



Mojave Desert Network Selected Large Springs

Death Valley National Park Benthic Macroinvertebrate and Springsnail Data 2014 to 2015

Natural Resource Data Series NPS/MOJN/NRDS—2017/1115



ON THE COVER

Saratoga Spring, Death Valley National Park.
Photograph by: G. J. M. Moret.

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Abstract

As part of the Selected Large Springs protocol, the Mojave Desert Network Inventory and Monitoring Program (MOJN I&M) collects samples of benthic macroinvertebrates (BMI) and measures water quality and discharge in several springs. The purpose of these actions is twofold:

- to provide data regarding the overall health of the aquatic ecosystems in the springs, and
- to monitor the endemic species present in the springs.

These data will be useful in determining the effects of any observed changes in hydrology or vegetation, and will provide baseline information that can be used to evaluate management actions at the springs.

MOJN I&M collects BMI samples from five Selected Large Springs in Death Valley National Park: Travertine Springs, Nevares Spring, Texas Spring, Mound Spring, and Saratoga Spring. This report presents the results of monitoring efforts at Travertine Springs and Nevares Spring in March 2014 and at Mound Spring, Texas Spring, and Saratoga Spring in February 2015.

Acknowledgments

The authors would like to acknowledge the assistance of Emma Bernard, Richard Friese, and Mary Levandowski in the field. The Utah State University National Aquatic Monitoring Center (NAMC) provided taxonomic analysis of the benthic macroinvertebrate samples.

Overview

The National Park Service (NPS) Mojave Desert Network Inventory and Monitoring Program (MOJN I&M) has developed a protocol to monitor the hydrology and ecology of large springs in the MOJN parks. The MOJN Selected Large Springs (SLS) protocol covers springs in Death Valley National Park (DEVA), Joshua Tree National Park (JOTR), Lake Mead National Recreation Area (LAKE), Mojave National Preserve (MOJA), and Grand Canyon-Parashant National Monument (PARA). The springs have been selected for their high discharges, stability, and biological importance, and were chosen in cooperation with park staff to address the resource management priorities of each park.

As part of the SLS protocol, MOJN I&M collects samples of benthic macroinvertebrates (BMI) and measures water quality and discharge in several springs. The purpose of these actions is twofold:

- to provide data regarding the overall health of the aquatic ecosystems in the springs, and
- to monitor the endemic species present in the springs.

These data will be useful in determining the effects of any observed changes in hydrology or vegetation, and will provide baseline information that can be used to evaluate management actions at the springs.

MOJN I&M collects BMI samples from five Selected Large Springs in DEVA: Travertine Springs, Nevares Spring, Texas Spring, Mound Spring, and Saratoga Spring. This report presents the results of monitoring efforts at Travertine Springs and Nevares Spring in March 2014 and at Mound Spring, Texas Spring, and Saratoga Spring in February 2015.

Travertine Springs

Travertine Springs is located near Furnace Creek in central DEVA and has the highest discharge of the Furnace Creek springs, estimated at 4630 m³/day for all outlets (Belcher and Sweetkind 2010). There are currently two outlets, Travertine 1 and Travertine 2, that flow in well-defined springbrooks (Figure 1).

Travertine 1 flows from a pipe (part of a former collection system) on top of a spring mound. The spring flows through a narrow channel down the flank of the spring mound into a wash below. Once in the wash, the spring flows for several hundred meters until it is diverted into a drain on the shoulder of Furnace Creek Road. Travertine 2 flows from a pipe near the head of a wash several hundred meters to the west of Travertine 1. Currently, the springbrook extends for several hundred meters. Until recently, much of the spring's discharge was diverted for park use. As of 2014, restoration is ongoing.

Laczniak, Smith, and DeMeo (2006) estimate that the spring supports 21.4 ac (8.7 ha) of riparian vegetation, resulting in 45 ac-ft/yr (152 m³/day) of evapotranspiration. Much of this vegetation was consumed by fire in August 2010. The Travertine-Texas-Nevares springs complex supports several endemic benthic invertebrates, including the springsnail *Ipnotobius robustus* (formerly *Tryonia robusta*; Hershler 2001), the Badwater snail (*Assimineia infima*; Sada 2001), the Nevares Spring

naucorid bug (*Ambrysus funebris*; Sada and Cooper 2012), the Furnace Creek riffle beetle (*Microcylloepus formicoideus*; Shepard 1990), the Travertine Springs amphipod (*Hyaella sandra*; Witt, Threlhoff, and Hebert 2006), and the Texas Spring amphipod (*Hyaella muerta*; Witt, Threlhoff, and Hebert 2006).

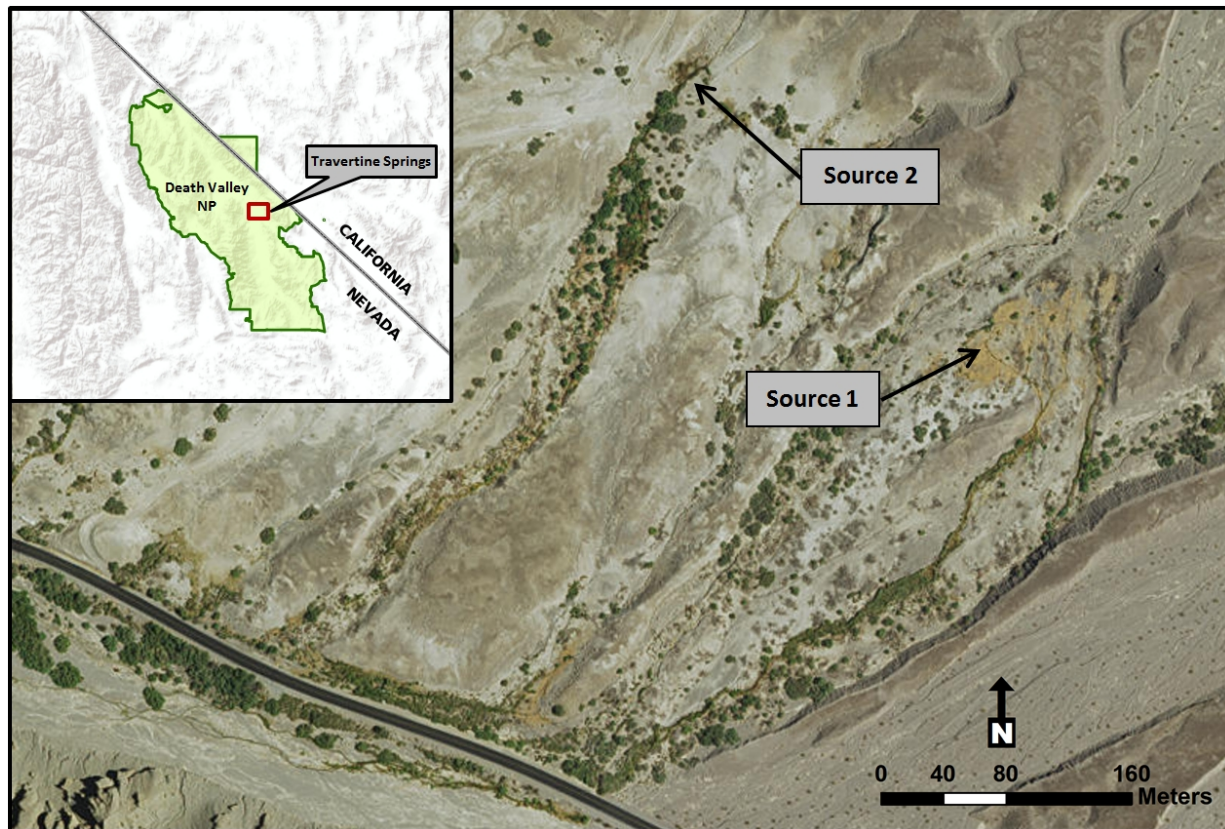


Figure 1. Aerial view of Travertine Springs. Inset: Location of Travertine Springs in DEVA.

Nevares Spring

Nevares Spring is located near Furnace Creek in central DEVA. Belcher and Sweetkind (2010) estimate the discharge at 1885 m³/day. The spring emerges in a marshy area on top of a spring mound. Much of the discharge then descends into a wash, where it flows in a springbrook for several hundred meters (Figure 2). Until recently, some of the discharge was diverted for park use. As of 2014, tests are underway to determine if a well at the top of the spring mound can be used as a water supply instead of the surface discharge.

