



Inventory of Spring Ecosystems at San Bernardino National Wildlife Refuge, Arizona

Physical and Biological Characteristics

Natural Resource Technical Report NPS/CHDN/NRTR—2013/821



ON THE COVER

Snail Spring, San Bernardino National Wildlife Refuge
Photograph: NPS

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Executive Summary

This report summarizes information gathered during an inventory of San Bernardino National Wildlife Refuge springs conducted in 2011. The inventory was conducted as part of a cooperative effort between the Inventory and Monitoring Programs of the U.S. Fish and Wildlife Service and the National Park Service. The purpose of the inventory was to provide a consistent base level of information on springs across refuges and parks and to provide information to develop a strategy for long-term monitoring.

Three springs were inventoried during this effort. All have been significantly altered by humans, including installation of tanks, dams, and fences. Vegetation is dominated by riparian species, including cottonwoods, willows, and common reed. Three non-native species were found, including Bermudagrass, stinkgrass, and dandelions.

Water was sufficient for water quality analysis at all springs inventoried. Water quality characteristics were mostly within expected values or standards set by the U.S. Environmental Protection Agency or Arizona Department of Environmental Quality. Exceptions were dissolved oxygen concentrations at all springs, which was very low. Water quality is largely dependent on the geologic features in the area and the size of the aquifer associated with the spring. Springs often present challenging environments for biota, either because of temperature or chemical extremes found naturally in the water.

Acknowledgments

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Introduction

Water in the San Bernardino National Wildlife Refuge (NWR), Arizona comes from seasonal runoff, thundershowers, and aquifers that support springs. Runoff and thundershowers often produce scouring flows that quickly pass through ephemeral streams, and springs often provide the only persistent, reliable water for humans and wildlife. Springs support aquatic and riparian systems where groundwater reaches the land surface through natural processes. They provide much of the aquatic environment in arid lands as well as a substantial portion of regional aquatic and riparian biodiversity. Springs and their related ecosystems are considered to be of high priority for providing goods and services to wildlife.

Spring ecosystems are small, relatively rare “biodiversity hot spots” in arid lands. In the desert southwest, these ecosystems historically supported a substantial proportion of aquatic, riparian, and terrestrial species (Myers and Resh 1999). About 80% of the terrestrial animal species, including two-thirds of non-game bird species, use riparian systems associated with springs (Thomas et al. 1979, Saab et al. 1995, Brussard et al. 1998). Springs in arid lands are sparsely distributed on the landscape and critical to the persistence of native biota and many endemic species. Thus, the ecological importance of springs is disproportionate to their spatial extent (Schmitz et al. 2007). As a consequence of their lengthy isolation and long-term persistence, many arid-land springs support an endemic, obligate-spring-dwelling fauna and flora. Several hundred endemic aquatic and riparian species and subspecies dwell in spring ecosystems in the U.S. (Minckley et al. 1986, Hershler et al. 2002).

When they are persistent, springs are generally more stable than arid-land rivers or streams, because seasonal variability in temperature and discharge is much less in springs. Arid-land springs are distinct from springs in more mesic regions because arid-land springs are typically isolated from other waters and more susceptible

to drought. Aquifers in these arid regions are strongly influenced by high elevations, rugged topography, and diverse geology. Characteristics of each aquifer are influenced most by climate, geology, and topography (Freeze and Cherry 1979). In springs unaffected by human activity, water chemistry, temperature, spring morphology, and persistence are primary factors influencing aquatic communities, and soil moisture, chemistry, and soil structure and particle size are factors that most affect riparian vegetation (Resh 1983, Knopf et al. 1988, Cushing 1996, McCabe 1998, Castelli et al. 2000).

Natural and human stressors similarly influence the structure of aquatic and riparian communities. Springs with high water temperature, high chemical concentrations, or that are disturbed by natural events (drought, fire, flood, avalanche scouring, etc.) and humans (reduced discharge from groundwater pumping or surface diversion, livestock trampling, impoundment, recreation, etc.) are harsh environments compared to persistent springs with cooler water that are unaffected by human or natural stressors. The influence of stressors on aquatic and riparian communities generally varies along a gradient of increasing frequency, duration, and magnitude of stressors. Biological communities of springs respond to stressing factors similar to other aquatic and riparian systems (e.g., Resh et al. 1988, Smith et al. 1991, Stromberg and Patton 1992, Fleischner 1994), however, the effect on arid-land spring biota appears to be more severe due to the naturally harsh arid environment, the isolation of springs from other aquatic systems, and challenges that these factors pose to organism dispersal and colonization. As harshness increases, aquatic communities become less speciose, support fewer environmentally intolerant species (e.g., non-baetid mayflies, caddisflies), and become increasingly dominated by environmentally tolerant and vagile species (e.g., beetles, water boatman, and midges; Sada et al. 2005). Harshness also affects riparian communities by decreasing

diversity and ground cover, and increasing the abundance of upland and non-native species (Fleischman et al. 2006).

