs were deployed to apply herbicide in areas with large contiguous patches of nonnative vegetation. Spray nozzles for both reel-spray and spot applications were chosen to maximize the size of droplets and reduce drift to nontarget vegetation. Spot applications were used in areas that included dense native vegetation, as the method allows for more exact applications of herbicide on target species. The herbicide use log is shown in Table 1.

Hand weeding was deployed in limited circumstances. Manual hand weeding ensured minimal seed of a target species was left behind, thus minimizing overall risk of species establishment. The method was used to eliminate small infestations of problematic species. Mechanical treatment using gas-powered weed-eaters was also used for species developed past the bolting period or in vernal pool basins. The bolting period of a developing weed is the ideal time for application of herbicide, as the herbicide uptake into the target species is rapid.

All water used for treatment of weeds was brought to the restoration site using a truck-mounted water tank. Water was transferred to backpack sprayers or filled in a truck mounted tank and loaded with chemical product prior to using the truck-mounted spray rig.

Table 1
Herbicide Use by Active Ingredient and Date

Date	Glyphosate (ounces)	Active Ingredient	EPA Product Registration No.
1/31/2013	165	glyphosate	524-343
2/18/2013	320	glyphosate	524-343
2/21/2013	700	glyphosate	524-343
2/22/2013	224	glyphosate	524-343
2/27/2013	800	glyphosate	524-343
3/1/2013	800	glyphosate	524-343
3/4/2013	830	glyphosate	524-343
3/5/2013	640	glyphosate	524-343
3/6/2013	1,060	glyphosate	524-343
3/7/2013	852	glyphosate	524-343
3/27/2013	312	glyphosate	524-343
4/23/2013	600	glyphosate	524-343
4/25/2013	300	glyphosate	524-343
4/30/2013	180	glyphosate	524-343
5/2/2013	90	glyphosate	524-343
5/17/2013	200	glyphosate	524-343
5/24/2013	200	glyphosate	524-343
5/31/2013	320	glyphosate	524-343
Total (oz.)	**8,593**		

EPA = Environmental Protection Agency

WORK SUMMARY

A total of 31 acres within the Refuge were treated two times. Treatment efforts with multiple techniques were concentrated in those areas that contained sensitive species, more abundant native cover, and/or presence of vernal pools. All weed-control efforts considered the health of the existing vegetation and the enhancement of the vernal pool complex. The goal of treatments was to eliminate additional influx of nonnative seed into the seedbank, ultimately allowing more solar and soil resources for potential native recruitment during the following growing season. A focus on two treatments ensured both early- and late-season target species would be managed. The first treatment addressed all species present and covered the entire acreage, generally requiring more treatment days and herbicide use. The second pass of coverage focused on newly emergent species and/or late-season weed species, with more spot applications, and less herbicide use. A record of herbicide use by date is available in Table 1.

Herbicide spot applications using backpack sprayers were deployed due to the potential for the presence of sensitive upland species such as variegated dudleya (*Dudleya variegata*), San Diego barrel cactus (*Ferocactus viridescens*), Otay tarplant (*Deinandra conjugens*), and San Diego goldenstar (*Muilla clevelandii*).

Additional sensitive vernal pool species present or potentially present included San Diego button celery, spreading navarretia, California Orcutt's grass (*Orcuttia californica*), and Otay Mesa mint. Some vernal pool species were seeded into selected basins by Refuge staff following establishment of the pool basins. No treatments within vernal pools were made to basins with known seeding or where native vernal pool flora was identified.

An initial reconnaissance site visit with Refuge staff in October 2012 identified site conditions resulting from natural ecological cycles and past management activities. Methods discussed above were applied as necessary according to ecological conditions, phenology of target species, and logistical capabilities identified during site visits. Species for particular focus during 2013 management were stands of Russian thistle (*Salsola tragus*) distributed throughout the restoration site, and primarily located near the main access gate on the east side of the restoration site (Figure A.2). Senesced mustard (*Brassica* sp.) was also present, primarily located in vernal pool basins (Figure A.3). Volunteer groups removed most of the senesced Russian thistle plant debris in January 2013, prior to restoration site treatments by AECOM. This effort allowed AECOM to direct chemical treatments to newly germinated species throughout the restoration site during the management period (January through June 2013). The volunteer activity is identified as a manual "dethatch" effort, which AECOM was not tasked with during this report period.