Laczniak, Smith, and DeMeo (2006) estimate that the spring supports 29 ac (11.7 ha) of riparian vegetation, resulting in 61 ac-ft/yr (206 m³/day) of evapotranspiration. Restoration efforts were ongoing in late 2016 and early 2017 to remove non-native fan palms (*Washingtonia filifera*) from the spring mound. Nevares Spring supports several benthic macroinvertebrates endemic to the Travertine-Nevares-Texas springs complex, including the springsnail *Ipnobius robustus* (Hershler 2001), the Badwater snail (*Assimineia infima*; Sada 2001), the Nevares Spring naucorid bug

(*Ambrysus funebris*; Whiteman and Sites 2008), and the Travertine Springs amphipod (*Hyaella sandra*; Witt, Threlhoff, and Hebert 2006).

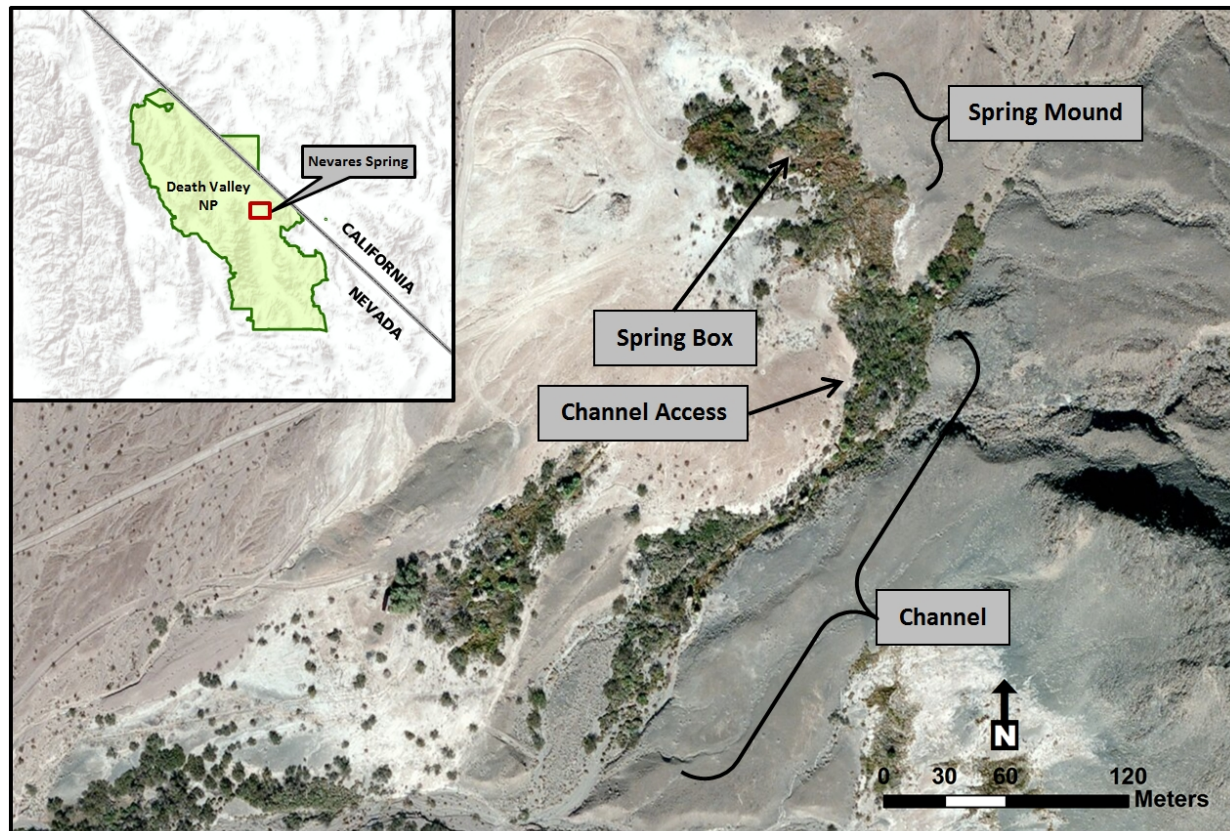


Figure 2. Aerial view of Nevares Spring. Inset: Location of Nevares Spring in DEVA.

Texas Springs

Texas Springs is located near Furnace Creek in central DEVA (Figure 3). Discharge from Texas Springs was diverted sometime before 1941 to provide water to the U.S. Borax and Chemical Corporation. Subsequently, Texas Springs provided water to the Texas Springs Campground and to a 2 million gallon storage tank that served as a potable water supply for the Furnace Creek area. The collection of galleries, French drains, and tunnel used to collect spring discharge left the spring ecosystem highly disturbed. The diversion is estimated to have reduced the historic springbrook length by 85% (Threlhoff and Koenig 1999).

Currently, the discharge from the historic collection system is released to the ground surface, where it forms a small pool. This water flows into a spring brook that runs for roughly 200 m before flowing into a narrow, deeply-incised ravine up to 5 m deep (Figure 4). The ravine does not appear to be safe to enter. Discharge at Texas Spring from 1989 to 1996 was estimated at 1220 m³/day (Belcher and Sweetkind 2010).

Lacznia, Smith, and DeMeo (2006) estimated that Texas Spring supports 11.2 ac (4.5 ha) of riparian vegetation, resulting in 24 ac-ft/yr (81 m³/day) of evapotranspiration. Benthic macroinvertebrates

endemic to the Travertine-Nevares-Texas springs complex are also found at the spring, including the Nevares naucorid bug (*Ambrysus funebris*; Whiteman and Sites 2008) and the Texas Spring amphipod (*Hyalella muerta*; Witt, Threlloff, and Hebert 2006).

