Appendix E: Physical Conditions of Dripping Springs, 2001

Peter G. Rowlands

Introduction

Description of the Dripping Springs Environment

> *"Dripping Springs is on a hillside in an indentation of the northeast side of the Dripping Springs Mountains[1], below a small pass in whitish rock which forms the 'puerto blanco' (white gateway). The approach to the spring leads through a valley that opens off of the valley of the Ajo…The water flows from cracks in the rock into a cave with an entrance 6 feet high and about 4 feet wide; within, the cave widens to 8 feet and is about five feet deep. A small concrete dam has been built across the entrance, and from this dam, a pipe leads to the foot of the slope. The water is milky and opalescent and has a temperature of 69.5° F. (Bryan 1925)*

The spring (actually a seep) lies in a well-protected rock cavity about 31 vertical m above the base of a steep, north-facing slope located on the north-central side of the Puerto Blanco Mountains (UTM 3544600N x 321400E). Dripping Springs can be accessed by walking about 0.8 km up an abandoned dirt road, which joins the North Puerto Blanco Road approximately 16 km from its beginning near Organ Pipe Cactus National Monument (OPCNM) headquarters. According to Brown et al. (1982), OPCNM staff had at one time established a picnic area and parking lot nearby. The facilities were removed and the access road closed in 1972. The spring is improved in that a small concrete dyke was installed across the mouth of the catchment basin (pool) below the spring to increase its capacity (Bryan 1925). Wherrell (1981) believed that the pool was dug out and enhanced as a catchment. There is a saddle about 62 vertical m. above the spring and a well-worn migrant trail connects the old road to the springs and the saddle above. Dripping Springs is surrounded by thick, woody vegetation, mostly paloverde, mesquite and bitter condalia. There appears to be no surface flow manifesting from the pool cavity at the present. Ami Pate, a Biological Technicians who has worked in the Monument for 10 years, has observed the pool overflowing the lip of the small retaining dam, generally during winter rainy periods, as it did in the winter of 1991-1992 (Pate, personal communication).

In March 2001, two volunteers visited the springs and took physical measurements. Their data were consistent with earlier studies (e.g., Brown et al 1982, Brown and Johnson 1983) and show the spring pool to be ellipsoidal in shape (W = 2.25 m, L = 2.46) with a depth of 1.60 m. "Normal" maximum depth is 152 cm, but there has been a recent drop in volume of the pool (from 2 cm below the lip of the small "dam" on 14-Apr-01 to about 100 cm below the lip on 12-June-01 to about 60 cm below the lip on 16-July-01). Present shallow spots, unreported by Bryan (1925) may have been created by rock debris being thrown into the cave or falling naturally from the roof.

Significance of Dripping Springs

Dripping springs is one of only two permanent sources of wildlife water in OPCNM, the other being Quitobaquito Springs, and is located in the Puerto Blanco Mountains within a designated wilderness area. Water chemistry of the spring is monitored several times a year as part of the OPCNM Ecological Monitoring Program (EMP). OPCNM also maintains a nearby weather station, permanent small mammal sampling grids, and vegetation monitoring plots. The spring site proper is also an important bat monitoring location. Mist netting is done at least once a year and occasionally twice a year.

Dripping Springs has some moderate cultural

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1 Puerto Blanco Mountains on recent USGS quads

and historical significance. Periodic human use and occupancy of the seep site has occurred over many years. Several bedrock mortars and smoked overhangs are located in very close proximity to the springs and indicate Native American use (Hoy 1968). United States Geological Survey hydrologist, Kirk Bryan, who first observed the site in 1917 described nearby abandoned mine workings, as well as other signs of disturbance due to historic mineral extraction and ranching

> "*At the end of the pipeline* [running from the spring to the foot of the slope][2] *is a small pool fed by it, and a well dug in the rock, 54 feet deep and 28 feet to water. The watering place is covered by mining claims belonging to the owners of the Dripping Springs Mine, half a mile southwest. The amount of water is sufficient to supply a few men only.* Bryan (1925)"

Local ranchers, Bill and Birdie Miller, probably dug the well mentioned by Bryan (1925) around 1913. There is no indication of any well in the area at the present time. Very probably it has become filled in with debris from periodic runoff. Hoy (1968) mentions that Dripping Springs was "a major water stop during early travel from Sonoyta – Santo Domingo, etc. to Ajo" and that "the route [was] also used by prohibition bootleggers.