Site visits by AECOM staff in December 2012 confirmed weed presence, which included early germination stages of filaree (*Erodium* sp.), mustards, and dwarf nettle (*Urtica urens*). Refuge staff and AECOM identified January 28 as ideal for commencement of restoration site treatment activities, according to on-the-ground conditions.

Late January treatments focused on mature dwarf nettle (Figure A.4). Large concentrations of dwarf nettle were found along the eastern restoration site fence line, which afforded the use of the reel-spray rig following mechanical removal of senesced weeds. Removal of senesced weeds prior to reel-spray rig treatment allowed for efficient herbicide uptake by dwarf nettle (Figure A.5). Target application with the reel-spray rig treated large concentrations of dwarf nettle efficiently in an area where few native species are located. Additional treatments during January included hand removal of castor bean (*Ricinus communis*). Hand-removed castor bean with mature fruits was bagged and taken off-site.

Treatments in February focused on completion of the first full treatment coverage of the restoration site. The majority of treatment efforts managed the following species: prickly ox-tongue (*Helminthotheca echioides*) (Figure A.6), curly dock (*Rumex* sp.) (Figure A.7), filaree, mustard, horseweed (*Erigeron* sp. [*Conyza*]) (Figure A.8), and sow thistle (*Sonchus oleraceus*). Prickly ox-tongue was seen in large amounts in upland areas in the southern portion of the restoration site. A reel-spray rig was used in these areas of large weed concentrations and for management of horseweed (identified for treatment in the southeastern portion of the restoration site) (Figure A.9). Curly dock was restricted to wet, non-vernal-pool areas, such as seeps and swales, where treatment primarily occurred. Backpack spraying was used to address spotty areas of mustard, primarily north of vernal pool 33. Figure A.10 provides examples of mustard prior to treatment of new basal sprouts; senesced stalks from prior year's growth are also visible.

March 2013 treatments involved a second round of herbicide applications throughout the restoration site. The second round of treatments focused on late-season weed emergence. Particular focus was made to newly emergent Russian thistle, present in large areas where dethatching had already been conducted (Figure A.11). Throughout the restoration site, spot treatments were primarily used, and continued vigilance was deployed to eliminate herbicide application to nontarget species. Emergent bulbs such as red skin onion *(Allium haematochiton)* were seen in the southeastern portion of the restoration site, and were avoided during spray operations (Figure A.12). Additional species avoided during this period included needlegrass (*Stipa* sp.), a perennial bunchgrass planted during prior years of restoration site management (Figure A.13). Needlegrass plantings often struggle to establish from outplantings, are affected by drought, mammalian browsing, and have a slow growth rate. Historical populations of needlegrass are easy to identify during weed treatments. However, recently planted specimen required extra vigilance for identification as they have a slow growth rate following outplantings and are hard to locate.

Small pockets of flowering mustard were manually treated, bagged, and removed from the restoration site. Other late-season annual weed species included sow thistle, which was also treated (Figure A.14).

During March, emergence of tarplant (*Deinandra* sp.) was evident. Otay tarplant (*Deinandra conjugens*) is a federally listed species and covered by the Multiple Species Conservation Plan (MSCP). The species is generally located in heavier clay soils, common in the southern portion of the restoration site. The soils in the northern area of the restoration site generally do not support Otay tarplant; rather, tarweed (*Deinandra fasciculata*) is common in the north. To eliminate impacts to remaining populations of Otay tarplant, AECOM crews did not use herbicide in populations of Otay tarplant (Figure A.15). Although tarplant is difficult to identify

to species without flowers, the *Deinandra* present in the southern clay soils was avoided. If problematic weed species were seen within populations of Otay tarplant, hand removal of weed species occurred.