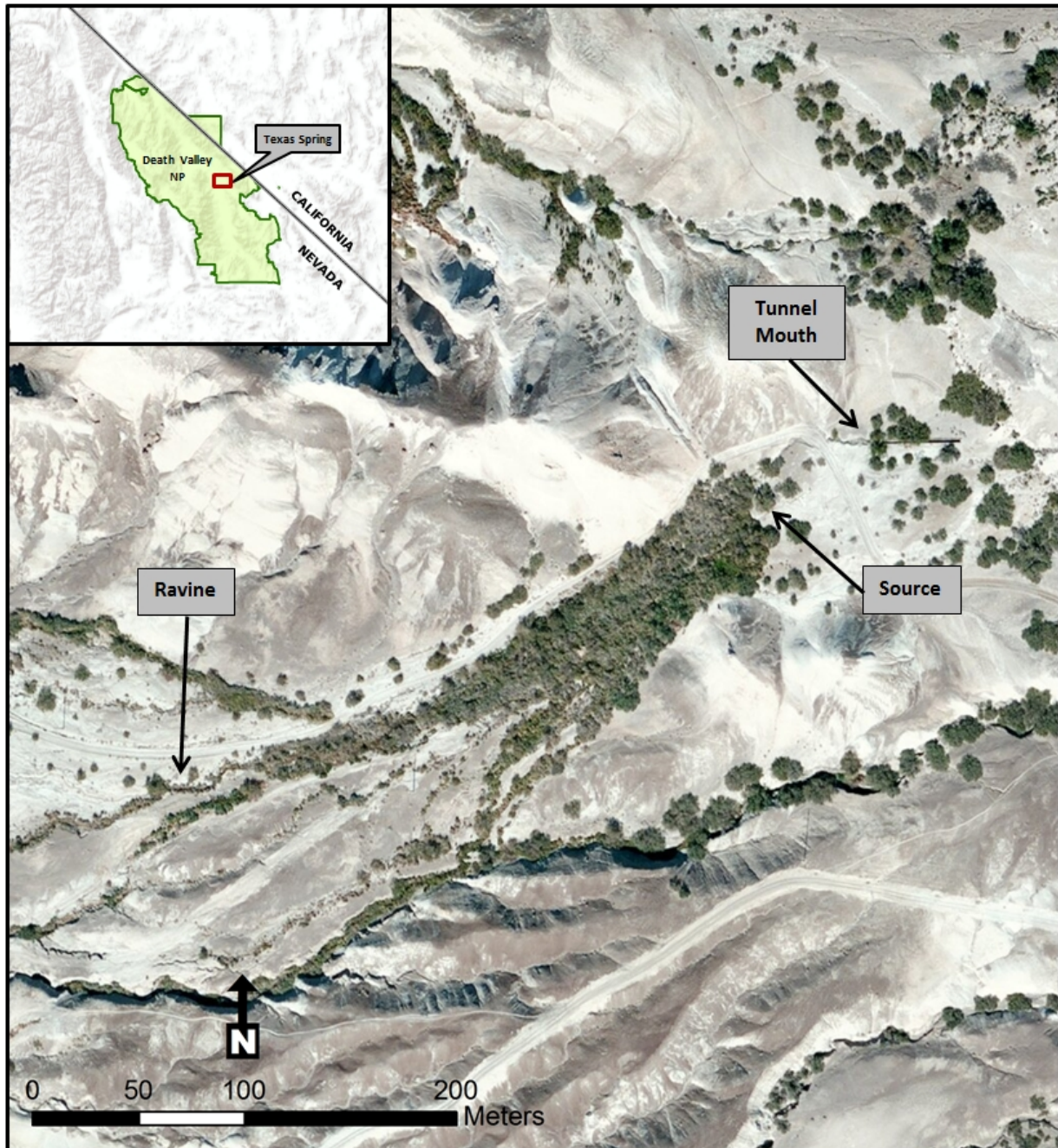


Figure 3. Aerial view of Texas Spring. Inset: Location of Texas Spring in DEVA.



Figure 4. View to the west of the incised ravine below Texas Spring.

Mound Spring

Mound Spring is located in the Grapevine Springs complex in the Grapevine Mountains of northeastern DEVA (Figure 5). The complex is composed of several discrete springs and diffuse discharge areas, with a total discharge estimated at $2450 \text{ m}^3/\text{day}$ (Belcher and Sweetkind 2010). Historically, some of the surface water was diverted to Scotty's Ranch.

Laczniak, Smith, and DeMeo (2006) estimated that the Grapevine Springs complex supports 191.3 ac (77.4 ha) of riparian vegetation, resulting in 405 ac-ft/yr ($1369 \text{ m}^3/\text{day}$) of evapotranspiration. A

stand of dead fan palms (*Washingtonia filifera*) is located at Mound Spring where monitoring occurs (Figure 6).

The Grapevine Springs complex supports two endemic springsnails of the *Tryonia* genus: *T. margae* and *T. rowlandsi* (Hershler, Mulvey, and Liu 1999). The complex also supports two springsnails of the *Pyrgulopsis* genus: *P. sanchezi* and *P. perforata*, the latter of which is endemic to the springs near Scotty's Castle (Hershler, Liu, and Bradford 2013).

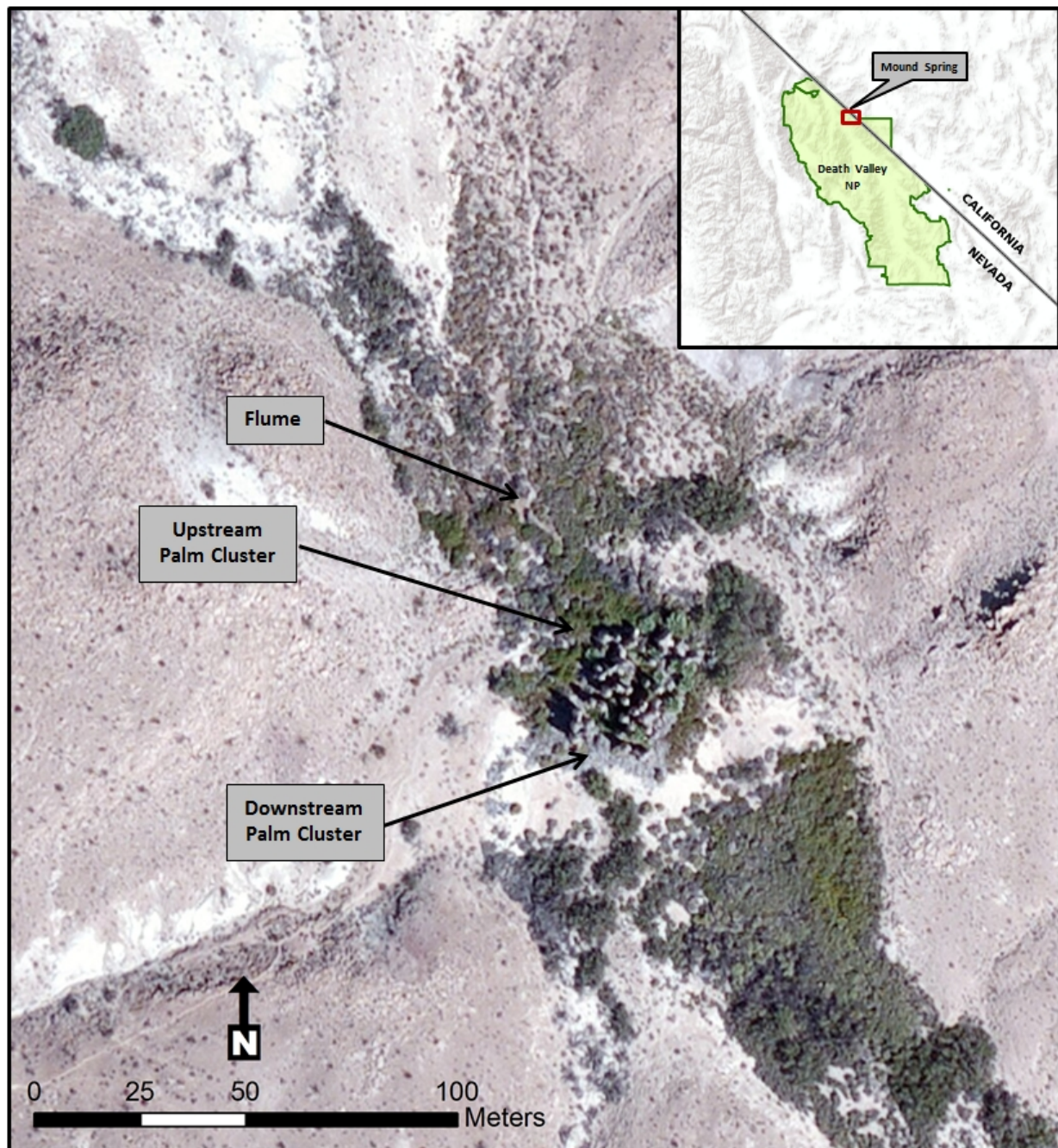


Figure 5. Aerial view of Mound Spring. Inset: Location of Mound Spring in DEVA.



Figure 6. View of Mound Spring looking north toward the dead palm clusters.

Saratoga Spring

Saratoga Spring is located in the far south of DEVA (Figure 7). Throughout its history, the spring has been used as a watering stop for mule teams, a water supply for nearby mines, the source for a water bottling operation, and a small tourist resort (Latschar 1981), so the area has been highly disturbed. Discharge from Saratoga Spring historically ranged from 76 to 80 gal/min (414 to 436 m³/day; Miller 1977).

The spring supports approximately 7 ha of wetlands vegetation (primarily reeds and bulrushes) and open water. At the southern end of the spring, water flows from a historic spring box to a source pool that is approximately 10 meters in diameter. From the source pool, water flows north along a low-banked channel through the reeds to a series of artificial downstream ponds (Figure 8), the largest of which is approximately 60 m by 200 m.

Saratoga Spring supports the endemic Saratoga Springs pupfish (*Cyprinodon nevadensis nevadensis*), the endemic Saratoga Spring belostoman bug (*Belostoma saratogae*), the Saratoga shore bug (*Pentacora saratogae*) which is endemic to Death Valley, and three springsnail species: *Pyrgulopsis amargosae*, *Pyrgulopsis sanchezi*, and *Tryonia variegata* (Hershler and Liu 2008; Hershler, Liu, and Bradford 2013; Hershler, Mulvey, and Liu 1999).