Currently, undocumented aliens (UDAs) rest or set up temporary camp here as they migrate north, seeking a better life in the United States. The great majority of UDAs are Mexican Nationals, but migrants from Central American countries are commonly encountered. Occasionally, drug smugglers moving contraband northward from Mexico also use the site.

The Problem

As a result of EMP activities, frequent visits are made to the Dripping Springs area and there are numerous recorded visual observations of the springs, proper. Since 1991, according to Ami Pate, OPCNM biological technician (Pate, personal communication), the water level in the spring has not been known to vary more than a few centimeters and is always at or near the maximum capacity of the reservoir.

On June 19 2001, EMP personnel, Ami Pate, Nancy Favour, Brian Barns and Bryan Milstead, visited the springs to complete annual bat monitoring. They were surprised to find that the area had been severely degraded and that the water level in the spring was about one meter below the reservoir lip. All around the spring site, there was a large quantity of rubbish and evidence of campfires. They deduced that UDAs created these impacts. The labels of the various discarded containers were in Spanish and the contents were made in Mexico. Great quantities and varieties of rubbish including food and beverage containers made of paper products, plastic or glass; cigarette packages; toilet paper; garments and other odd bits of debris had been scattered abroad. Refuse was abundant at the spring itself, along the trail from the base of the slope below the springs, the slopes above the springs and over the surface of the saddle itself. The most impacted areas of the immediate landscape had the appearance of a landfill.

There were so many honeybees collecting water from seepage along the rock walls of the cavity above the spring pool that one could not hear the normal sounds of water dripping into the spring. The surface of the water was completely covered with dead bees to a depth of several centimeters, along with floating milk jugs and a large piece of plastic sheeting. The stench emanating from the water was reminiscent of an open sewer. The monitors conjectured that either migrating humans and / or thirsty bees were taking more water than was being replenished by the spring. Their initial inclination was to leave the site as rapidly as possible, but then decided to proceed with their plans to mist net for bats in order to see if the observed changes in the spring affected bat activity.

The results from the bat netting were striking (Figure E-1); capture success was much lower

[2] Text within brackets by Rowlands

than in previous years, as was species richness. Heretofore, Dripping Springs had been an important bat watering site but now they appeared to be avoiding it. To ascertain whether this decrease was specific to Dripping Springs, data from White Horse Tank was also analyzed (Figure E-2). The results appear to indicate that the phenomenon was restricted to Dripping Springs.

Having made these preliminary findings, the OPCNM EMP team decided to undertake a small mitigation project at Dripping Springs. Our objectives were to take a closer look at Dripping Springs, determine the cause of the stench and the drastic reduction in reservoir capacity, perform a general clean up of the springs and remove rubbish from the immediate area and both upslope and downslope of the springs proper. On Jul 16, 2001, Bryan Milstead, Ami Pate, Peter Rowlands, Scott Sweet, Tim Tibbitts, Brian Barns, Izar Izaguirre, Nancy Favour and Charles Conner traveled to Dripping Springs to perform water quality tests, clean out the floating debris and decomposing organic matter and remove refuse discarded by UDAs. Figures E-3 though E-11 consist of digital photographs, which were taken as part of the project documentation.

Project Results

General Observations

The pool, itself was found to be fetid. Almost the entire surface was covered with decaying organic material and some of us were almost overcome by the overwhelming stench of hydrogen sulfide (H_2S) and organic compounds produced by the putrefaction. The water was brown and murky, rather than its normal, pale milky color due to the high content of silica [101 mg/l] and suspended silica [92 mg/l]. During the clean up, approximately 3048 cm^3 or more of decomposing and putrefying organic matter was removed from the pool surface by Charles Conner, who skimmed it off with a dip net. This organic material consisted primarily of the remains of dead Italian honeybees (*Apis melifera*), an introduced insect. Water is an essential item for bees since they use it to dilute the honey to feed to the brood and in the hot weather they bring the water back to the hive and evaporate it to cool the hive. Bees will drown, however, if they land in the water. Domestic honeybees require access to at least four L/day of clean water per hive (hives average about 40,000 individual bees). Over 94 % of bees that are collecting water for commercial or hobby hives are found within 500 m of home apiaries (Gary et al. 1979). However, according to Justin Schmidt of the USDA Agricultural Research Service (personal communication) feral colonies, which number around 30,000 individuals can subsist on about 200 ml/day. Considering the relatively small difference in population numbers between commercial and feral colonies, the two independent estimates are somewhat incongruous. It may well be that feral colonies are simply more “thrifty” when it comes to resource utilization. At the time of the clean up, there was a steady and dense stream of visiting honeybees, which may have represented several hives, foraging for water. The pool also contained dead animals including 2 red-spotted toads; one partially decomposed, one intact and bloated; a highly decomposed white-winged dove and another unidentified animal, which Charles could not retrieve. Decomposition of all this organic matter had driven this small aquatic system into near-anoxia and eutrophication as evidenced by the low dissolved oxygen readings and low pH.

