Final Project Report

Contract #: 19-516-0000-00007

ESTABLISHING VIABLE IMPERILED SPRINGSNAIL REFUGE POPULATIONS AT THE ALBUQUERQUE BIOPARK AQUATIC CONSERVATION FACILITY, NM

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December 28, 2019

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Background

Springsnails are among the most diverse and imperiled mollusks in North America. Of the seven *Pyrgulopsis* species documented to have recently occurred in New Mexico, one is extirpated (*P. metcalfi*), three are listed as both Federally and State endangered (*P. chupaderae, P. roswellensis, P. neomexicana*), and three are listed as State threatened (*P. thermalis, P. gilae, P. pecosensis*). Four other springsnails--outside the genus *Pyrgulopsis*--are found in New Mexico, with three listed as Federally and State endangered (*Assiminea pecos, Juturnia kosteri, Tryonia alamosae*) and one (*J .tularosae*) listed as a State species in need of conservation. Due to extreme endemicity, several of the springsnail species listed above have likely never existed in any condition other than what we currently define as endangered or threatened.

Of the six endangered springsnail species in New Mexico, one (*P. chupaderae*) does not have a USFWS recovery plan, two (*P. neomexicana, T. alamosae*) have a shared USFWS recovery plan last updated in 1993, and three (*A. pecos, J. kosteri, P. roswellensis*) have a shared USFWS recovery plan finalized in 2019. The recent 2019 recovery plan states: "*An emergency captive rearing plan should develop techniques necessary to preserve the species from extinction in the event of a catastrophic event*". Given the similar threats-- climate change, groundwater pumping, declines in water quality, limited mobility, specialized habitat tolerances, fragmented habitat, and invasive species--shared by the six endangered springsnail species in New Mexico one would presume that when older springsnail recovery plans are revised, and/or new recovery plans are developed, similar requirements as those listed in the 2019 plan will be included. In addition, the 2019 recovery plan notes: "*Other benefits of captive rearing include educating and engaging the public on conservation issues and providing opportunities for research of the species, yielding knowledge that can be applied to conservation in the wild*."

This project begins the process of developing a captive propagation plan and establishing and maintaining a captive breeding program with two State threatened springsnail species—*P. thermalis and P. gilae*. The equipment, information, and experience acquired will then be applied to provide a more secure future for endangered springsnails in New Mexico with the potential of bringing *P. chupaderae* into captivity in the future. This project is also expected to provide a deeper understanding of springsnail habitat requirements and life-history which can assist in managing in situ populations. The foundational knowledge gained in maintaining viable captive springsnail populations at the Albuquerque BioPark Aquatic Conservation Facility (BioPark) may also be applied to maintaining similar springsnail populations at other locations, including the Ladder Ranch, NM.

Prior to this project, in November 2017, Turner Endangered Species Fund (TESF), New Mexico Department of Game and Fish (NMGF), and BioPark personnel collected ~300 *P. gilae* and *P. thermalis* from Alum Spring, Grant County, NM and placed them in an aquarium at the BioPark Aquatic Conservation Facility. We did not document reproduction; however, we were able to keep the snails alive in the aquarium for six months and, in the process, began to refine husbandry techniques.

Scope of Work

Listed are the four primary objectives for this project:

Objective 1. A. Assemble and install aquariums at the BioPark and stabilize water physio-chemical parameters to match those collected by M. Myers at Alum Spring in 2008. Aquariums will be designed to mimic slope and flow at the springsnail collection site and will generally follow the design described in Funkhouser (2014). We will, however, use glass aquariums (long, shallow, and narrow), rely on natural light and photoperiods, and use substrate from the springsnail collection site.

B. Initially the tanks will be filled with distilled water and chemical parameters adjusted to match those measured at the collection site(s).

C. Water physio-chemical properties will be collected with a LaMotte Aquaculture Test Kit and will include measurements of: ammonia nitrogen, nitrite nitrogen, pH, alkalinity (total as $CaCO_3$), carbon dioxide, chloride, dissolved oxygen, hardness, and temperature.

D. As the aquariums are assembled and installed we will consult with Collin Funkhouser—or someone else with similar experience—and have him inspect the springsnail aquariums, identify any deficiencies, and perhaps serve as a project collaborator.

Objective 2. Schedule a trip to Alum Spring to measure physio-chemical qualities of the spring, and collect water, rock substrate, and *P. gilae*/*P. thermalis* and transport back to the BioPark. During this trip we will confirm water physio-chemical properties collected by M. Myers and collect ~300 springsnails, enough substrate to cover the bottom of the aquariums, and several gallons of spring water, all of which will be transported to the BioPark. It is possible we will inoculate the aquariums with substrate and water from Alum Spring several weeks prior to introducing the springsnails.

Objective 3. Water physio-chemical properties in the aquariums will be measured and data recorded throughout this project (daily if necessary) until a suitable, stable, and predictable state is established, at which time measurements will occur weekly.

Objective 4. Non-invasive counts of springsnails living in the aquariums will be performed three times per week. At this point we are uncertain on the methodology for this task given our intention for counts to be non-invasive and the expected difficulty in counting snails in the natural substrate we plan to use. If total counts seem reliable and replicable, we will use those; if not, we will establish sub-sample plots within the aquariums. During population counts additional observations will be documented including: springsnail location in the aquarium, springsnail behavior, evidence of coupling or egg laying, evidence of juvenile snails indicating reproduction, number of dead snails, etc.