Surface-water dynamics and water chemistry have strong effects on aquatic biota; therefore, biological assemblages (e.g. aquatic macroinvertebrates) are often excellent indicators of flow regime, water chemistry, and disturbance history. Alteration of surface-water resources within desert ecosystems has profound ecological and management implications, including loss of species diversity, extinction or extirpation of special-status and endemic species, alteration in the composition and distribution of plant and animal communities, alteration of culturally significant sites, and inability of parks to meet legal and policy mandates.

Discharge rates, aquifer sources, and the presence of rare species (e.g., fishes, aquatic

macroinvertebrates, rare plants, etc.) are known for a number of large springs in arid regions of the western U.S., but basic information describing the physical and biological characteristics of most springs is limited. This paucity of knowledge has stifled spring management strategies and little attention has been given to balancing human use with maintaining ecological integrity (Shepard 1993). As a consequence, most springs have been degraded by human activity and few springs resemble their historic biological and environmental condition (Shepard 1993, Sada 2001, Sada and Vinyard 2002).

The purpose of this inventory is to provide a consistent, base level of information on springs across several U.S. Fish and Wildlife Service (USFWS) refuges and National Park Service (NPS) parks and to provide information to develop a strategy for long-term monitoring.

Methods

Three springs in San Bernardino NWR, Arizona were inventoried in October 2011 following the Level 1 procedures described by Sada and Pohlmann (2006; located on enclosed CD). These springs were selected for inclusion in the inventory by USFWS staff led by Steve Cullinan. This inventory provided observations that focus on locating spring sources and recording information to assess their biotic potential, prioritize the importance of individual sites for long-term monitoring, and guide management.

The foundation for the protocol developed by Sada and Pohlmann (2006) is a number of hydrological and biological studies of springs in the western U.S. and elsewhere (e.g., Ferrington 1995, Botosaneanu 1998, Meffe and Marsh 1983, Williams and Danks 1991, Thomas et al. 1996, Sada et al. 2005, and many others cited herein) that examined spring physicochemical conditions and their influence on spring-fed aquatic and riparian communities. The Sada and Pohlmann (2006) protocol contains two levels of field procedures. The level of the Sada and Pohlmann (2006) protocol conducted at each spring depends on the amount of spring flow. The Level I procedure compiles information that characterizes salient aspects of each spring's aquatic and riparian environment and the communities that they support. This inventory focused on locating spring sources and recording information to assess their biotic potential, prioritize the importance of individual sites for long-term monitoring, and guide management (see below). The Level II procedure was applied to springs with sufficient flow to support riparian communities. It includes more quantitative estimates of spring habitat and vegetation characteristics (see below).

The Level I inventory consisted of identifying and recording spring orifices (source or water emergence points) using a Trimble Geo XH GPS unit; making site maps and descriptions; evaluating current and historic natural and anthropogenic disturbance; collecting benthic macroinvertebrates; and measuring water quality (water temperature, dissolved oxygen, pH, total dissolved solids [TDS], and conductance collected with a YSI ProPlus meter, and alkalinity, chloride, magnesium, sulfate, and calcium concentration with a YSI field spectrophotometer). Water quality meters were calibrated each morning prior to the sampling event, and post-calibration was conducted at the end of each day to ensure the meter remained calibrated throughout the day. Water quality measurements were taken at every orifice with sufficient flow. The crew also measured morphological characteristics such as brook length (if present) or wetted area of pool formations, water depth, discharge, substrate, emergent cover (vegetation), bank cover (vegetation), documented spring type, and took photo points. In addition, the crew documented presence of wildlife and common, rare, or exotic plants. Level I surveys were conducted on all springs at San Bernardino NWR (Table 1). See Appendix A for a full list of attributes collected during Level I surveys.

Data collected from each spring were compiled in a Microsoft Access® database developed by U.S. National Park Service database managers. Data used to prepare this report were analyzed by querying this database (located in enclosed CD).

Table 1. Springs included in the inventory at San Bernardino National Wildlife Refuge including location.