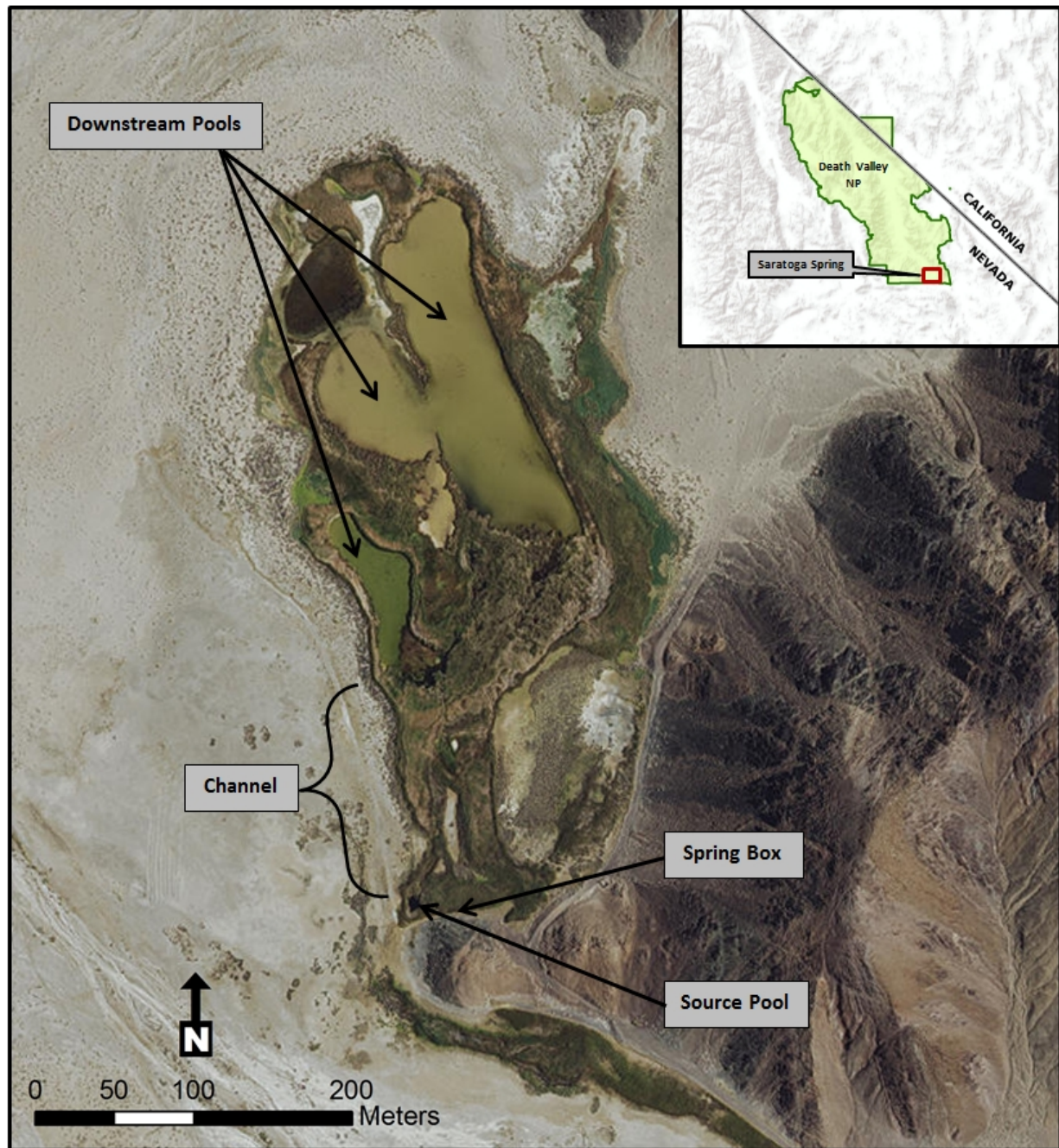


Figure 7. Aerial view of Saratoga Spring. Inset: Location of Saratoga Spring in DEVA.



Figure 8. View of Saratoga Spring looking south over the downstream ponds.

Methods

BMI Samples

For more detailed information on BMI collection methods used at each of the springs in DEVA, refer to SOP 8: Water Sampling, Benthic Macroinvertebrate Sampling, and Springsnail Monitoring (Moret et al. 2016).

BMI samples collected at the springs were preserved in ethanol and shipped to the Utah State University National Aquatic Monitoring Center (NAMC) for processing. There, the samples were sorted, identified to the lowest resolute taxon, and enumerated. Identifications were made by taxonomists certified by the Society for Freshwater Science using the taxonomic keys recommended by the Southwest Association of Freshwater Invertebrate Taxonomists (Richards and Rogers 2011). In order to provide a more complete taxa list, the samples were visually searched for 10 minutes for additional big and/or rare taxa. The NAMC's full procedures can be reviewed on their website (<http://www.usu.edu/buglab/SampleProcessing/LaboratoryProcedures/>, accessed 26 July 2017). The specimens from the samples are archived by the NAMC under the terms of a long-term loan agreement with the NPS.

Travertine Spring

BMI sampling at Travertine Spring occurred on March 14, 2014. Three composite samples were collected: one upstream sample and one downstream sample from Travertine 1 as well as one sample from Travertine 2.

The upstream sample of Travertine 1 was collected from 0 m to 60 m away from the spring source at 10 m intervals. The first 30 m of the springbrook were too narrow for a 10 cm x 10 cm quadrat, so a 3 cm x 3 cm quadrat was used instead. Beyond 30 m, the springbrook was wider, so the 10 cm x 10 cm quadrat was used. The submerged vegetation in each quadrat was jabbed three times, and the substrate in each quadrat was disturbed with a paintbrush for 30 seconds. Material was captured in a 15-cm kicknet placed just downstream of the quadrat. The material collected at these seven locations was combined into a single composite reachwide sample for a total of 0.034 m² area sampled.

The downstream sample of Travertine 1 was collected from 90 m to 390 m away from the spring source at 30 m intervals. No material was collected at the 270 m interval because the springbrook was inaccessible at this location. Beyond 390 m, the springbrook approached the culvert at Highway 190. This section of the springbrook wide enough to use the 10 cm x 10 cm quadrat. The material collected at these ten locations was combined into a single composite reachwide sample for a total of 0.1 m² area sampled.

The sample of Travertine 2 was collected from 0 m to 130 m away from the spring source at 10 m intervals. Material was collected at each interval using the 10 cm x 10 cm quadrat, and the material collected at these 14 locations was combined into a single composite reachwide sample for a total of 0.14 m² area sampled.

Nevares Spring

BMI sampling at Nevares Spring occurred on March 7, 2014. One composite sample was collected from the marshy area on top of the spring mound. The submerged vegetation in each 10 cm x 10 cm quadrat was jabbed three times, and the substrate in each quadrat was disturbed with a paintbrush for 30 seconds. The material was captured in a 15-cm kicknet placed just downstream of the quadrat. Material was collected from ten locations in the primary source channel, which was about 18 m long, as well as from five locations in a secondary source channel, which was about 10 m long (Figure 9). Material was also collected from two locations within a small source pool roughly 2 m x 2 m and from three locations in the channel below the springbox. The material collected from these 20 locations was combined into a single composite source sample for a total of 0.2 m² area sampled.



Figure 9. Secondary source channel on the spring mound at Nevares Spring. Blue flags indicate locations where material was collected for the BMI sample.

Texas Spring

BMI sampling occurred on February 11, 2015. One composite sample was collected from the springbrook. Material was collected from ten 30 cm x 30 cm quadrats spaced every 10 m from 0 m to 90 m downstream of the source. The substrate in each quadrat was disturbed by lightly sweeping the quadrat with a wader boot for 30 seconds. Material was captured in a 30-cm kicknet placed just downstream of the quadrat. The material collected at the ten sample locations was combined into a single composite sample for a total of 0.9 m² area sampled.

Mound Spring

BMI sampling occurred on February 10, 2015, which was the first time Mound Spring was visited for the SLS protocol. Two composite samples were collected: one downstream palm cluster sample and one upstream palm cluster sample. Material was collected from five 10 cm x 10 cm quadrats in different locations within the downstream palm cluster. At each location, material was collected by disturbing the substrate within each quadrat upstream of a 15-cm kicknet for 30 seconds. These five locations were combined into one composite downstream sample for a total of 0.05 m² area sampled. Material was additionally collected from five quadrats within the upstream palm cluster and combined into one composite upstream sample for a total of 0.05 m² area sampled.