Progress to Date

Objective 1. A. Completed. Two aquariums and supporting equipment (pumps, filters, heaters, light, etc.) were purchased and assembled at the BioPark (Figures 1-3). Due to the relatively low number of snails collected, our concern that snails may be too highly dispersed in two tanks to find one another and reproduce (a lesson learned from 2017-2018's effort), and observed high snail densities at Alum Spring, we decided to maintain snails in a single aquarium rather than in two separate ones. We also decided to replicate Alum Spring physiochemical properties as determined by water analysis by an accredited laboratory rather than those values collected by M. Myers in 2008 (see Addenda 1 and 2).

The aquarium was modified to mimic Alum Spring flows by inserting baffles which offered vertical and horizontal surfaces for the snails to utilize (Figures 2 and 3). An acrylic aquarium was used rather than glass to minimize weight and fragility and to allow for easier aquarium modification. An aquarium lid was included in the design to limit evaporation.

Natural light is supplemented with artificial light set on a timer to enhance periphyton and vegetative growth (Figure 2 and 3).

B. Completed. The aquarium was filled with tap water to test pumps, filters, heaters, plumbing, sump, etc. Once the aquarium was determined to be operating correctly, the tap water was drained. In the proposal we indicated we would fill the tanks with distilled water and adjust the physiochemical properties to match Alum Spring. Instead, after testing aquarium function with tap water and draining, we filled the aquarium with water collected from Alum Spring (Figure 4). Reverse osmosis water is occasionally added to compensate for evaporation.

C. Completed. After filling the aquarium with water from Alum Spring we began routinely testing physiochemical properties using a LaMotte Aquaculture Test Kit (see Addendum 3). Three water samples from the snail aquarium have been submitted to an accredited water analysis laboratory to confirm values collected at the BioPark and to test for additional properties (see Addendum 2).

D. Completed. We have not contacted Colin Funkhouser but did, and continue to, consult with Dr. Carter Kruse (Turner Enterprises Inc., Director of Natural Resources) on his experience managing water chemistry in closed systems.

Objective 2. Completed. On 31 January 2019 TESF, NMGF, and BioPark personnel visited Alum Spring and collected water and substrate and submitted a water sample for testing at an accredited water analysis laboratory. The water and substrate collected at this time was placed into the aquarium to allow the system to stabilize and “inoculate” the tank before snails were introduced. On 21 March 2019, approximately 300 *P. gilae/P. thermalis* were removed from Alum Spring and placed into the aquarium (Figure 5).

Objective 3. Completed. See Objective 1.C. above.

Objective 4. Completed. Non-invasive counts of springsnails proved to be difficult because of the size of the springsnails and the structure of the substrate. Population estimates were performed by counting all of the observable springsnails without moving the substrate. Once non-invasive counts indicated no springsnails were alive, the substrate was removed and observed to confirm the absence of springsnails. As noted in Table 1, the number of springsnails living in the tank declined relatively quickly, especially when compared to our efforts in 2017-2018, when springsnails persisted for 6 months.

Table 1. Springsnail counts at the Albuquerque BioPark Aquatic Conservation Facility from 21 March 2019 – 14 June 2019.

Date	Total Count	Comments
21-Mar-19	~300	initial collection
30-Mar-19	327	
9-Apr-19	221	
27-Apr-19	125	
11-May-19	101	
25-May-19	28	
14-Jun-19	0	

Future Considerations and Plans (2020)

We will continue with this project in 2020 using the experience provided by the SWW grant to continue efforts to establish a reproducing population of springsnails. Following are observations, lessons, and considerations for the future.

Throughout the project, physiochemical parameters remained relatively stable with some variation in the readings of ammonia nitrogen (increases and decreases) and slight decreases in alkalinity, chloride, turbidity, and sulfate. It is unclear at this time whether these physio-chemical fluctuations were a limiting factor in the survival of the captive springsnails, but activated carbon was added approximately one month after tank set up as a precautionary measure.

Fluctuations in the ammonia nitrogen test results were somewhat worrisome as they may have indicated an unbalanced nitrogen cycle. However, the LaMotte Aquaculture Test Kit would often produce significantly different results in repeated ammonia nitrogen tests from the same water sample. When that water sample was then tested with a Hach DR 3900 Benchtop Visible Spectrophotometer, the levels were generally more stable and within acceptable ranges. As such, future testing of the nitrogen cycle compounds (ammonia, nitrite, and nitrate) will be tested with the Hach Spectrophotometer at the BioPark.

At some point (likely when the substrate was added), snails from the genus *Physa* were inadvertently introduced to the aquarium. The *Physa* likely reproduced in the aquarium (based on continued observations of varying size classes) and eradication of those snails from the tank was difficult.

Non-invasive population estimates were not effective in determining the aquarium's springsnail population. To provide reliable population estimates in the existing aquarium either a more invasive survey technique will be required or a new survey technique developed. Springsnail counts on small pieces of saltillo tile placed within the aquarium may be a more effective method for providing an index of population trends.