Spring Code	Spring Name	Unit Code	Survey Level	Date	Spring Type	Latitude	Longitude
SBNWR003	Figtree Spring	SBNWR	Level 1	9/29/2011	Heleocrene	31° 20' 21.937" N	109° 16' 24.301" W
SBNWR006	Snail Spring	SBNWR	Level 1	9/29/2011		31° 20' 11.607" N	109° 16' 40.010" W
SBNWR007	Goat Tank Spring	SBNWR	Level 1	9/29/2011	Other	31° 20' 11.062" N	109° 16' 44.599" W

Results and Discussion

The three springs inventoried at San Bernardino NWR include: Figtree Spring, Goat Tank Spring, and Snail Spring (Figure 1). All springs inventoried have experienced flow-altering human disturbance, such as excavation and construction of dams and enclosures. All data for individual springs are presented in Appendix B. A list of the plant species detected is included in Appendix C. Note this list reflects dominant or common species and is not intended to be a thorough inventory of plant taxa.

Spring Descriptions

According to refuge staff, water from **Figtree Spring** used to collect in Thule Pool and downstream holding tanks. Both Thule Pool and the tank were excavated to provide habitat for the endangered Yaqui Topminnow (*Poeciliopsis occidentalis sonoriensis*). Relics of human modification remain, including pipes, hoses, and the excavated pools. Water levels have now declined significantly due to water use by adjacent Slaughter Ranch, an historic site. An old water depth chart sits at the

western end of Thule Pool, but the current water level is too low to be measured on it. Remnants of Thule Pool consist of several mud puddles and one 8 by 3 m pool about 8 cm in depth. The pool is in a stand of thick vegetation, including Fremont cottonwoods (*Populus fremontii*), netleaf hackberry (*Celtis reticulata*), willows (*Salix* sp.), large mesquite bushes (*Prosopis* sp.), and common reed (*Phragmites australis*). Two non-native species, Bermuda grass (*Cynodon dactylon*) and stinkgrass (*Eragrostis cilianensis*), were also present. NWR staff tried to remove *Phragmites* by burning. Historic holding tanks downstream of Thule Pool are not generally associated with any riparian vegetation, and have experienced much sedimentary in-fill. Substrate in the pool consisted of 100% fines. Javelina were observed at this spring.

Goat Tank Spring emerges from two orifices on the southeast side of a stand of three large cottonwoods on ranch lawn. The primary orifice is a 120 by 80 cm cement spring box with a green metal cover. The water in the tank was about 100 cm deep and water

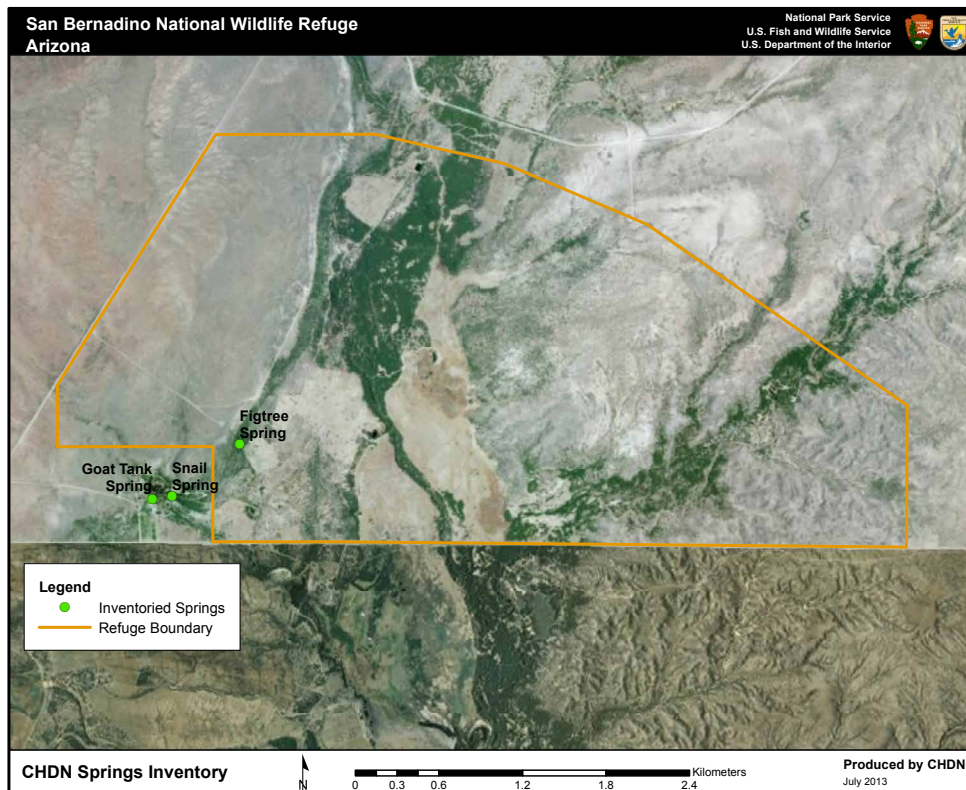


Figure 1. Map of the San Bernardino National Wildlife Refuge and location of springs.