Saratoga Spring

BMI sampling occurred on February 27, 2015. Four composite samples were collected: one from the fine mud at the bottom of source pool, one from the vegetated perimeter of the source pool, one from the channel, and one from the most accessible downstream pond.

Source Pool

Material was collected from ten 30 cm x 30 cm quadrats spaced evenly along the bottom of the source pool. The substrate in each quadrat was disturbed by lightly sweeping the quadrat with a wader boot for 30 seconds. Material was captured in a 30-cm kicknet placed just downstream of the quadrat. The material collected at the ten locations was combined into a single composite benthic sample for a total of 0.9 m² area sampled.

Material was also collected from ten locations spaced evenly around the perimeter of the source pool along emergent rushes and sedges. Material was collected at each location using the 30-cm kicknet. The material collected at the ten locations was combined into a single composite perimeter sample. Because of the imprecise nature of sampling dense streambank vegetation with a kicknet, this sample was considered qualitative, and there is no total area associated with the sample.

Channel

Material was collected from ten 30 cm x 30 cm quadrats spaced every 10 m from 0 m (upstream start of the channel) to 90 m (downstream end of the channel). The substrate in each quadrat was disturbed by lightly sweeping the quadrat with a wader boot for 30 seconds. Material was captured in a 30-cm kicknet placed just downstream of the quadrat. The material collected at the ten locations was combined into a single composite channel sample for a total of 0.9 m² area sampled.

Downstream Pond

Material was collected from ten locations along the western margin of the downstream pond fed by the channel. At five locations, material was collected via jabs at the emergent vegetation along the perimeter of the pond. At an additional five locations, material was collected from the substrate, which generally consisted of anoxic mire. Both collection methods used the 30-cm kicknet. The material collected at the ten sample locations was combined into a single composite downstream pond sample. Because of the multiple sampling methods used and the imprecise nature of sampling dense streambank vegetation with a kicknet, this sample was considered qualitative, and there is no total area associated with the sample.

Springsnail Field Counts

While springsnails were included in the BMI sampling discussed above, MOJN I&M also monitored the density and spatial extent of the springsnail populations in Travertine Springs and Nevares Spring. Springsnail monitoring occurred on March 14, 2014 at Travertine Spring and on March 7, 2014 at Nevares Spring. The methods were modified from those outlined by Sada (2009) and were designed to monitor the extent and density of the springsnail (Hydrobiidae) population.

The extent of the springsnail population was determined by observing the presence or absence of springsnails at accessible locations. At each location, a sample of substrate was brushed into a sieve. The portion of the substrate retained in the sieve was then spread across a white plastic tray and visually inspected for springsnails. Monitoring points were selected at accessible locations across the reach of the springbrook where springsnails were present. A measuring tape was used to select monitoring points at regular intervals.

In upstream Travertine 1, there were seven monitoring points every 10 m from 0 m to 60 m away from the source. In downstream Travertine 1, there were eleven monitoring points every 30 m from 90 m to 390 m away from the source. In Travertine 2, there were thirteen monitoring points every 10 m from 0 m to 120 m away from the source. In Nevares Spring, there were eleven monitoring points distributed across the spring mound.

At each monitoring point, a quadrat was placed on the bottom of the springbrook. A 3 cm x 3 cm quadrat was used for the first 30 m of Travertine 1. A 10 cm x 10 cm quadrat was used for Travertine 1 beyond 30 m and for Travertine 2. A 5 cm x 5 cm quadrat was used for Nevares Spring. The surface material and loose substrate within the quadrat were brushed into a sieve. The material retained from the sieve was transferred to a sorting tray, and approximately 1 cm of water was added. The number of springsnails in the tray was then counted. All springsnails were returned to the locations from which they were collected.

Results

Water Quality

Several water quality parameters were measured near the source of each spring at the time of BMI sample collection. The values of these measurements are provided in Table 1.

Table 1. Water quality parameters measured at springs in DEVA in 2014 and 2015.

Parameter	Travertine 1 Source	Travertine 2 130 m Dstrm	Nevares 11 sites*	Texas Source Pipe	Mound Flume**	Saratoga Springbox
Temp (°C)	34.5	32.0	25.4-37.6	31.51	37.5	28.60
pH	—	—	7.04-8.28	7.60	7.14	7.63
SpCond (µS/cm)	1134	812	—	945	1112	4590
DO (%)	—	—	—	103.4	—	53.0
DO (mg/L)	4.43	5.10	—	7.60	3.24	4.04

* Nevares water quality data were measured at 11 locations on the top of the spring mound. The range of the 11 measurements for each parameter is reported here.

** Mound Spring water quality data were measured by DEVA staff at the time of BMI sampling.

Dash indicates that the parameter was not measured.

BMI Samples

The results of the BMI sample processing and taxonomic analysis conducted by the NAMC are shown for Travertine Springs in Table 2, Nevares Spring in Table 3, Texas Spring in Table 4, Mound Spring in Table 5, and Saratoga Spring in Table 6. Selected population metrics reported by the NAMC are shown in Tables 7 and 8.

Table 2. BMI abundance per square meter in Travertine Spring.

Phylum	Class	Order	Family	SubFamily	Genus	Species	Travertine 1 Upstream	Travertine 1 Downstream	Travertine 2
Arthropoda	Arachnida	Trombidiformes	—	—	—	—	0	0	1486
Arthropoda	Arachnida	Trombidiformes	Hydryphantidae	—	Wandesia	—	118	0	0
Arthropoda	Arachnida	Trombidiformes	Lebertiidae	—	Lebertia	—	0	0	29
Arthropoda	Insecta	Coleoptera	Elmidae	—	Microcylloepus	—	0	160	0
Arthropoda	Insecta	Coleoptera	Elmidae	Elminae	Microcylloepus	formicoideus	0	60	0
Arthropoda	Insecta	Coleoptera	Hydroscaphidae	—	Hydroscapha	—	235	0	0
Arthropoda	Insecta	Coleoptera	Hydroscaphidae	—	Hydroscapha	natans	0	0	457
Arthropoda	Insecta	Diptera	Ceratopogonidae	—	—	—	0	0	114
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	Probezzia	—	0	0	86
Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyheleinae	Dasyhelea	—	0	0	600
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyiinae	—	—	0	0	57
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyiinae	Atrichopogon	—	118	0	0
Arthropoda	Insecta	Diptera	Chironomidae	—	—	—	0	0	114
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Apedilum	—	0	0	57
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Micropsectra	—	0	0	943
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	—	0	20	800
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Polypedilum	—	471	0	2829
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Rheotanytarsus	—	0	0	343
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Tanytarsus	—	0	0	29
Arthropoda	Insecta	Diptera	Chironomidae	Orthoclaadiinae	—	—	0	20	0

Table 2 (continued). BMI abundance per square meter in Travertine Spring.

	Phylum	Class	Order	Family	SubFamily	Genus	Species	Travertine 1 Upstream	Travertine 1 Downstream	Travertine 2
	Arthropoda	Insecta	Diptera	Chironomidae	Orthoclaadiinae	Tvetenia	—	118	40	0
	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Larsia	—	0	0	400
	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	—	0	20	29
	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Procladius	—	0	20	0
	Arthropoda	Insecta	Diptera	Stratiomyidae	—	—	—	0	0	29
	Arthropoda	Insecta	Diptera	Tipulidae	—	—	—	0	100	0
	Arthropoda	Insecta	Ephemeroptera	Acanthametropodidae	—	Analetris	—	24824	0	0
	Arthropoda	Insecta	Ephemeroptera	Baetidae	—	Fallceon	—	0	0	57
16	Arthropoda	Insecta	Hemiptera	Naucoridae	—	—	—	618	0	0
	Arthropoda	Insecta	Hemiptera	Naucoridae	Ambrysinae	Ambrysus	—	118	20	0
	Arthropoda	Insecta	Lepidoptera	Crambidae	Nymphulinae	Petrophila	—	0	0	57
	Arthropoda	Insecta	Odonata	Coenagrionidae	—	—	—	0	0	143
	Arthropoda	Insecta	Odonata	Coenagrionidae	—	Argia	—	0	0	14
	Arthropoda	Insecta	Odonata	Gomphidae	—	—	—	0	60	29
	Arthropoda	Insecta	Odonata	Gomphidae	—	Erpetogomphus	—	0	0	50
	Arthropoda	Insecta	Odonata	Libellulidae	—	Libellula	comanche	0	10	0
	Arthropoda	Insecta	Trichoptera	Helicopsychidae	—	Helicopsyche	—	0	120	5429
	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Cheumatopsyche	—	0	40	0
	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	Hydroptila	—	0	0	29
	Arthropoda	Insecta	Trichoptera	Philopotamidae	—	—	—	0	0	114
	Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarrinae	Chimarra	—	0	0	179

Table 2 (continued). BMI abundance per square meter in Travertine Spring.