A recurring concern was the lack of algal growth within the tank, despite a two month “inoculation” period. The addition of extra LED aquarium lighting in May significantly improved this situation. In hindsight, we probably should have collected our inoculation water and substrate later in the year, when temperatures were warmer, days longer, and more algal growth likely to occur, and we should have added the LED lighting during the “inoculation” period (Figure 6).

Despite not having documented reproduction in the captive springsnail population at the BioPark, the experience gained from this project has been encouraging and we intend to continue with and expand the project. In 2020 we will redouble efforts to establish a captive springsnail population at the BioPark and move the extra tank currently at the BioPark to the Ladder Ranch and begin the process of preparing that tank for habitation by springsnails. The Ladder Ranch has several springs whose chemical properties are likely very similar to those found at Alum Spring (and possibly Willow Spring). Being able to routinely change out water from a local and easily accessible source may improve survival and stimulate reproduction.

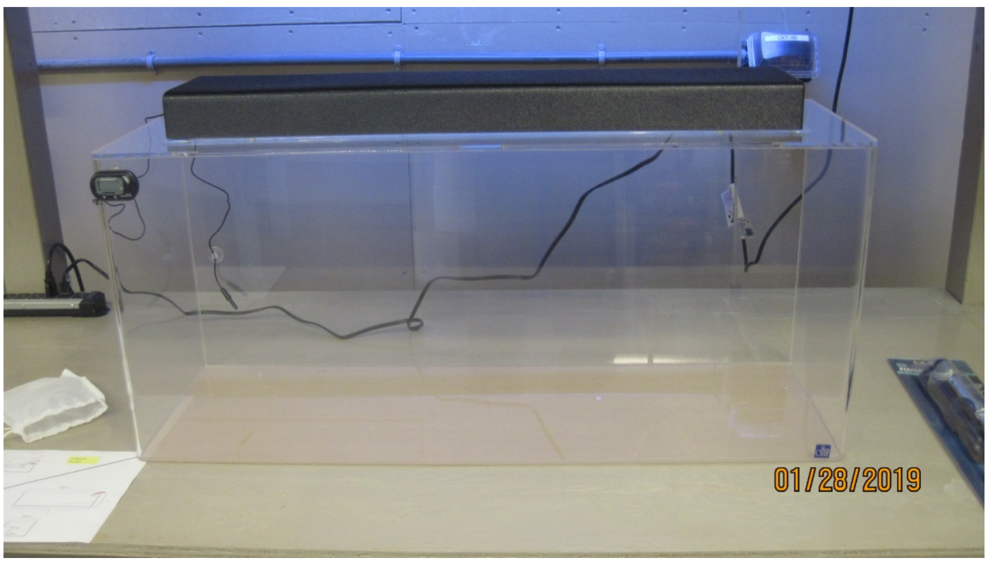

Figure 1. Acrylic aquarium used to house springsnails at the Albuquerque BioPark Aquatic Conservation Facility prior to modification.

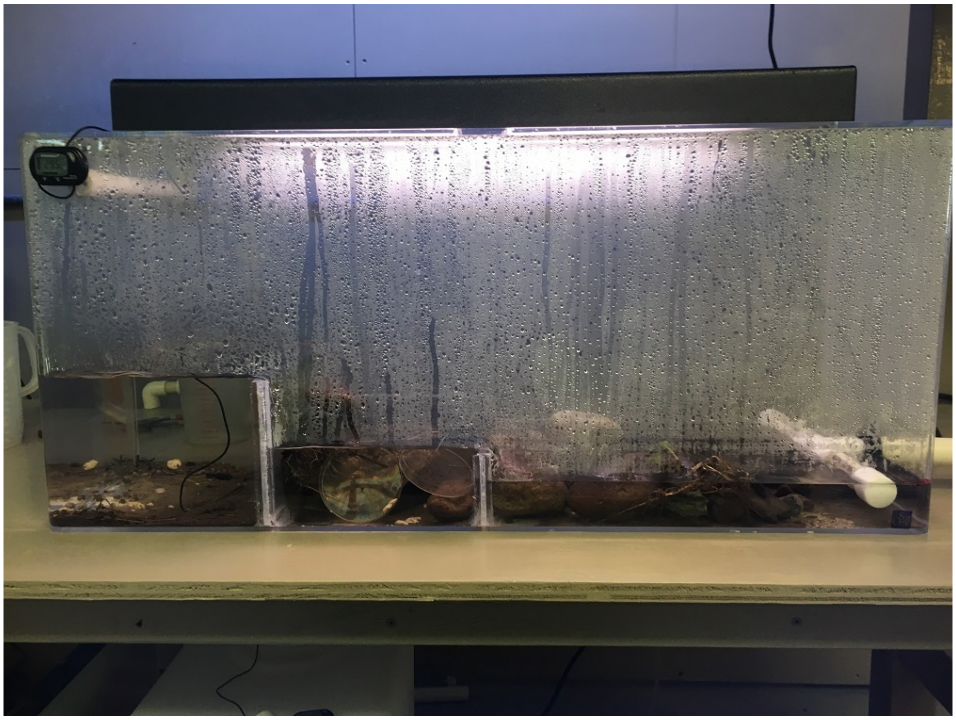

Figure 2. Aquarium at the Albuquerque BioPark Conservation Facility being “inoculated” with water and substrate from Alum Spring prior to the introduction of *P. gilae* and *P. thermalis*.

