1.0 INTRODUCTION

1.1 *Background*

Vernal pools are seasonal, depression-type wetlands that result from a unique set of physical parameters and support a specific biological assemblage. These ecosystems have been greatly reduced due to development and other anthropogenic factors, and several plants and animals endemic to vernal pools have been listed as federal and/or state endangered species. As habitat for these species, vernal pools are considered to be critical environmental resources.

Several physical factors combine to create a functional vernal pool ecosystem. Vernal pools form in small, shallow, oval or circular basins from one to 700 square meters (Zedler, 1987). In this document, the term "basin" will refer to the physical depression in which ponding occurs. Although such basins may occur on level surfaces, they are often associated with hillocks known as Mima mounds. In San Diego county, these circular features range from three to 20 meters in diameter and 0.4 to 1.2 meters in height and function as water catchments with vernal pools forming in inter-mound swales (Zedler, et al., 1979). The basins are sealed by impermeable hardpan soils or a clay layer that expands during saturation (Greenwood and Abbot, 1980).

Although seasonal wetlands are found worldwide, vernal pools sharing physical and biological parameters occur within the Mediterranean climate zone of the western United States, from southern Oregon, U.S.A., to northern Baja California, Mexico. In southern California, remnants of historic vernal pool complexes occur on coastal mesas in Santa Barbara, Los Angeles, Orange and San Diego counties, as well as inland in the San Diego foothills and Riverside basalt terraces. Within the City of San Diego, groups of vernal pools called "series" are found in the following areas: Del Mar Mesa, Mira Mesa, Carmel Mountain, Kearny Mesa, Mission Trails Regional Park, Otay Mesa and nearby Otay Lakes, and Marron Valley (Figure 1). Series are spatially associated clusters of basins found on a single soil type and supporting similar biological assemblages. "Complex" refers to a designation of geographically grouped vernal pools by Beauchamp (1979) and Bauder (1986) commonly used by management agencies today. For example, J 12 located in Otay Mesa refers to series J complex 12 and contains four vernal pool basins.

Vernal pools are habitat for a mix of species adapted to a highly dynamic ecosystem. Many plants and animals, including several threatened/endangered species, rely on the water and nutrients provided by vernal pools. Vernal pools are also influential in local hydrology as surface water conveyance and storage mechanisms (Zedler, 1987).

The extent and quality of these specialized ecosystems have been substantially reduced by grazing, agriculture, and development (Bauder, 1986). Bauder and McMillan (1998) estimated that vernal pool soils historically covered nearly 200 square miles of San Diego county. Approximately 5% of southern California vernal pool basins remained in 1998 (USFWS, 1998). The majority of these have been degraded or are threatened by grazing, agriculture, off-road vehicles and urban development. Urbanization has also increased the occurance of edge effects, invasion by exotic species, pollution, and changes in basin hydrology (Bauder, 1986b).

In 2002, the City of San Diego (City) received funding through a U. S. Fish and Wildlife Service (USFWS) Section 6 Planning Grant to complete an inventory and management plan of vernal pools within the City's jurisdiction (refer to Fig. 1).

Figure 1 – Regional distribution of San Diego vernal pools

This inventory builds on several previous studies and surveys, which were used to determine the general locations of individual vernal pools and complexes. Beauchamp (1979) and Bauder (1986) covered the greater portion of San Diego County, and represent complexes as polygons. Villasenor and Riggan (1979) and Zedler and Ebert (1979) mapped the boundaries of individual vernal pool basins within Kearny Mesa and Del Mar Mesa, respectively. Much of the area currently owned by the City and other jurisdictions has never been surveyed for specific vernal pools and, in many cases, historical maps do not accurately represent the existing basins. This inventory does not, however, include vernal pools known to occur on military lands (i.e., MCAS Miramar, Navy Chollas Heights) within the City but not under City jurisdiction.

1.2 *Purpose of project*

This project utilized advanced geospatial technology to update information on the location of individual vernal pools and complexes, including documentation of changes in vernal pool distribution due to development and restoration efforts subsequent to Bauder's report (1986). Specialized software combined with a sub-meter global positioning system (GPS) were used to precisely record each basin. This inventory expands and updates existing information, and provides the basis for a gap analysis of vernal pool conservation efforts within the City of San Diego.