Phylum	Class	Order	Family	SubFamily	Genus	Species	Travertine 1 Upstream	Travertine 1 Downstream	Travertine 2
Arthropoda	Malacostraca	Amphipoda		—	—	—	0	0	229
Arthropoda	Malacostraca	Amphipoda	Hyaellidae	—	Hyaella	—	36735	1420	0
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	—	—	0	0	3429
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	Ipnobius	—	0	12360	0
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	Ipnobius	robustus	10588	0	0
Platyhelminthes	Turbellaria	—	—	—	—	—	353	0	0

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Table 3. BMI abundance per square meter in Nevares Spring.

Phylum	Class	Order	Family	SubFamily	Genus	Species	Spring Mound
Annelida	Clitellata	—	—	—	—	—	360
Arthropoda	Arachnida	Trombidiformes	Mideopsidae	—	Mideopsis	—	20
Arthropoda	Insecta	Diptera	Ceratopogonidae	—	—	—	20
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Polypedilum	—	20
Arthropoda	Malacostraca	Amphipoda	—	—	—	—	280
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	—	—	14610

Table 4. BMI abundance per square meter in Texas Spring, DEVA.

Phylum	Class	Order	Family	Sub Family	Genus	Species	Reachwide
Arthropoda	Insecta	Diptera	Ceratopogonidae	—	—	—	5.9
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	Probezzia	—	3.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	—	3.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Polypedilum	—	5.9
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Sublettea	—	5.9
Arthropoda	Insecta	Diptera	Tipulidae	—	—	—	5.9
Arthropoda	Insecta	Hemiptera	Gelastocoridae	—	Gelastocoris	—	3.0
Arthropoda	Insecta	Hemiptera	Naucoridae	Ambrysinae	Ambrysus	—	5.9
Arthropoda	Insecta	Odonata	Gomphidae	—	Erpetogomphus	compositus	3.0
Arthropoda	Insecta	Trichoptera	Hydropsychidae	—	—	—	3.0
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	—	Hyalella	—	187.8
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	—	—	1614.8
Platyhelminthes	Turbellaria	—	—	—	—	—	3.0

Table 5. BMI abundance per square meter in Mound Spring, DEVA.

Phylum	Class	Order	Family	Sub Family	Genus	Species	Upstream Palms	Downstream Palms
Arthropoda	Arachnida	Trombidiformes	—	—	—	—	160.0	—
Arthropoda	Insecta	Diptera	Ceratopogonidae	—	—	—	—	20.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	—	1920.0	53.3
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Larsia	—	—	53.3
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Thienemannimyia group	—	—	53.3
Arthropoda	Insecta	Odonata	Gomphidae	—	—	—	—	53.3
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	—	Hyalella	—	320.0	160.0
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	—	—	98240.0	33786.7

Table 6. BMI abundance per square meter in Saratoga Spring, DEVA. The source pool benthic and channel abundances are quantitative values reported per square meter. The source pool perimeter and downstream pond abundances are qualitative values reported per sample.

Phylum	Class	Order	Family	Sub Family	Genus	Species	Source Pool Benthic	Source Pool Perimeter	Channel	Downstream Pond
Annelida	Clitellata	—	—	—	—	—	—	—	22.2	—
Arthropoda	Arachnida	Trombidiformes	—	—	—	—	—	—	8.9	—
Arthropoda	Arachnida	Trombidiformes	Arrenuridae	—	Arrenurus	—	—	7.1	—	—
Arthropoda	Arachnida	Trombidiformes	Unionicolidae	—	—	—	—	99.6	—	—
Arthropoda	Insecta	Coleoptera	Curculionidae	—	—	—	—	3.6	—	—
Arthropoda	Insecta	Coleoptera	Elmidae	—	—	—	—	21.3	—	—
Arthropoda	Insecta	Coleoptera	Elmidae	—	Microcylloepus	—	—	—	530.0	—
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Hydrophilinae	Enochrus	—	—	3.6	—	—
Arthropoda	Insecta	Diptera	Ceratopogonidae	—	—	—	—	—	40.0	—
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	Probezzia	—	—	—	35.6	—
Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyheleinae	Dasyhelea	—	—	—	13.3	—
Arthropoda	Insecta	Diptera	Chironomidae	—	—	—	—	7.1	8.9	—
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Apedilum	—	—	103.1	—	28.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Chironomus	—	—	—	—	2.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Dicrotendipes	—	—	—	—	1.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Endotribelos	—	—	—	4.4	15.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Micropsectra	—	—	—	4.4	5.0
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratanytarsus	—	—	10.7	—	—
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Polypedilum	—	—	42.7	35.6	—
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Rheotanytarsus	—	—	3.6	35.6	—
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Tanytarsus	—	—	—	22.2	—
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Paraphaenocladus	—	—	—	8.9	—

Table 6 (continued). BMI abundance per square meter in Saratoga Spring, DEVA. The source pool benthic and channel abundances are quantitative values reported per square meter. The source pool perimeter and downstream pond abundances are qualitative values reported per sample.

Phylum	Class	Order	Family	Sub Family	Genus	Species	Source Pool Benthic	Source Pool Perimeter	Channel	Downstream Pond
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Larsia	—	—	—	22.2	2.0
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	—	—	—	22.2	1.0
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Tanypus	—	—	—	—	9.0
Arthropoda	Insecta	Diptera	Stratiomyidae	—	Caloparyphus	—	—	3.6	—	—
Arthropoda	Insecta	Diptera	Stratiomyidae	—	Nemotelus	—	—	—	14.4	—
Arthropoda	Insecta	Hemiptera	Corixidae	—	—	—	—	—	—	2.0
Arthropoda	Insecta	Hemiptera	Naucoridae	Naucorinae	Pelocoris	—	—	1.0	4.4	—
Arthropoda	Insecta	Hemiptera	Veliidae	—	—	—	—	—	4.4	—
Arthropoda	Insecta	Odonata	Coenagrionidae	—	—	—	—	10.7	8.9	4.0
Arthropoda	Insecta	Odonata	Coenagrionidae	—	Argia	—	—	—	4.4	—
Arthropoda	Insecta	Odonata	Gomphidae	—	—	—	—	—	1.1	—
Arthropoda	Insecta	Odonata	Libellulidae	—	—	—	8.9	—	—	—
Arthropoda	Insecta	Trichoptera	Helicopsychidae	—	Helicopsyche	—	—	3.6	—	—
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	Oxyethira	—	—	—	—	30.0
Arthropoda	Malacostraca	Amphipoda	Hyaellidae	—	Hyaella	—	142.2	746.1	271.1	11.0
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	—	—	26.7	—	1266.7	2.0
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	Ipnobius	robustus	1591.1	—	—	—
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	Pyrgulopsis	—	3368.9	839.1	921.1	—
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	—	Tryonia	—	88.9	99.6	330.0	—
Mollusca	Gastropoda	Neotaenioglossa	Thiaridae	—	Melanoides	tuberculata	26.7	—	4.4	—

Table 7. Selected population metrics for 2014 DEVA BMI samples.