Figure 3. Baffle system developed to mimic vertical and horizontal flow found at Alum Spring.

Figure 4. Trip to the Gila Wilderness to collect substrate and water from Alum Spring.

Figure 5. Surface from which *P. gilae* and *P. thermalis* were collected at Alum Spring, NM.

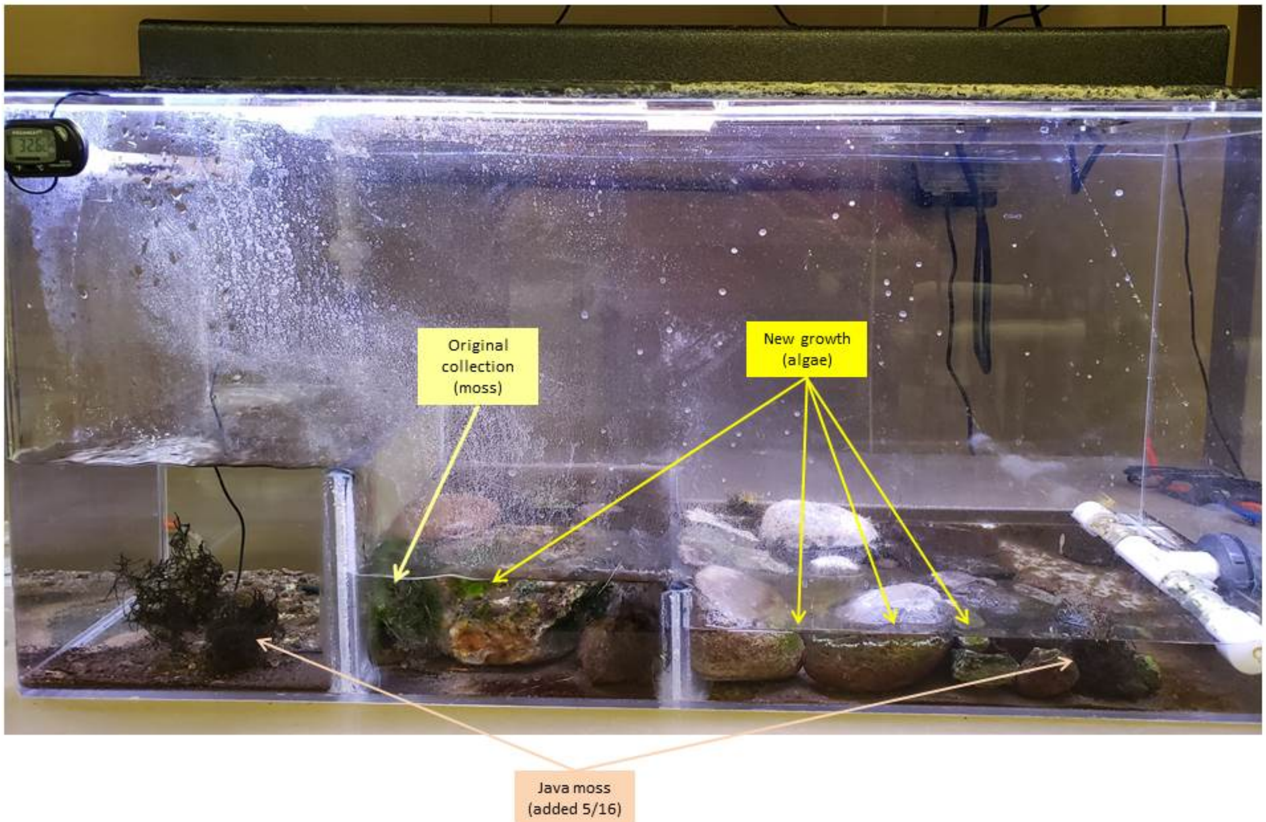

Figure 6. Algal growth in the springsnail tank at the Albuquerque BioPark.

ADDENDUM 1. Physiochemical parameters collected by M. Myers at Alum Spring in 2008.

See attached file: m myers alum spring notes

ADDENDUM 2. Water quality analysis results for water samples from Alum Spring and aquariums at the Albuquerque BioPark.

See attached files: 190130 alum spring water analysis
190220 alum spring-biopark water analysis
190321 alum spring-biopark water analysis

Informational Water Quality Report

WaterCheck Lite

National Testing Laboratories, Ltd.
Quality Water Analysis
6571 Wilson Mills Rd
Cleveland, Ohio 44143
1-800-458-3330

Client:

Ordered By:
Long, Dustin 4424 Shadow Glen Dr Bozeman, MT 56718 ATTN: Dustin Long

Sample Number: 893561

Location:	Alum Spring
Type of Water:	Other
Collection Date and Time:	1/31/2019 10:00 AM
Received Date and Time:	2/4/2019 8:55 AM
Date Completed:	2/12/2019

Definition and Legend

This informational water quality report compares the actual test result to national standards as defined in the EPA's Primary and Secondary Drinking Water Regulations.

Primary Standards: Are expressed as the maximum contaminant level (MCL) which is the highest level of contaminant that is allowed in drinking water. MCLs are enforceable standards.