Figtree Spring.

flows out of the tank and down the lawn as a trickle. Tree roots have grown into tank through crack in the cement. The secondary orifice emerges at base of a cottonwood 2 m to the left of the primary orifice. Chris Lohrengel (San Bernardino NWR staff) indicated that the secondary orifice emerged only a few years previously. It is a small, 20 x 20 cm pool, that is then diverted elsewhere (unknown) by a buried PVC pipe. The primary orifice is home to an endangered spring snail. Vegetation around springs includes cottonwoods, grass (*Paspalum* sp.), Bermudagrass (a non-native), Bristle grass (*Setaria leucopila*), and dandelions (*Taraxacum officinale*).

At **Snail Spring**, water emerges from a pipe and flows in a small 0.5 m wide x 60 m long stream with a water depth of about 4 cm. The source of the pipe is unknown. Discharge was estimated at about 10 L/min. An old, dry spring box is located upslope from the piped spring channel. Yerba mansa (*Anemopsis californica*) grows downslope from spring box and up to channel, which suggests the presence of small amount of underground seepage. The channel is cut through the soil and passes through a pipe under the road. Water emerges on other side of the road and continues flowing through a cattle pasture. The area around the spring is mostly irrigated, with mowed lawn from the ranch. A dense thicket of cottonwoods,

hackberries, and mesquite grow around spring. Sedges, herbs, and yerba mansa grow along the channel.

Water Quality

Sufficient water for water quality measurements was present at all springs inventoried. Water temperatures were fairly warm, ranging from 15.1 to 21.8°C. Dissolved oxygen (DO) concentrations were <1.0-2.85 mg/L. The level of DO necessary to protect fish and other aquatic life is 4 mg/L according to the U.S. Environmental Protection Agency (EPA) standard, and 6.0 mg/L DO standard for the Arizona Department of Environmental Quality (AZDEQ) for warm waters. DO levels at all springs failed to meet these criteria. pH levels varied from 6.6 to 7.4. The AZDEQ standard for pH is between 4.5 and 9.0. All springs meet this criteria. Total dissolved solids (TDS) ranged from 261 to 358 mg/L. The EPA doesn't have a standard for TDS, and AZDEQ has set one only for the Colorado River; however these values are fairly low and would likely meet any standard. Electrical conductance were 378-448 µS/cm, which is in the expected range for fresh water.

Crews used a field spectrophotometer to analyze water samples for alkalinity and common ions. Alkalinity (the water's capacity to neutralize acids) was measured



NPS

Goat Tank Spring.

as concentration (in mg/L) of calcium carbonate (CaCO_3), bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}). Alkalinity in the water results from any dissolved species (though usually weak acid ions such as carbonic acid) that can accept and neutralize protons. Because carbon dioxide (CO_2) is soluble and relatively abundant in water, and carbonates are common minerals over much of the Earth, the property of alkalinity of freshwater is determined by the presence of bicarbonates and carbonates. The $\text{CO}_2\text{—HCO}_3^-\text{—CO}_3^{2-}$ equilibrium system is the major buffering system in fresh water. Calcium carbonate levels ranged from 205-350 mg/L, bicarbonate levels were 250-420 mg/L, and carbonate values were 125-210 mg/L. These levels are typical for fresh water, given the range of pH values around neutral.

In addition to measuring alkalinity, concentration of common ions was also measured, including calcium (Ca^{2+}), chloride (Cl^-), magnesium (Mg^{2+}), and sulfate (SO_4^{2-}), all of which, when combined with bicarbonate and carbonate, constitute total salinity. Salinity of surface water depends on ionic influences of the surrounding land (geology), atmospheric deposition

(e.g. wind-blown dust), and evaporation rates relative to precipitation (Wetzel 2001). Calcium is a required nutrient for growth of freshwater flora and fauna and has direct influence on population growth. Many diatoms and invertebrates have calcium as a component of their outer covering or exoskeleton. Chloride is influential in osmotic balance and ion exchange. Magnesium is a component of chlorophyll and is therefore required universally by plants. Sulfur is utilized by all living organisms for protein synthesis. However, our interests are related to pollution from fertilizer and atmospheric deposition.