Population Metric	Travertine 1 Upstream	Travertine 1 Downstream	Travertine 2	Nevares
# of Taxa*	8	8	10	2
Abundance	74294	14470	18157	15310
Dominant Family	Hyaellidae	Hydrobiidae	Chironomidae	Hydrobiidae
% Dominant Family	49.4	85.4	30.5	95.4
# of EPT Taxa*	0	2	3	0
EPT Abundance	24824	160	5807	0
# of Shredder Taxa*	0	0	1	0
Shredder Abundance	471	100	2829	20
# of Scraper Taxa*	1	1	1	1
Scraper Abundance	235	120	9371	14610
# of Collector-Filterer Taxa*	0	1	1	0
Collector-Filterer Abundance	0	40	664	0
# of Collector-Gatherer Taxa*	2	3	2	0
Collector-Gather Abundance	37206	1660	2829	640
# of Predator Taxa*	1	2	2	1
Predator Abundance	853	120	2436	40
# of Long-Lived Taxa*	0	2	0	0

Values for richness (diversity) based metrics are standardized to operational taxonomic units and a fixed count of 300. Standardized metrics are indicated with an asterisk. Density (abundance) metrics are presented as the estimated number of individuals per square meter for quantitative samples and the number of individuals collected in each sample for qualitative samples. EPT stands for the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).

Table 8. Selected population metrics for 2015 DEVA BMI samples.

Population Metric	Texas	Mound Upstrm Palms	Mound Dstrm Palms	Saratoga Source Benthic	Saratoga Source Perimeter	Saratoga Channel	Saratoga Dstrm Pond
# of Taxa*	6	3	3	3	6	12	6
Abundance	1850	100640	34180	5253	567	3646	112
Dominant Family	Hydrobiidae	Hydrobiidae	Hydrobiidae	Hydrobiidae	Hydrobiidae	Hydrobiidae	Chironomidae
% Dominant Family	87.3	97.6	98.9	96.6	46.6	69.1	56.3
# of EPT Taxa*	0	0	0	0	1	0	1
EPT Abundance	3	0	0	0	1	0	30
# of Shredder Taxa*	0	0	0	0	0	0	0
Shredder Abundance	12	0	0	0	13	36	0
# of Scraper Taxa*	1	1	1	1	1	1	1
Scraper Abundance	1615	98240	33787	3396	237	2188	2
# of Collector-Filterer Taxa*	0	0	0	0	0	0	0
Collector-Filterer Abundance	3	0	0	0	1	58	0
# of Collector-Gatherer Taxa*	2	2	1	1	3	5	2
Collector-Gatherer Abundance	194	2240	213	142	251	878	62
# of Predator Taxa*	2	0	1	0	0	5	1
Predator Abundance	21	160	180	9	34	152	16
# of Long-Lived Taxa*	0	0	0	0	0	2	0

Values for richness (diversity) based metrics are standardized to operational taxonomic units and a fixed count of 300. Standardized metrics are indicated with an asterisk. Density (abundance) metrics are presented as the estimated number of individuals per square meter for quantitative samples and the number of individuals collected in each sample for qualitative samples. EPT stands for the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).

Travertine Springs

The upstream sample of Travertine 1 had the highest BMI abundance at Travertine Springs. *Hyaella* sp. (amphipods) was the dominant taxon with 36,735 specimens per m². The mayfly *Anaetris* sp. was the most abundant insect taxon with 24,824 specimens per m². There were also greater than 10,000 springsnails (*Ipnobius robustus*) per m². This species of springsnail is endemic to the Travertine-Texas-Nevares springs complex. Naucorid bugs (*Ambrysus* sp.) were also abundant. These naucorid bugs may have been the Nevares Spring naucorid bug (*Ambrysus funebris*), which is also endemic to the Travertine-Texas-Nevares springs complex.

In the downstream sample of Travertine 1, the springsnail *Ipnobius robustus* was the dominant taxon with 12,360 specimens per m². There were also greater than 1,000 *Hyaella* sp. per m². The most abundant insect taxon was the Furnace Creek riffle beetle (*Microcylloepus formicoideus*), which is endemic to Travertine Spring. Naucorid bugs (*Ambrysus* sp.) were also present in the sample.

The Travertine 2 sample had the highest BMI diversity at Travertine Springs. The caddisfly *Helicopsyche* sp. was the dominant taxon with 5,429 specimens per m². There were also 3,429 springsnails (Hydrobiidae) per m². Other abundant taxa exceeding 1000 specimens per m² included nonbiting midges (*Polypedilum* sp.) and mites (Trombidiformes).

Nevares Spring

The Nevares Spring sample had low BMI diversity. Springsnails (Hydrobiidae) were the dominant taxon with 14,610 specimens per m². There were also 360 segmented worms (Clitellata) per m² and 280 freshwater amphipods (Amphipoda) per m². Nonbiting midges (*Polypedilum* sp.), biting midges (Ceratopogonidae), and mites (*Mideopsis* sp.) were also present. No naucorid bugs (*Ambrysus* sp.) were collected in the sample, but at least one specimen was observed at the spring during springsnail monitoring (Figure 10).



Figure 10. Naucorid bug (*Ambrysus* sp.) observed during monitoring at Nevares Spring.

Texas Spring

Hydrobiidae (springsnails) was the most abundant family, with 1,615 springsnails per m² comprising 87.3% of the BMI sampled. There were smaller populations of amphipods (*Hyalella* sp.), biting midges (Ceratopogonidae), clubtail dragonflies (Gomphidae), and crane flies (Tiplulidae). Several different chironomid (non-biting midge) species were also present in the sample, along with net-spinning caddisflies (Hydropsychidae). Two genera in the order Hemiptera (true bugs) were also counted in the sample: *Gelastocoris* sp. in the family Gelastocoridae (toad bugs) and *Ambrysus* sp. in the family Naucoridae (creeping water bugs).

Mound Spring

The upstream palms location had a very high abundance of Hydrobiidae (springsnails), with an estimated density of 98,240 individuals per m². This family made up 97.6% of the BMI sampled. There was a smaller population of the chironomid *Paratendipes* sp. Freshwater amphipods (*Hyalella* sp.) and mites (Trombidiformes) were present in the sample as well.

The downstream palms location also had a high abundance of Hydrobiidae, with an estimated density of 33,787 individuals per m². This family comprised nearly all of the BMI sampled at 98.9%. There were small populations of *Hyalella* sp., several chironomid species, club-tailed dragonflies (Gomphidae), and biting midges (Ceratopogonidae) collected from this location.

Saratoga Spring

Source Pool

The source pool benthic location was comprised of 96.6% Hydrobiidae, with 5,076 springsnails per m². The dominant hydrobiid was *Pyrgulopsis* sp., and there was a smaller population of *Tryonia* sp. The invasive snail *Melanoides tuberculata* (Malaysian trumpet snail) was also present in the sample. There was not much diversity in the sample, but freshwater amphipods (*Hyalella* sp.) and skimmer dragonflies (Libellulidae) were also collected from this location.

The source pool perimeter location was less homogeneous than previous locations. *Hydrobiidae* was still the most abundant family, but comprised only 46.6% of the sample. The springsnail *Pyrgulopsis* sp. and the amphipod *Hyalella* sp. were the most dominant taxa. Three families of beetles (*Coleoptera*) were present in the sample: true weevils (Curculionidae), riffle beetles (Elmidae), and water scavenger beetles (Hydrophilidae), along with other insects such as soldier flies (Stratiomyidae), pond damselflies (Coenagrionidae), the naucorid bug *Pelocoris* sp., and *Helicopsyche* sp. in the order Trichoptera (caddisflies). Mites (Trombidiformes) and non-biting midges (Chironomidae) were also collected from this location.

Channel

The channel location was the most diverse, with 12 different taxa represented. Hydrobiidae was the most abundant family with 1,251 springsnails per m² comprising 69.1% of the BMI sampled. The riffle beetle *Microcyloepus* sp. and the amphipod *Hyalella* sp. were found in smaller populations, and the invasive snail *M. tuberculata* was present in the sample. Also present were several species of biting midge (Ceratopogonidae), non-biting midge (Chironomidae), soldier flies (Stratiomyidae),

creeping water bugs (Naucoridae), riffle bugs (Veliidae), and damselflies (Coenagrionidae). Mites (Trombidiformes) and segmented worms (Annelida) were collected from this location as well.