Secondary standards: Are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor,or color) in drinking water. Individual states may choose to adopt them as enforceable standards.

Action levels: Are defined in treatment techniques which are required processes intended to reduce the level of a contaminant in drinking water.

mg/L (ppm): Unless otherwise indicated, results and standards are expressed as an amount in milligrams per liter or parts per million.

Minimum Detection Level (MDL): The lowest level that the laboratory can detect a contaminant.

ND: The contaminant was not detected above the minimum detection level.

NA: The contaminant was not analyzed.

✓ The contaminant was not detected in the sample above the minimum detection level.

● The contaminant was detected at or above the minimum detection level, but not above the referenced standard.

▲ The contaminant was detected above the standard, which is not an EPA enforceable MCL.

✚ The contaminant was detected above the EPA enforceable MCL.

✖ These results may be invalid.

Status	Contaminant	Results	Units	National Standards		Min. Detection Level
			Inorganic Analytes - Metals			
▲	Aluminum	0.3	mg/L	0.2	EPA Secondary	0.1
●	Arsenic	0.007	mg/L	0.010	EPA Primary	0.005
✓	Barium	ND	mg/L	2	EPA Primary	0.30
✓	Cadmium	ND	mg/L	0.005	EPA Primary	0.002
●	Calcium	19.0	mg/L	--		2.0
✓	Chromium	ND	mg/L	0.1	EPA Primary	0.010
✓	Copper	ND	mg/L	1.3	EPA Action Level	0.004
●	Iron	0.180	mg/L	0.3	EPA Secondary	0.020
✓	Lead	ND	mg/L	0.015	EPA Action Level	0.002
●	Lithium	0.286	mg/L	--		0.001
●	Magnesium	0.83	mg/L	--		0.10
●	Manganese	0.006	mg/L	0.05	EPA Secondary	0.004
✓	Mercury	ND	mg/L	0.002	EPA Primary	0.001
✓	Nickel	ND	mg/L	--		0.020
●	Potassium	2.8	mg/L	--		1.0
✓	Selenium	ND	mg/L	0.05	EPA Primary	0.020
●	Silica	75.2	mg/L	--		0.1
✓	Silver	ND	mg/L	0.100	EPA Secondary	0.002
●	Sodium	133	mg/L	--		1
●	Strontium	0.061	mg/L	--		0.001
●	Uranium	0.005	mg/L	0.030	EPA Primary	0.001
✓	Zinc	ND	mg/L	5	EPA Secondary	0.004
			Physical Factors			
●	Alkalinity (Total as CaCO3)	100	mg/L	--		20
●	Hardness	51	mg/L	100	NTL Internal	10
✓	pH	8.2	pH Units	6.5 to 8.5	EPA Secondary	
▲	Total Dissolved Solids	620	mg/L	500	EPA Secondary	20

Status	Contaminant	Results	Units	National Standards		Min. Detection Level
	Turbidity	2.8	NTU	1.0	EPA Action Level	0.1
	Inorganic Analytes - Other					
	Bromide	ND	mg/L	--		0.5
	Chloride	200.0	mg/L	250	EPA Secondary	5.0
	Fluoride	15.0	mg/L	4.0	EPA Primary	0.5
	Nitrate as N	ND	mg/L	10	EPA Primary	0.5
	Nitrite as N	ND	mg/L	1	EPA Primary	0.5
	Ortho Phosphate	ND	mg/L	--		2.0
	Sulfate	110.0	mg/L	250	EPA Secondary	5.0

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

These test results are intended to be used for informational purposes only and may not be used for regulatory compliance.

National Testing Laboratories, Ltd.

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Informational Water Quality Report

WaterCheck Lite

National Testing Laboratories, Ltd.
Quality Water Analysis

6571 Wilson Mills Rd
Cleveland, Ohio 44143
1-800-458-3330

Client:
Kathy Lang (ABQ BioPark ACF) 2601 Central Ave NW Albuquerque, NM 87104

Ordered By:
Long, Dustin 4424 Shadow Glen Dr Bozeman, MT 56718 ATTN: Dustin Long

Sample Number: 894540

Location:	ACF Snaiis
Type of Water:	Other
Collection Date and Time:	2/20/2019 4:00 PM
Received Date and Time:	2/26/2019 9:25 AM
Date Completed:	3/7/2019

Definition and Legend

This informational water quality report compares the actual test result to national standards as defined in the EPA's Primary and Secondary Drinking Water Regulations.

Primary Standards:	Are expressed as the maximum contaminant level (MCL) which is the highest level of contaminant that is allowed in drinking water. MCLs are enforceable standards.
Secondary standards:	Are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor,or color) in drinking water. Individual states may choose to adopt them as enforceable standards.
Action levels:	Are defined in treatment techniques which are required processes intended to reduce the level of a contaminant in drinking water.
mg/L (ppm):	Unless otherwise indicated, results and standards are expressed as an amount in milligrams per liter or parts per million.
Minimum Detection Level (MDL):	The lowest level that the laboratory can detect a contaminant.
ND:	The contaminant was not detected above the minimum detection level.
NA:	The contaminant was not analyzed.