Calcium levels range from 14 mg/L to 24 mg/L. Calcium concentration greater than 20 mg Ca/L is associated with hard water (Wetzel 2001). Chloride levels ranged from 2.5 to 17 mg/L. Concentrations between 1 and 100 mg Cl/L are common in freshwater. Magnesium levels were <90-800 mg/L. Sulfate concentration were <1-10 mg/L. Typical ranges for sulfate concentration in freshwater is about 5-30 mg/L. All values were within the ranges typical for fresh water.

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Appendix A List of Attributes

The following elements were recorded during Level 1 surveys:

- Site Code—identification number for each spring within a national park or refuge. Consists of park or refuge name abbreviation and number
- Date the survey is conducted
- Person (Surveyor) conducting the spring survey
- Park Code—park or refuge name abbreviation
- Access. Record the ease at which the public could visit a spring. Categories 1 through 5. Category 1=inaccessible sites, access only by cross-country hiking; Category 2=sites that can be accessed only by arduous trail hike (e.g., >5 miles); Category 3=sites accessed by easy trail hike (e.g., 1 to 5 miles) and four-wheel drive vehicle; Category 4=sites easily accessed by walking less than 1 mile or a two-wheel drive, high clearance vehicle; and Category 5=sites immediately adjacent to high-quality gravel road or a paved road.
- Description of site access
- Extent of sampling effort with comments
- Sample start and end times
- Total time spent sampling
- Global Positioning System (GPS) location and the datum of the spring source and terminus. Record the UTM zone in the North American Datum of 1983 (NAD83) unless otherwise specified. Document GPS files in a gps log. All geographic information system (GIS) data layers created from GPS files must include FGDC Geospatial and Biological Profile (NBII) compliant metadata. Record PDOP or “+” the number of meters as metrics indicating accuracy of the GPS reading.
- Photos. Photographs should be taken to show the spring and its landscape context. One should overview the spring source and looking downstream, and the second from the spring brook’s end looking upstream. At larger springs, take one photo of the source and a second from a distant area that encompasses as much of the riparian area as possible. Photos should be labeled by site ID number, date, site name, photographer, subject, and GPS coordinates of the point where the photo was taken. Photos should be taken using a digital camera. Maintain a photo log with digital photograph number and description using the Location ID. Note on the site map where photos were taken.
- Site Description—description of overall ecological community and geologic setting in which the spring is situated.
- Site Map—includes locations of orifices, water quality measurements, photo points, and more.
- Important animals and plants. Important species are those that occupy or use the aquatic or riparian environments, and noted during the survey. This list may differ among management areas, and it should be compiled accordingly. It should include (1) rare species, (2) species that are indicative of spring characteristics (e.g., species of woody vegetation, obligatory and facultative wetland vegetation, crenobiontics), (3) species of management interest or concern, and (4) non-native species. Species should be identified, if possible. If a species cannot be identified, the presence of plants and

animals within any of the important groups should be recorded (e.g., native fish and trees, mollusks, aquatic insects, non-native species, etc.). Also note the presence of important terrestrial species, such as bats, if seen. Noting the presence of these types of species provides information that assists with identifying management issues and can be used to determine management priorities. Important species occupy a wide variety of habitats, and they may be very scarce or abundant.

- Aquatic macroinvertebrates can be readily captured from aquatic vegetation, debris, or substrate. Each species prefers a distinct microhabitat, and sampling must include all habitat types that occur in a spring (e.g., sand, gravel, & cobble substrates, all types of emergent and submerged vegetation, all current velocities, mid-channel, backwater, and lateral habitats).
- **Site Condition.** This evaluation qualitatively identifies (1) disturbance factors stressing a spring and (2) the amount of stress of each factor on the spring environment. Influences of flooding are indicated by location of a spring in the bottom of a gully, presence of a naturally incised channel, and usually a paucity of vegetation. The presence of pipes, dikes, or spring box indicates modifications for diversion. Abundance of hoof prints and droppings, and evidence of grazing indicates ungulate use of a spring. The presence of campsites and trash indicates recreation. The most common stressing factors are listed on the field form, and the appropriate factor(s) affecting a spring should be circled. Disturbance may be influenced by multiple factors such as trampling by intensive livestock and diversion into a trough; recreation use along a spring brook that tramples vegetation and the spring brook is channelized away from areas used for picnicking. Each spring is categorized as undisturbed, slightly, moderately, or highly disturbed:
 - **Undisturbed** springs have been unaffected by recent or historical factors or activities. All evidence of trampling, diversion, fire, or drying is absent. Since most springs have been altered by humans, drought, fire, or flood, these types of springs are rare and most undisturbed springs are naturalizing from past disturbances.
 - **Slightly Disturbed** springs exhibit little evidence that vegetation or soil have been disturbed. Vegetation shows slight signs of browsing and foraging, and animal footprints and scat are present but not prominent. Recreation may be evident, but its impact on riparian or aquatic environments is minimal. Evidence of fire or flooding in the distant past may be visible but these events occur infrequently; riparian vegetation is vigorous.
 - **Moderately Disturbed** springs exhibit evidence of recent, comparatively high disturbance. Use by native and non-native ungulates, and recreation has reduced vegetation height and coverage from natural conditions. Vegetation covers, hoof prints, footprints, and scat are common. Where there has been diversion, a spring box may be present but at least 50% of natural discharge remains within the natural spring brook. Neither the spring nor spring brook has been impounded. Where flooding or fire is apparent, >50% of the spring brook banks are covered by vegetation; flood and fire are infrequent and the spring is naturalizing.
 - **Highly Disturbed** springs have little similarity to undisturbed springs. Less than 50% of their banks are covered by vegetation, their spring brooks contain <50% of natural discharge, they are impounded or dredged, or spring boxes collect water. All impounded springs are highly disturbed because flow has been interrupted and functional characteristics of the aquatic system have been highly altered. Hoof prints and scat are abundant where ungulate use is heavy, and campsites are large, trashy, and vehicle use evident. These activities have decreased vegetative cover of spring brook banks to <50%. Springs affected by drought (springs that are dry