Downstream Pond

The downstream pond location was the only location in the spring where Hydrobiidae was not the most abundant family. Non-biting midges (Chironomidae) comprised 56.3% of the BMI sample, whereas Hydrobiidae comprised only 1.8% of the sample. Also present in the sample was *Oxyethira* sp., a microcaddisfly in the order Trichoptera (caddisflies). The families Corixidae (water boatmen), Coenagrionidae (damselflies), and Hyalellidae (amphipods) were represented as well. No invasive Malaysian trumpet snails (*Melanoides tuberculata*) were collected from this location.

Based on laboratory counts and field observations, springsnails were abundant in all locations except for the downstream pond at Saratoga Spring, which did not yield very many BMI of any taxon. The sample at this location was collected in stagnant, open water from a soft, anoxic mucky substrate, which is not a habitat that is favorable to springsnails or other BMI.

Springsnail Field Counts

In addition to collecting BMI samples, MOJN I&M also counted springsnails in the field during the pilot study visits to Travertine Springs and Nevares Spring in March 2014. Tables 9 and 10 show the observed springsnail abundances in Travertine Springs, and Table 11 shows the abundances in Nevares Spring.

Table 9. Springsnail population abundances observed in the Travertine 1 outlet at Travertine Spring.

Location on Transect 0 m = Source	UTM Coordinates	Substrate	Comment	Abundance in Quadrat
0 m	4033086 N 515431 E	Small rocks mostly loose with patches that are packed	Fast-flowing water coming from pipe, partially shaded	2 (0.0009 m ²)
10 m	—	Loose sediment with large rocks	Highly vegetated, fully shaded	1 (0.0009 m ²)
20 m	—	Rocks, soft sediment	Fast flow, partially shaded	13 (0.0009 m ²)
30 m	—	Soft sediment with large rocks	Roots, vegetation, partially shaded	24 (0.0009 m ²)
40 m	—	Loose sediment with large rocks	Fast flow	175 (0.01 m ²)
50 m	—	Coarse sediment	Fast flow, travertine-armored snails	65 (0.01 m ²)
60 m	4033043 N 515463 E	—	Fast flow, sunny	84 (0.01 m ²)
90 m	4033016 N 515453 E	Fine roots	Slow flow, partially shaded	3 (0.01 m ²)
120 m	—	Soft sediment, travertine	Fast flow, nearly fully shaded, naucorid bug observed	1 (0.01 m ²)
149.9 m	4032971 N 515415 E	Travertine	Dense patch of springsnails → opportunistic observation, no vegetation, slightly sunnier than 150 m	22 (0.01 m ²)
150 m	—	Travertine, decayed vegetation	Flowing water, partially shaded	1 (0.01 m ²)
180 m	—	Soft sediment and algae over travertine	Partially shaded	147 (0.01 m ²)
210 m	—	Soft sediment and algae over travertine	Completely shaded	7 (0.01 m ²)
240 m	—	Soft sediment, roots	Completely shaded	2 (0.01 m ²)
270 m	—	—	Inaccessible	—
300 m	—	Gravel, sand, roots, plant debris	Fully shaded	1 (0.01 m ²)
330 m	—	Gravel, travertine	Fully shaded, naucorid bug observed	0 (0.01 m ²)
360 m	—	Travertine	Flowing water, fully shaded	0 (0.01 m ²)
390 m	4032843 N 515227 E	Travertine, gravel	Flowing water, fully shaded	5 (0.01 m ²)

Table 10. Springsnail population abundances observed in the Travertine 2 outlet at Travertine Spring.

Location on Transect 0 m = Source	UTM Coords.	Substrate	Comment	Abundance in Quadrat (0.01 m ²)
0 m	4033249 N 515229 E	Large rocks, roots	Fast flowing water coming from pipe, partially shaded, cattail patch	0
10 m	—	Roots, fines	Still water, partly shaded, springsnails observed on root mat	52
20 m	—	Roots	Shaded	0
30 m	—	Loose sediment and roots, pebbles, sand, gravel	Fast flow, vegetative cover, partially shaded	0
40 m	—	Large rocks, pebbles, travertine	Fast flow, partial cover	0
50 m	—	Coarse rocks, travertine	Fast flow, full sun exposure	0
60 m	—	Coarse rocks	Slower flow, partially shaded	0
70 m	—	Large rocks, travertine	Fast flow, full sun exposure	0
80 m	—	Coarse rocks	Fast flow, partially shaded	0
90 m	—	Fines, large rocks	Fast flow, full sun exposure	0
100 m	—	Fines, roots	Edge of cattails, good sun exposure	0
110 m	—	Large rocks	Runs under vegetation, fully shaded	0
120 m	—	Rock	Shaded	0
130 m	4033136 N 515211 E	Soft sediment, roots	—	0

Table 11. Springsnail population abundances observed in Nevares Spring.

Location 11 = Source	UTM Coords.	Substrate	Comment	Abundance in Quadrat (0.0025 m ²)
1	4040797 N 516000 E	Algae, compacted sand and fines	Partially shaded by bank vegetation, furthest downstream extent of springsnail population	47
2	4040824 N 516013 E	Fines, algae	20% shaded by palm fronds 1 m above sampling location, mostly sunny	67
3	4040817 N 516020 E	Mostly fines, some pebbles	Sunny, very exposed, location in small source pond	226
4	4040820 N 516023 E	Fines, sand	Partially shaded on one side by bank veg, location in primary source channel	15

Table 11 (continued). Springsnail population abundances observed in Nevares Spring.

Location 11 = Source	UTM Coords.	Substrate	Comment	Abundance in Quadrat (0.0025 m²)
5	4040800 N 516030 E	Litter, fines	Almost entirely shaded due to leaf and litter cover	7
6	4040797 N 516025 E	Fines, algae mat, salt crust	90% sunny, mostly exposed, too many springsnails to count	>1000
7	4040804 N 516027 E	Fines	50% shaded by bank vegetation, 50% sunny	37
8	4040806 N 516008 E	Fines, algae, calcified sand	85% shaded by bank vegetation	24
9	4040804 N 516008 E	Fines	30% shaded by bank and emergent cover	29
10	4040802 N 516019 E	Fines, sand, litter	50% shaded by bank vegetation, location in secondary source channel	88
11	4040801 N 515992 E	Fines, compacted sediment, algae	100% shaded by palm thicket, springsnail population at source	5

At Travertine Springs, springsnails were observed in the source and throughout the upstream and downstream reaches of Travertine 1. There was a high population density of about 17,500 specimens per m² at a distance of 40 m and another high population density of about 14,700 specimens per m² at a distance of 180 m. The average density of the upstream reach was 10,833 specimens per m², similar to the 10,588 specimens per m² reported by the lab. The average density of the downstream reach was 1,518 specimens per m² (not including the observation at 149.9 m) or 1,575 specimens per m² (including the observation at 149.9 m). Both of these densities were much lower than the 12,360 specimens per m² reported by the lab.

There were no springsnails observed in the spring source of Travertine 2. The only springsnails observed across the reach of the outlet were the 5,200 specimens per m² at a distance of 10 m. The average density of 371 specimens per m² was much lower than the 3,429 specimens per m² reported by the lab.

At Nevares Spring, springsnails were present in the spring source and throughout the spring mound. There was a high population density of about 90,400 specimens per m² in the small source pool and another very high population density of >400,000 specimens per m² in one of the source channels. The average density of about 56,000 specimens per m² was much higher than the 14,610 specimens per m² reported by the lab.

Hand counting of springsnails will be eliminated in future monitoring efforts as this method proved to be inaccurate and unreliable during field testing. Springsnail estimates at Travertine Springs were generally much lower than those reported by the lab. It is possible that juvenile springsnails were too small to discern with the naked eye and that a large number of specimens went uncounted in the

field. Additionally, springsnails may have been buried within the substrate and overlooked. On the other hand, springsnails were too overwhelmingly abundant at Nevares Spring to count accurately and were overestimated in the field. Complicating the discrepancy between the field observations and the lab report is that the eleven springsnail monitoring locations at Nevares Spring were not the same as the twenty locations where the BMI sample was collected. The discrepancy may therefore reflect heterogeneity in springsnail population density across the spring mound as opposed to (or in addition to) error in estimating numbers. Laboratory counts alone will be used in the future to monitor springsnail populations at springs in DEVA.

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