Precipitation was below average for the 2012/2013 season (Table 2), and the restoration site was visibly dried out during the April 2013 treatment visits. Treatments focused on emergence of late-season weed species such as white tumbleweed (*Amaranthus albus*) (Figure A.16). Large populations of white tumbleweed were treated using the reel-spray rig, as extensive patches were located in the southeast portion of the restoration site where native plant density was low. A continued effort for treatment of Russian thistle was also conducted. Other species targeted for treatment during April were bristly ox-tongue and nonnative grasses such as various bromes (*Bromus* spp.) and false brome (*Brachypodium distachyon*). Mustard in flower, locally present in isolated populations, was hand-pulled and removed from the site during April. The species was mechanically treated with gas-powered weed trimmers when identified prior to fruit and flowering stage. Additional mechanical removal of weed species, primarily mustard and sow thistle, was completed in vernal pool basins that were not seeded and did not have vernal pool flora present. Mechanical removal of both senesced mustard (remaining from 2012 growing seasons) and flowering mustard was completed. No floristic inventories of vernal pools were completed by AECOM at this time, although general surveys were conducted in pool basins prior to mechanical weed removal efforts.

May 2013 treatments continued to focus on late-season weeds. Additional treatment methods included hand removal of fruiting grasses identified for treatment in April. Although most grasses were treated at this time, some individuals were still seen with fruit during a site visit by Refuge staff and AECOM in late May (Figure A.17). AECOM staff followed up by bagging fruiting grasses, primarily false brome, during this treatment month.

Table 2
Precipitation, July 2012–June 2013

Date	Precipitation (inches)	Date	Precipitation (inches)
8/24/2012	0.04	1/8/2013	0.34
9/10/2012	0.05	1/10/2013	0.10
11/8/2012	0.06	1/25/2013	0.65
11/9/2012	0.08	1/26/2013	0.75
11/10/2012	0.12	1/27/2013	0.04
12/1/2012	0.02	1/28/2013	0.01
12/13/2012	1.71	2/8/2013	0.24
12/14/2012	0.07	2/9/2013	0.08
12/15/2012	0.09	2/19/2013	0.03
12/17/2012	0.02	2/20/2013	0.30
12/18/2012	0.04	3/8/2013	0.83
12/24/2012	0.03	3/9/2013	0.25
12/30/2012	0.36	4/2/2013	0.02
12/31/2012	0.03	4/8/2013	0.02
1/8/2013	0.34	4/15/2013	0.07
1/10/2013	0.10	5/6/2013	0.19
1/25/2013	0.65	5/7/2013	0.02
2012 Total	**3.81**	**2013 Total**	**3.94**
Rain Year Totals (inches)			**7.75**

Source: http://www.wrh.noaa.gov/sgx/obs/rtp/rtpmap.php?wfo=sgx

MONITORING RESULTS

Quantitative monitoring was conducted by Refuge and AECOM staff. Meetings to discuss qualitative restoration site conditions and efficacy of treatments were conducted by Refuge and AECOM staff on October 26, 2012 (kickoff), and January 11, March 14, April 15, and May 30, 2013. The restoration site was walked to determine efficacy of past treatments, focus for future treatments, and overall restoration site conditions. Refuge staff found the restoration site in good condition and found overall weed treatments to be successful. During the May 30, 2013, site visit, an unknown plant was targeted for identification and possible treatment. The unknown species was identified once flowering and fruiting stages were present as willow herb (*Epilobium brachycarpum*), a native with no need for treatment.

Quantitative monitoring was conducted by AECOM in June 2013. Formal photo points taken in February and June 2013 are shown in Appendix B. Refuge staff identified 10 areas for monitoring; 1-by1-meter quadrats were used to determine percentage of live weeds present. The quantitative monitoring grid at each location is shown in Appendix C photographs. Results of quantitative monitoring included counts of live weeds and (if possible) treated (dead) weeds. Only those species able to be identified were counted. Annual species treated early during the

management period (January, February, and March) may not have been present during quantitative monitoring. Some species present may have germinated following the end of the treatment period (June 1). Thus, limited data was gathered during the quantitative monitoring period, as discussed below.