when sampled or experience seasonal or annual drying) should also be categorized as highly disturbed. These springs can be identified by the presence of upland riparian species and absence of obligatory wetland plants. Riparian vegetation is sparse at springs recently affected by fire or flooding, there is recent evidence of elevated discharge, and spring brooks are usually incised.

- Dissolved Oxygen Concentration, (D.O., in mg/liter) using a field meter measured as close to the spring source as possible and in flowing water if available.
- Water Temperature in degrees Centigrade
- Conductivity (also called electrical conductance). Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. This ability is dependent on the amount of dissolved ions, and is therefore an indicator of total dissolved solids in the solution. Conductivity provides insight into water sources and it is important to aquatic life because of requirements to maintain osmoregulatory balance. Conductivity is measured using a field meter and recorded in microsiemens.
- pH. pH is the measure of hydrogen activity, which indicates the acid/basic qualities of water.
- Total dissolved solids (TDS) in mg/L. Measure of all organic and inorganic substances dissolved in the water.
- The following are measured field spectrophotometer using water samples collected in the field:
 - Alkalinity—the water’s capacity to neutralize acids—measured as concentration (in mg/L) of calcium carbonate (CaCO_3), bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}).
 - Chloride concentration in mg/L
 - Magnesium concentration in mg/L
 - Sulfate concentration in mg/L
 - Calcium concentration in mg/L
- Spring Brook Length, measured in meters. Use a tape to measure distance from the spring source (upstream limit of surface water) to the downstream limit of surface water.
- Estimated discharge by recording the length of time required to fill a container with a known volume. Unfortunately, it is usually not possible to use this method because most arid land springs are very small and it is difficult to capture water in a container (their small size also prevents using a water current velocity meter to measure discharge). While these factors limit the precision of most discharge estimates, the amount of water issuing from spring sources should be estimated in liters/minute. These estimates combined with water width, depth, and spring brook length provide sufficient information to characterize spring discharge rates.
- Average Water Depth. This is a qualitative estimate of the vertical distance from substrate to water surface (in centimeters) that is found throughout the aquatic habitat.
- Average Water Width. This is a qualitative estimate of the distance covered by water (and perpendicular to its flow) that lies between banks of the spring brook, less islands, emergent rocks, etc., in centimeters. (This is formally described as the length of wetted contact between flowing or standing water and the spring brook bank in a vertical plane at right angles to the direction of flow.)