- ✓ The contaminant was not detected in the sample above the minimum detection level.
- ● The contaminant was detected at or above the minimum detection level, but not above the referenced standard.
- ▲ The contaminant was detected above the standard, which is not an EPA enforceable MCL.
- ✚ The contaminant was detected above the EPA enforceable MCL.
- ✖ These results may be invalid.

Status	Contaminant	Results	Units	National Standards		Min. Detection Level
	Inorganic Analytes - Metals					
	Aluminum	ND	mg/L	0.2	EPA Secondary	0.1
	Arsenic	0.014	mg/L	0.010	EPA Primary	0.005
	Barium	ND	mg/L	2	EPA Primary	0.30
	Cadmium	ND	mg/L	0.005	EPA Primary	0.002
	Calcium	28.8	mg/L	--		2.0
	Chromium	ND	mg/L	0.1	EPA Primary	0.010
	Copper	ND	mg/L	1.3	EPA Action Level	0.004
	Iron	ND	mg/L	0.3	EPA Secondary	0.020
	Lead	ND	mg/L	0.015	EPA Action Level	0.002
	Lithium	0.322	mg/L	--		0.001
	Magnesium	1.93	mg/L	--		0.10
	Manganese	ND	mg/L	0.05	EPA Secondary	0.004
	Mercury	ND	mg/L	0.002	EPA Primary	0.001
	Nickel	ND	mg/L	--		0.020
	Potassium	5.4	mg/L	--		1.0
	Selenium	ND	mg/L	0.05	EPA Primary	0.020
	Silica	100.0	mg/L	--		1.0
	Silver	ND	mg/L	0.100	EPA Secondary	0.002
	Sodium	162	mg/L	--		1
	Strontium	0.103	mg/L	--		0.001
	Uranium	0.009	mg/L	0.030	EPA Primary	0.001
	Zinc	0.004	mg/L	5	EPA Secondary	0.004
	Physical Factors					
	Alkalinity (Total as CaCO3)	150	mg/L	--		20
	Hardness	80	mg/L	100	NTL Internal	10
	pH	8.5	pH Units	6.5 to 8.5	EPA Secondary	
	Total Dissolved Solids	590	mg/L	500	EPA Secondary	20

Status	Contaminant	Results	Units	National Standards		Min. Detection Level
	Turbidity	0.1	NTU	1.0	EPA Action Level	0.1
	Inorganic Analytes - Other					
	Bromide	ND	mg/L	--		0.5
	Chloride	120.0	mg/L	250	EPA Secondary	5.0
	Fluoride	9.0	mg/L	4.0	EPA Primary	0.5
	Nitrate as N	ND	mg/L	10	EPA Primary	0.5
	Nitrite as N	ND	mg/L	1	EPA Primary	0.5
	Ortho Phosphate	ND	mg/L	--		2.0
	Sulfate	73.0	mg/L	250	EPA Secondary	5.0

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

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Informational Water Quality Report

WaterCheck Lite

National Testing Laboratories, Ltd.
Quality Water Analysis

6571 Wilson Mills Rd
Cleveland, Ohio 44143
1-800-458-3330

Client:
ABQ BioPark ACF Kathy Lang 2601 Central Ave NW Albuquerque, NM 87104

Ordered By:
Long, Dustin 4424 Shadow Glen Dr Bozeman, MT 56718 ATTN: Dustin Long

Sample Number: 897001

Location:	ACF Snails- Snail System Water
Type of Water:	Other
Collection Date and Time:	3/21/2019 4:25 PM
Received Date and Time:	3/27/2019 9:30 AM
Date Completed:	5/13/2019

Definition and Legend

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Primary Standards:	Are expressed as the maximum contaminant level (MCL) which is the highest level of contaminant that is allowed in drinking water. MCLs are enforceable standards.
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Action levels:	Are defined in treatment techniques which are required processes intended to reduce the level of a contaminant in drinking water.
mg/L (ppm):	Unless otherwise indicated, results and standards are expressed as an amount in milligrams per liter or parts per million.
Minimum Detection Level (MDL):	The lowest level that the laboratory can detect a contaminant.
ND:	The contaminant was not detected above the minimum detection level.
NA:	The contaminant was not analyzed.
✓	The contaminant was not detected in the sample above the minimum detection level.
●	The contaminant was detected at or above the minimum detection level, but not above the referenced standard.
▲	The contaminant was detected above the standard, which is not an EPA enforceable MCL.
✚	The contaminant was detected above the EPA enforceable MCL.
✖	These results may be invalid.