Quantitative monitoring point ST1 was primarily populated by coastal sage (*Artemesia californica*) and tarweed. Two live Russian thistle and two treated (dead) Russian thistle were identified. Live Russian thistle was hand-removed following monitoring. No other weed species were identified in this quadrat. Monitoring point ST2 contained one treated sow thistle and three treated matted sandmat (*Chamaesyce serpens*). Quadrat ST3 had only one treated matted sandmat. Quadrat ST4 contained no live weed species; treated species identified were six white tumbleweed and seven matted sandmat. Thirty-two dead white tumbleweed were seen in quadrat ST5. Similarly, quadrat ST6 contained no live weeds, and treated species included were five filaree and three matted sandmat. Quadrat ST7 contained two treated Russian thistle and five treated white tumbleweed. Quadrat ST8 only contained treated filaree, with 10 dead filaree seen in the surveyed area. ST9 had 23 white tumbleweed (treated). Quadrat ST10 had three live matted sandmat and 15 treated white tumbleweed.

Table 3 presents quantitative results of quadrat monitoring. Quantitative monitoring found a 95% mortality rate of weeds identified within the quadrats. A project goal was 90% or greater mortality rate of weeds identified during the monitoring period, which was achieved.

Table 3
Quantitative Monitoring of Quadrats

Quadrat	Live Weed Individuals	Treated (Dead) Weed Individuals	Percentage of Dead Weeds
ST1	2	2	50.00%
ST2	1	3	75.00%
ST3	0	1	N/A
ST4	0	13	N/A
ST5	0	32	N/A
ST6	0	8	N/A
ST7	0	7	N/A
ST8	0	10	N/A
ST9	0	23	N/A
ST10	3	15	83.33%
Total	**6**	**114**	**94.73%**

RECOMMENDATIONS

Future management recommendations include continued deployment of spot applications, reel-spray applications, and mechanical removal methods on a yearly basis. Coordination with Refuge staff at an early stage in the treatment year, according to precipitation patterns, is advised. Early and timely treatment regimens ensure the efficacy of herbicide treatment and labor.

Typical late-season species such as Russian thistle could occur earlier and be seen during a larger management window depending on variable precipitation patterns and fluctuating ecological conditions. During this report period, Russian thistle was the primary species of concern, and efforts made to remove (dethatch) last season's senesced plants and treat the new crop of germinated specimens were successful. However, it is expected that some individuals will continue to develop into the summer, past AECOM's contracted period of treatment. Follow-up treatments during subsequent management periods will contribute to an effective eradication of the species from the restoration site. Areas of concentration of the species, such as near the eastern gate, were focused on intensively, and should be considered for establishment of native flora following treatment periods.

Other species located predominantly along the eastern fence line in larger numbers were white tumbleweed and dwarf nettle. These species are seen as less aggressive and less problematic ecologically, but the large numbers and lack of local density of native vegetation warrant continued potential treatment. It is recommended to target these areas of particular dense stands of weed species as locations for future native plant establishment.

Filaree was also managed, but overall populations of the species were low due to sporadic rain patterns. Precipitation germinated some of the seed bank, but, during more adequate rainfall years, the species could potentially be more aggressive; thus, monitoring and early treatment will be needed. Other species seen in limited numbers due to precipitation patterns included nonnative grasses. Most of the nonnative grasses were identified and managed in the northern half of the restoration site, outside of the heavy clay soils. As the northern portion of the site is more densely populated with native flora, management of nonnative grasses does not include additional native plant establishment recommendations. The focus on areas with nonnative grasses includes a reduction of seed bank presence in these areas. Dual management treatments are warranted, using herbicide applications early and mechanical removal late in the management period.

Vernal pool basins managed with mechanical treatments could benefit from formal floristic surveys. As Refuge staff have seeded pools historically, any intensive weed control and restoration program involving vernal pool resources would benefit from additional floral information. During seasons with low precipitation and no inundation of pools, nonnative species have greater potential for invading pool basins, particularly grasses. Continued influx of nonnative seed into the basin seed bank during low-precipitation years will hinder for establishment of native vernal pool flora during normal or higher precipitation years.