- **Emergent Cover.** Estimate to the nearest 10 percent the vegetative, debris, or other material that arises within the water width and covers the water surface.
- **Vegetative Bank Cover.** Estimate to the nearest 10 percent the proportion of spring brook banks that is covered by live vegetation.
- **Substrate Composition.** Qualitatively estimate using a Wentworth particle scale analysis, which describes the substrate by the proportional composition of materials, where materials are classified as: fines (<1 mm), sand (1-5 mm), gravel (>5-80 mm), cobble (>80-300 mm), boulder (>300 mm), or bedrock. Size is defined as the minimum particle size of substrate as measured on a two-dimensional axis, as would pass through a substrate sieve.
- **Spring Type,** as: **Rheocrene** (a spring that discharges into a defined channel), **Limnocrene** (a spring that discharges into a ponded or pooled habitat before flowing into a defined channel), **Helocrene** (similar to a Limnocrene, but marshy and comparatively shallow, not an open pond or pool), or unknown. In some areas, springs have been altered by native peoples or settlers by excavating the source to create a **Qanat**, which is a type of hand-dug well. Where these occur, water is regionally scarce and where surface water is scarce. Also record if a site is a mechanically dug **Well** (usually with rock, metal, or plastic casing). Record **Other** when the source is something else, such as a cliff face, boil, etc. Record spring type as **Unknown** at highly disturbed sites where no semblance of natural characteristics of a spring remains, or where the spring is dry. Examples of disturbances that prevent identifying spring type include impoundment by dikes, sources in a spring box, or dredging and filling to capture water in a pipe leading to a trough. Spring alterations and spring condition are assessed, and recorded, in the Site Condition section below. If further description is necessary, it can be summarized in the Notes Section.
- **Notes,** to include additional pertinent information. This may include observations further describing site condition, use of the spring by other animals (e.g., bats, wild horses, etc.), clarification of difficulties in accessing the spring, etc.

Appendix B Spring Data

The following are data collected at each San Bernardino National Wildlife Refuge spring.

SBNWR003—Figtree Spring

Sample Date: 9/29/2011

Physical characteristics.

Parameter	Value
Brook Length (m)	0
Discharge (L/min)	0
Mean Water Depth (cm)	8
Mean Water Width (cm)	200
Emergent Cover (%)	200
Vegetated Bank Cover (%)	50
Fines (%)	100
Gravel (%)	0
Cobble (%)	0
Boulder (%)	0
Sand (%)	0
Comments	Thule pond

Disturbance. Scores for natural and anthropogenic disturbance. Categories are 1=undisturbed, 2=slightly disturbed, 3=moderately disturbed, 4=highly disturbed.

Parameter	Value
Roads	2
Hiking	1
RecUse	1
FlowMod	4
Livestock	1
Contemp	4
Historic	4
Flood	1
Wind	1
Graze	2
Insect	1
Fire	2
Drying	2
Flow Mod	TRUE
Modification Type	Pipe Diversion; Dam Diversion; Open Trough/Tank; Excavation

Vegetation observations. For Wetland Indicator, FACW=facultative wetland.

USDA Code	Scientific Name	Common Name	Nativity	Wetland Indicator	WI Source
CERE2	<i>Celtis reticulata</i>	netleaf hackberry	Native		
CYDA	<i>Cynodon dactylon</i>	Bermudagrass	Non-Native		
CYPER	<i>Cyperus</i> sp.	flatsedge	N/A	YES	CHDN
ERCI	<i>Eragrostis cilianensis</i>	stinkgrass	Non-Native		
PHAU7	<i>Phragmites australis</i>	common reed	Native	FACW	USDA
POFR2	<i>Populus fremontii</i>	Fremont cottonwood	Native	YES	CHDN
PROSO	<i>Prosopis</i> sp.	mesquite	N/A		
SALIX	<i>Salix</i> sp.	willow	N/A	YES	CHDN
SCIRP	<i>Scirpus</i> sp.	bulrush	N/A	YES	CHDN
SELE6	<i>Setaria leucopila</i>	streambed bristlegrass	Native		

Water quality characteristics. Except for pH, all units are mg/L unless otherwise indicated.

Parameter	Value
Orifice	1
Shade	Shade
Temp	15.1
DO (mg/L)	1.14
DO (%)	11.3
pH	7.30
TDS	358.8
EC (μS)	447.6
Notes	Figtree Spring - mostly shade, in aquatic vegetation, center of pool
Alka_CaCO ₃	350
Alka_HCO ₃ ⁻	420
Alka_CO ₃ ²⁻	210
Chloride	1.5
Magnesium	800
Sulphate (SO ₄ ²⁻)	0
Sulphur (S)	0
Calcium (Ca)	24
Location	Center of pool
Notes	No contact with soil

SBNWR006—Snail Spring

Sample Date: 9/29/2011

Physical characteristics.

Parameter	Value
Brook Length (m)	20
Discharge (L/min)	10
Mean Water Depth (cm)	4
Mean Water Width (cm)	50
Emergent Cover (%)	100
Vegetated Bank Cover (%)	100
Fines (%)	100
Gravel (%)	0
Cobble (%)	0
Boulder (%)	0
Sand (%)	0
Comments	

Disturbance. Scores for natural and anthropogenic disturbance. Categories are 1=undisturbed, 2=slightly disturbed, 3=moderately disturbed, 4=highly disturbed.