Status	Contaminant	Results	Units	National Standards		Min. Detection Level
			Inorganic Analytes - Metals			
✓	Aluminum	ND	mg/L	0.20	EPA Secondary	0.05
✓	Arsenic	ND	mg/L	0.010	EPA Primary	0.005
✓	Barium	ND	mg/L	2.000	EPA Primary	0.100
●	Cadmium	0.0022	mg/L	0.0050	EPA Primary	0.0002
●	Calcium	14.0	mg/L	--		0.1
✓	Chromium	ND	mg/L	0.100	EPA Primary	0.005
✓	Copper	ND	mg/L	1.300	EPA Action Level	0.004
✓	Iron	ND	mg/L	0.300	EPA Secondary	0.020
✓	Lead	ND	mg/L	0.015	EPA Action Level	0.002
●	Lithium	0.120	mg/L	--		0.010
●	Magnesium	1.40	mg/L	--		0.10
✓	Manganese	ND	mg/L	0.050	EPA Secondary	0.020
✓	Mercury	ND	mg/L	0.002	EPA Primary	0.001
✓	Nickel	ND	mg/L	--		0.020
●	Potassium	3.10	mg/L	--		0.10
✓	Selenium	ND	mg/L	0.05	EPA Primary	0.020
●	Silica	54.6	mg/L	--		1.0
✓	Silver	ND	mg/L	--		0.0002
●	Sodium	79	mg/L	--		1
●	Strontium	0.070	mg/L	--		0.010
✓	Uranium	ND	mg/L	0.030	EPA Primary	0.001
●	Zinc	0.050	mg/L	--		0.010
			Physical Factors			
●	Alkalinity (Total as CaCO3)	92	mg/L	--		20
●	Hardness	41	mg/L	--		10
✓	pH	8.2	pH Units	6.5 to 8.5	EPA Secondary	
●	Total Dissolved Solids	340	mg/L	--		20

Status	Contaminant	Results	Units	National Standards		Min. Detection Level
●	Turbidity	0.1	NTU	1.0	EPA Action Level	0.1
			Inorganic Analytes - Other			
✓	Bromide	ND	mg/L	--		0.5
●	Chloride	76.0	mg/L	250	EPA Secondary	5.0
✚	Fluoride	5.6	mg/L	4.0	EPA Primary	0.5
●	Nitrate as N	1.5	mg/L	10	EPA Primary	0.5
✓	Nitrite as N	ND	mg/L	1	EPA Primary	0.5
✓	Ortho Phosphate	ND	mg/L	--		2.0
●	Sulfate	47.0	mg/L	250	EPA Secondary	5.0

We certify that the analyses performed for this report are accurate, and that the laboratory tests were conducted by methods approved by the U.S. Environmental Protection Agency or variations of these EPA methods.

These test results are intended to be used for informational purposes only and may not be used for regulatory compliance.

National Testing Laboratories, Ltd.

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ADDENDUM 3. Springsnail aquarium physiochemical data collected by staff at the Albuquerque BioPark.

See attached file: 2019 nmgf sww-biopark water chemistry

Alum Spring Aquarium Physiochemical Data

DATE	LAB 1/31	ACF 2/12	ACF 2/18	see note 1	LAB 2/20	ACF 2/26	see note 3	ACF 3/5	see note 4	ACF 3/13	ACF 3/20	LAB 3/21
Ammonia Nitrogen (ppm)		0.5	0.3			2.0 *(see note)*		0.05		*0.05*	0.6 *(see note)*	
Nitrite Nitrogen (ppm)	ND	0	0		ND	0		0.05		0.05	0.05	ND
Nitrate Nitrogen (ppm)	0				ND							1.5
ph	8.2	7.8	8.3		8.5	8.0		8.0		8.0	8.3	8.2
Alkalinity (ppm)	100	130	200		150	110		95		80	80	92
Carbon Dioxide (ppm)		0	0			0		0		0	0	
Chloride (ppm)	200	135	175		120	95		85		80	70	76
Dissolved Oxygen (ppm)		5	4.6			4.8		4.9		5	4.6	
Hardness (ppm)	51	84	100		80	60		55		50	50	41
Temperature (°C)		32.7	33.1			31.7		31.7		32.1	31.3	
Aluminum	0.3				ND							ND
Arsenic	0.007				0.014							ND
Barium	ND				ND							ND
Cadmium	ND				ND							0.0022
Calcium	19				28.8							14
Chromium	ND				ND							ND
Copper	ND				ND							ND
Iron	0.18				ND							ND
Lead	ND				ND							ND
Lithium	0.286				0.322							0.12
Magnesium	0.83				1.93							1.4
Manganese	0.006				ND							ND
Mercury	ND				ND							ND
Nickel	ND				ND							ND
Potassium	2.8				5.4							3.1
Selenium	ND				ND							ND
Silica	75.2				100							54.6
Silver	ND				ND							ND
Sodium	133				162							79
Strontium	0.061				0.103							0.07
Uranium	0.005				0.009							ND
Zinc	ND				0.004							0.05
Total Dissolved Solids	620				590							340
Turbidity	2.8				0.1							0.1
Bromide	ND				ND							0.5
Fluoride	15				9							5.6
Ortho Phosphate	ND				ND							ND
Sulfate	110				73							47
Notes (numbered)			1			2, 3				4	5	