Genetic sampling of San Diego fairy shrimp (*Branchinecta sandiegonensis*) has been used to estimate current population size and breeding structure, improve understanding of species evolution, and calculate the genetic diversity within a population or genetic divergence between populations. Dr. Andrew Bohonak (San Diego State University) and Dr. Marie Simovich (University of San Diego) are currently sequencing mitochondrial DNA of *B. sandiegonensis* to determine the evolutionary relationships between series. The genetic data analyses are being used to evaluate the status of *B. sandiegonensis* and identification of ecologically significant units for conservation.

Presence/absence of juvenile amphibians in all basins were noted to ascertain the localized ranges of Western toad (*Bufo boreas*), Pacific treefrog (*Hyla regilla*), and Western spadefoot toad (*Spea hammondii*), and assess the importance of vernal pools as habitat for tadpoles of these species. Additional grant monies are being sought to conduct genetic research using tadpoles sampled from vernal pools in conjunction with the U. S. Geological Survey (USGS).

A comprehensive vernal pool plant survey has been completed for each complex within the City. City staff estimated percent cover for the six vernal pool species listed as endangered or threatened by the state and/or federal government, or considered covered (ie. adequately conserved) by the Multiple Species Conservation Program (MSCP).

The updated inventory provides current and expanded information regarding the location of vernal pool basins and rare, threatened, and endangered biota within the City of San Diego. The resulting data, which includes vernal pools on private and public lands, will be analyzed to determine the extent of vernal pool protection, as well as current preservation and management needs. This new information will serve as the basis for updating the City of San Diego Vernal Pool Management Plan (1996), which

identifies and prioritizes management activities for vernal pools on land owned by the City of San Diego.

2.0 METHODS

2.1 *Research on existing vernal pool inventories*

In fall 2002, City staff researched historical and recent reports and current expert knowledge to determine locations and existing survey data for vernal pools within the City's jurisdiction. Site names reflecting location, ownership, or project were assigned to series and/or complexes, and all areas were reviewed using aerial photographs to determine their current status. A Geographic Information System (GIS) was then utilized to document all sites containing extant vernal pools. Unnatural pools formed in tire tracks, called road ruts, were included when vernal pool indicator species were present. The following general geographic areas of interest were identified: Del Mar Mesa, Carmel Mountain, Mira Mesa, Nobel Drive, Kearny Mesa, Mission Trails Regional Park, urban San Diego areas, Otay Mesa, Otay Lakes, and Marron Valley (refer to Fig. 1). Vernal pool complexes within each area were identified, and data were compiled for each complex, including previous site designation and recent survey information, such as number of vernal pools, plants and/or animals present, and specific threats to the site.

2.2 *Field data collection*

Each site was visited following storm events with recorded rainfall of 0.33 inches or more from January through May 2003. At or near maximum inundation, individual basin boundaries were recorded using a differential sub-meter GPS, and the following attributes were documented: site name; Bauder identification number (if any); vernal pool identification number (assigned by series at time of survey); date; time; state of inundation; comments; presence/absence and percent cover for *Eryngium aristulatum* (San Diego button celery), *Navarretia fossalis* (spreading prostrate navarretia), *Orcuttia californica* (California Orcutt grass), *Myosurus minimus* (little mousetail), *Pogogyne abramsii* (San Diego mesa mint), and *Pogogyne nudiscula* (Otay mesa mint); presence/absence for *Branchinecta* spp. (unidentified fairy shrimp), *Branchinecta sandiegonensis* (San Diego fairy shrimp), *Branchinecta lindahli* (versatile fairy shrimp), *Streptocephalus woottoni* (Riverside fairy shrimp), tadpoles/metamorphs (unidentified), *Spea hammondi* (tadpole/metamorph/adult Western spadefoot toad), *Bufo boreas* (tadpole/metamorph/adult Western toad), and *Hyla regilla* (tadpole/metamorph/adult Pacific tree frog). Where possible, the spatial and/or biological data were obtained from current consultant survey information. In cases when such data were not available, information was collected during site visits by City staff. Dates and personnel information for data collection are available in Appendix A.

Two hand-held devices were used in spatial data collection: Trimble TSC1 datalogger using Asset Surveyor version 5.00, and Compaq iPaq running ESRI's ArcPad 6.0. Each collection device was linked to a Trimble Pro XR sub-meter GPS receiver. The Pro XR utilizes real-time differential GPS correction which results in increased field accuracy while eliminating the need for post-processing data correction. In the office, spatial data and attributes from each collection system were combined using Trimble's Pathfinder Office 3.00 and ESRI's ArcView 3.3 software, respectively.