Parameter	Value
Roads	4
Hiking	1
RecUse	1
FlowMod	4
Livestock	3
Contemp	4
Historic	4
Flood	1
Wind	1
Graze	1
Insect	1
Fire	1
Drying	1
Flow Mod	TRUE
Modification Type	Pipe Diversion; Pumping; Encasement

Vegetation observations. For Wetland Indicator, OBL=wetland obligate.

USDA Code	Scientific Name	Common Name	Nativity	Wetland Indicator	WI Source
ANCA10	<i>Anemopsis californica</i>	yerba mansa	Native	OBL	USDA
CERE2	<i>Celtis reticulata</i>	netleaf hackberry	Native		
CYDA	<i>Cynodon dactylon</i>	Bermudagrass	Non-native		
	Cyperaceae		N/A	YES	CHDN
POFR2	<i>Populus fremontii</i>	Fremont cottonwood	Native	YES	CHDN
SALIX	<i>Salix</i> sp.	willow	N/A	YES	CHDN

Water quality characteristics. Except for pH, all units are mg/L unless otherwise indicated.

Parameter	Value
Orifice	1
Shade	Shade
Temp	20.5
DO (mg/L)	1.34
DO (%)	15.3
pH	6.57
TDS	268.05
EC (μS)	
Notes	
Alka_CaCO ₃	255
Alka_HCO ₃ ⁻	310
Alka_CO ₃ ²⁻	150
Chloride	3
Magnesium	220
Sulphate (SO ₄ ²⁻)	9
Sulphur (S)	3
Calcium (Ca)	14
Location	Sample taken from fountain
Notes	No contact with surface water

SBNWR007—Goat Tank Spring

Sample Date: 9/29/2011

Physical characteristics.

Parameter	Value
Brook Length (m)	
Discharge (L/min)	0
Mean Water Depth (cm)	100
Mean Water Width (cm)	120
Emergent Cover (%)	0
Vegetated Bank Cover (%)	0
Fines (%)	
Gravel (%)	
Cobble (%)	
Boulder (%)	
Sand (%)	
Comments	Spring box

Disturbance. Scores for natural and anthropogenic disturbance. Categories are 1=undisturbed, 2=slightly disturbed, 3=moderately disturbed, 4=highly disturbed.

Parameter	Value
Roads	3
Hiking	1
RecUse	1
FlowMod	4
Livestock	1
Contemp	4
Historic	4
Flood	1
Wind	1
Graze	1
Insect	1
Fire	1
Drying	1
Flow Mod	TRUE
Modification Type	Pipe Diversion; Open Trough/Tank; Encasement

Vegetation observations.

USDA Code	Scientific Name	Common Name	Nativity	Wetland Indicator	WI Source
CYDA	<i>Cynodon dactylon</i>	Bermudagrass	Non-native		
POPUL	<i>Populus</i> sp.	cottonwood	N/A	YES	CHDN
SELE6	<i>Setaria leucopila</i>	streambed bristlegrass	Native		

Water quality characteristics. Except for pH, all units are mg/L unless otherwise indicated.

Parameter	Value	
Orifice	1	2
Shade	Shade	Shade
Temp	21.8	21.8
DO (mg/L)	2.85	0.65
DO (%)	32.3	7.4
pH	7.40	7.22
TDS	261.3	301.6
EC (μS)	378	
Notes	Taken in tank. CHDN #1. Goat Spring 1, Snail Spring 2	Snail spring 2 = secondary orifice
Alka_CaCO ₃	205	
Alka_HCO ₃ ⁻	250	
Alka_CO ₃ ²⁻	125	
Chloride	10	
Magnesium	90	
Sulphate (SO ₄ ²⁻)	10	
Sulphur (S)	3	
Calcium (Ca)	18	
Location	Tank/spring box	
Notes		

Appendix C List of Plants Detected

Table C1. List of plants detected at San Bernardino National Wildlife Refuge springs.

Scientific Name	Common Name	Nativity
<i>Anemopsis californica</i>	yerba mansa	Native
<i>Celtis reticulata</i>	netleaf hackberry	Native
<i>Cynodon dactylon</i>	Bermudagrass	Non-native
<i>Cyperus</i> sp.	flatsedge	N/A
<i>Eragrostis cilianensis</i>	stinkgrass	Non-native
<i>Phragmites australis</i>	common reed	Native
<i>Populus fremontii</i>	Fremont cottonwood	Native
<i>Prosopis</i> sp.	mesquite	N/A
<i>Salix</i> sp.	willow	N/A
<i>Setaria leucopila</i>	streambed bristlegrass	Native
<i>Taraxacum officinale</i>	dandelion	Non-native

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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