Quantitative monitoring of the pools will allow for allocation of treatment resources in a directed manner, provide information for translocation of seed resources, and contribute to the long-term health of the vernal pool watershed. Several key methods have been used or proposed for use in monitoring vernal pool habitat, including the Hydrogeomorphic Model (HGM), California Rapid Assessment Method (CRAM), and USFWS protocols. At minimum, quantitative monitoring should include estimation of species cover, population size/density, and presence/absence at each pool.

Defined management objectives and adaptive management techniques should mirror those identified in "Adaptive Management and Monitoring Strategy for the City of San Diego Vernal Pool Habitat Conservation Plan" (VPHCP). The goal of the VPHCP is to provide management and monitoring strategies, directives, and recommendations for all lands containing vernal pools in the VPHCP Preserve in order to preserve and/or restore their biological components, particularly the focal sensitive species. Habitat-based and focal species-specific objectives were developed to support the VPHCP's biological goal. The VPHCP uses a tiered three-level approach to adaptive monitoring and management that is applied to individual vernal pool complexes:

- Level 1 – *maintain* existing habitat conditions and existing focal species population status
- Level 2 – *stabilize* focal species population status by improving habitat conditions to a level that can support existing populations
- Level 3 – *remediate* declining focal species population status by improving habitat conditions to a level that can support baseline focal species populations

The quantitative monitoring will provide information that can be used for the long-term management of the vernal pool restoration site. Particular weed concerns identified during nonprotocol, qualitative monitoring efforts during the reporting period include presence in pools of nonnative grasses and presence of hyssop loosestrife *(Lythrum hyssopifolia)*. Although

mustards were seen in some pool basins, the presence is easily identified and removal efforts are not as great as those needed when treating nonnative grasses and hyssop loosestrife.

Short-term management goals need to address nonnative grasses and hyssop loosestrife. Increased hand-weeding efforts, although time-consuming, will greatly reduce these species when emergent in the pool basins. Treatments assume hand removal only, unless herbicide use is approved, although sensitivity of fairy shrimp cysts must be considered. Hand removal of weed species should focus on the vernal pool basin "wick" zone, where pool inundation levels fluctuate throughout the rainy season from pool bottom to outer (upland) edge of pools. Soil moisture and inundation of pools are related to seasonal precipitation, weed composition, and densities. Managing weeds as they emerge and mature within the wick zones ensures timely treatment and removal of weed species as they mature. Managing weeds according to current wick zones also ensures the minimization of impacts due to weed treatment operations, avoiding additional soil compaction by working on dry portions of the basin.

Timely treatment of vernal pool weed species will allow for the expansion of native flora within the pool basin and, over time, ensure the health and stability of the pool resources. Similarly, systematic removal of weed species will help determine where available seed resources can be distributed to expand native flora within the complex. This *fourth* goal, not part of the required management actions for the VPHCP, will allow for more rapid habitat improvement within the vernal pool restoration site. Seed collections from sensitive species should be completed and redistributed throughout the site according to needs identified in the quantitative monitoring, in order to increase diversity and abundance within the vernal pools.

Dethatching should be used in pool basins in certain circumstances. Dethatching is most appropriately performed in the winter (prior to rainy season), with potential follow-up visits during the spring and early summer. Dethatching also makes future weed control measures more effective and efficient by exposing germinating weed species for treatment operations. Collection of target native plant seed should occur prior to any dethatching to minimize the removal of the native seed bank. Seed can be stored until the next growing season or put back on-site following completion of dethatching and nonnative seed removal.

Because of seasonal climate variability and resulting effects on the expression of both invasive species (weed germination, flowering, and seed-set; dispersal of invasive animals; etc.) and focal species (plant germination, flowering, and seed-set; shrimp hatching, development, and reproduction; etc.), the activities described above should be applied for a minimum of 3 to 5 years.

APPENDIX A

REPRESENTATIVE PHOTOGRAPHS

Photograph A.1. Truck-mounted reel-spray rig.