DATE	ACF 3/27	ACF 4/2	ACF 4/9	ACF 4/16	ACF 4/21	ACF 4/23	ACF 5/1	ACF 5/7	ACF 5/13	see note 9	ACF 5/20	see note 10	ACF 5/31	ACF 6/6	ACF 6/14	see note 11
Ammonia Nitrogen (ppm)	0.4	*0.5 (see note)*	0.05	*0.1 (see note)*	0	0.05	.05 / .75	.05 - 2.0	1 - 2		.1 - .25		.1 - 1.2	.05 - 1.2	.05 - 1.0	
Nitrite Nitrogen (ppm)	0.05	0.05	0.05	0.05	0.007	0.05	0.05	0.05	0.05		0		0	0	0	
Nitrate Nitrogen (ppm)																
ph	8.0	8.0	8.3	8.3	8.6	8.3	8.3	8.0	8.0		8.0		8.0	7.7	8.0	
Alkalinity (ppm)	80	75	75	75		65	60	55	50		55		50	45	55	
Carbon Dioxide (ppm)	-	-	-	0	-	-	-	-	0		-		-	-	0	
Chloride (ppm)	70	70	65	65	-	70	60	55	50		50		42	40	40	
Dissolved Oxygen (ppm)	5.2	4.6	4.7	4.6	-	4.8	4.9	5.7	5.2		6.2		5.2	5.1	5.2	
Hardness (ppm)	40	40	40	40	-	45	40	38	38		35		35	38	35	
Temperature (°C)	32.3	31.4	32.9	31.7	27.2	32.0	32.5	32.0	31.7		31.5		31.4	32.5	31.6	
Aluminum																
Arsenic																
Barium																
Cadmium																
Calcium																
Chromium																
Copper																
Iron																
Lead																
Lithium																
Magnesium																
Manganese																
Mercury																
Nickel																
Potassium																
Selenium																
Silica																
Silver																
Sodium																
Strontium																
Uranium																
Zinc																
Total Dissolved Solids																
Turbidity																
Bromide																
Fluoride																
Ortho Phosphate																
Sulfate																
Notes (numbered)		6		7					8		9		10		11	

DATE	ACF 6/19	ACF 6/27	ACF 7/3	ACF 7/10	ACF 7/20	ACF 7/26	see note 12	ACF 8/1	ACF 8/9	ACF 8/19	ACF 8/28	see note 13	ACF 9/4	ACF 9/11	ACF 9/26	ACF 10/20	ACF 10/27	ACF 11/6	ACF 11/24	ACF 12/2	ACF 12/9	ACF 12/17
Ammonia Nitrogen (ppm)	.05 - 1.0	.05 - 2+	.1 - 2+	.25 - 2.0	.25 - 1.5	1.5 - 2+		.05 - 1.5	.1 - 2+	.1 - .25	.1 - 2+		.1 - 1.5	.05 - 0.5	0.0 - 0.5	.5 - 2+	.5 - 2+	.05 - .1	.05 - 1.2	.05 - 2+	0.0 - 1.0	1.5 - 2
Nitrite Nitrogen (ppm)	0	0	0	0	0	0		0.05	0.05	0	0		0.05	0	0	0	0	0	0.15	0.05	0.05	0.1
Nitrate Nitrogen (ppm)																						
ph	8.0	8.0	8.0	8.0	8.0	7.5		8.0	8.0	8.0	8.0		6.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Alkalinity (ppm)	55	55	60	62	58	50		55	50	50	55		50	60	60	55	40	40	40	40	35	25
Carbon Dioxide (ppm)	-	-	0	0	0	0		0	0	0	0		0	0	0	1	1	1	1	1	1	1
Chloride (ppm)	40	40	40	50	40	45		38	40	30	50		30	30	25	15	15	15	15	15	15	15
Dissolved Oxygen (ppm)	5.2	5.2	5.6	6.7/5.3	5.0	4.8		5.5	5.0	6.4	5.5		6.0	6.0	6.0	4.8	5.8	5.5	5.5	5.0	5.2	5.1
Hardness (ppm)	38	40	40	40	30	30		30	35	35	40		40	50	55	30	35	50	60	55	45	40
Temperature (°C)	31.3	31.2	32.0	31.5	31.0	31.5		29.9	29.5	29.3	21.3		27.4	27.2	31.5	31.5	30.6	30.6	31.1	30.8	31.7	30.8
Aluminum																						
Arsenic																						
Barium																						
Cadmium																						
Calcium																						
Chromium																						
Copper																						
Iron																						
Lead																						
Lithium																						
Magnesium																						
Manganese																						
Mercury																						
Nickel																						
Potassium																						
Selenium																						
Silica																						
Silver																						
Sodium																						
Strontium																						
Uranium																						
Zinc																						
Total Dissolved Solids																						
Turbidity																						
Bromide																						
Fluoride																						
Ortho Phosphate																						
Sulfate																						
Notes (numbered)						12					13											

NOTES

1. Sump level raised (increasing total volume of system) on 2/19
2. Lamotte NH3 test repeated 3X to check high results; Test strips & spectrophotometer readings were both low (< 0.1)
3. Activated carbon added to sump on 2/27 due to possible high ammonia level
4. Pump clogged overnight on 3/11; temp dropped to 20C; sump siphoned; 2 gallons bottled water added
5. Lamotte NH3 test repeated 3X to check results
6. Lamotte NH3 test repeated 4X (>2.0, 0.5, 0.25, 1.25)
7. Lamotte NH3 test repeated 3X (with varying results) on 4/16, 5/1 and 5/7
8. Ammonia tests all high on 5/13 - possibly related to algae pellets (uneaten)
9. New light added on 5/14; Java moss added on 5/16
10. Plant growth (algae) noted on rocks ~5/24; very few snails visible
11. Removed java moss on 6/14 (mostly dead); no springsnails observed
12. Water change - 5 gallons of Reverse Osmosis water added (not from Alum Spring)
13. Moved plug & reset thermostat control (outlet kept tripping)