Photograph A.2. Russian thistle near main gate, October 2012.

Photograph A.3. Sinesced mustard in vernal pool basin, October 2012.

Photograph A.4. Dwarf nettle along eastern fence line targeted for January 2013 treatment.

Photograph A.5. Eastern fence line following January 2013 treatments.

Photograph A.6. Prickly ox-tongue (*Helminthotheca echioides*).

Photograph A.7. Curly dock (*Rumex* sp.).

Photograph A.8. Horseweed with blue dye-marker following herbicide application.

Photograph A.9. Reel-spray rig being deployed near large weed concentrations.

Photograph A.10. Basal sprouts of mustard treated in February 2013.

Photograph A.11. Russian thistle targeted for treatment, March 2013.

Photograph A.12. Alliums marked prior to treatment of surrounding weeds.

Photograph A.13. Planted needlegrass avoided during spray operations.

Photograph A.14. Treated sow thistle (right).

Photograph A.15. AECOM technician treating weeds near emergent Deinandra. Last season's senesced plant also visible.

Photograph A.16. White tumbleweed targeted for treatment.

Photograph A.17. Fruiting grasses targeted for hand removal.

APPENDIX B

PHOTOGRAPHS FROM FORMAL PHOTO POINTS

Photopoint 1: Facing north. February 2013

Photopoint 1: Facing north. June 2013

Photo Sheet 5a
Photographs from Formal Photo Points

Photopoint 1: Facing south. February 2013

Photopoint 1: Facing south. June 2013

Photo Sheet 5b
Photographs from Formal Photo Points

Photopoint 1: Facing east. February 2013

Photopoint 1: Facing east. June 2013

Photo Sheet 5c
Photographs from Formal Photo Points

Photopoint 1: Facing west. February 2013

Photopoint 1: Facing west. June 2013

Photo Sheet 5d
Photographs from Formal Photo Points

Photopoint 2: Facing north. February 2013

Photopoint 2: Facing north. June 2013

Photo Sheet 5e
Photographs from Formal Photo Points

Photopoint 2: Facing south. February 2013

Photopoint 2: Facing south. June 2013

Photo Sheet 5f
Photographs from Formal Photo Points

Photopoint 2: Facing east. February 2013

Photopoint 2: Facing east. June 2013

Photo Sheet 5g
Photographs from Formal Photo Points

Photopoint 2: Facing west. February 2013

Photopoint 2: Facing west. June 2013

Photo Sheet 5h
Photographs from Formal Photo Points

Photopoint 3: Facing north. February 2013

Photopoint 3: Facing north. June 2013

Photo Sheet 5i
Photographs from Formal Photo Points

Photopoint 3: Facing south. February 2013

Photopoint 3: Facing south. June 2013

Photo Sheet 5j
Photographs from Formal Photo Points

Photopoint 3: Facing east. February 2013

Photopoint 3: Facing east. June 2013

Photo Sheet 5k
Photographs from Formal Photo Points

Photopoint 3: Facing west. February 2013

Photopoint 3: Facing west. June 2013

Photo Sheet 5l
Photographs from Formal Photo Points

Photopoint 4: Facing north. February 2013

Photopoint 4: Facing north. June 2013

Photo Sheet 5m
Photographs from Formal Photo Points

Photopoint 4: Facing south. February 2013

Photopoint 4: Facing south. June 2013

Photo Sheet 5n
Photographs from Formal Photo Points

Photopoint 4: Facing east. February 2013

Photopoint 4: Facing east. June 2013

Photo Sheet 5o
Photographs from Formal Photo Points

Photopoint 4: Facing west. February 2013

Photopoint 4: Facing west. June 2013

Photo Sheet 5p
Photographs from Formal Photo Points

APPENDIX C

PHOTOGRAPHS OF QUANTITATIVE MONITORING GRIDS

Photograph C.1

Photograph C.2

Photograph C.3

Photograph C.4

Photograph C.5

Photograph C.6

Photograph C.7

Photograph C.8

Photograph C.9

Photograph C.10