Some physical parameters of the pool water taken during the Spring over the past four years are shown in Table E-1, below along with the most recent measurements taken on the day of the clean up. All measurements in Table E-1 were taken between approximately 1100 AM and 1500 PM. Rates of inflow are not estimated during monitoring visits. In the future this should be done.

After the cleanup, Charles Conner attempted to oxygenate the pool by agitating the water with the dip net for several minutes. This action caused some increase in dissolved oxygen concentration (D.O.) of the pool to 1.11 μg/L, not a particularly

Table E-1. Summary of periodic water quality measurements of the Dripping Springs pool over the past three years. ([1] Eight days later, on 24-July-01, the water level had increased by ≈ 8 cm.)

Parameter	27-May-98	04-Mar-99	14-Apr-00	16-Apr-01	16-July-01
Air Temperature °C	25°	21°	31°	35°	36.7°
Water Temperature °C	16°	14.5°	16°	13.8°	21°
pH	7.2	7.18	7.18	7.24	6.58
Dissolved Oxygen μg/L	1.79	0.48*	1.75	4.90	0.91
Alkalinity mg/L as $CaCO_3$	92	97.6	86	52.8	375
Conductivity μSiemens	365	340	360	295	895
Comments	none	none	none	Water 2 cm below dam lip	Water 60 cm below dam lip1

substantial improvement. In the past, D.O. has varied from a low of 0.48 to a high of 4.90. The minimum low D.O. concentration (0.20 μg/L) was recorded during a visit to the spring on 5-Sept-01. This is about 4 times lower than it was on 16-July-01 during eutrophication and may be the result of an equipment malfunction. Eutrophication notwithstanding, it is possible that D.O. concentrations may be related to inflow. Water dripping into the pool from the roof of the spring cave undoubtedly oxygenates the pool water in relation to the number of drops (or intensity of the flow, in the inflow is in the form of a stream), which disturb the pool surface.

Alkalinity on 16-July-01 was approximately 4 – 6 times as high as on previous occasions; conductivity was approximately 2 – 3 times as high. These observations may argue in favor of evaporative water loss as a major factor in the decline of the pool volume. Dissolved salts would become more concentrated as pool volume decreased. Also, byproducts of decomposition, in part, may be responsible for these increases.

Dripping Springs is a so-called “fracture spring” because it is fed by water circulating though fault fractures and water feeding the spring is due to local recharge from precipitation and that regional aquifers no longer play a role (Bryan 1925). This finding has never, to my knowledge, been reevaluated. Inflow to the pool is in the form of drip-points (“dozens” according to Wherrell 1981) on the roof of the cavity. The pool is approximately 2.1m wide x 3 m long x 1.5 m deep and was estimated to have a maximum capacity of approximately (including sediment) of approximately 9,513 L. A recent survey by OPCNM staff revealed that the correct dimensions are, in fact, 2.25 m long x 2.46 m wide x 1.6 m deep giving an estimated volume of 4,637 L, assuming a half - ellipsoid. Flow rate in the past has varied from less than 48 – 761 L/day (Brown et al. 1982). I estimated the flow rate to be 16 – 32 L/hr (or 384 – 768 L/day) (based on visual observations of the flow from various rated emitters on my home drip irrigation system). The latter is a crude estimate, founded on a somewhat dubious method, but agrees, within an order of magnitude, with Brown et al (1982). These estimates will have to suffice until future monitoring can produce a meaningful time series of flow fluctuations.

Daily evaporation in June and July in southern Arizona is approximately 12.3 mm/day (Sellers and Hill 1974) as measured by standard class A evaporation pans (122 cm in dia. and 25.4 cm deep). Converted to volume, this is approximately $\pi*(0.66 \text{ m})^{2}*.012 \text{ m/day} = .01642 \text{ m}^3\text{/day}$ or 16.42 L/day. The surface area of the Dripping Springs pool (assuming an ellipse) is about 3.7 times that of an evaporation pan. Evaporation from the pool in July could be as high as 61 L/day, admittedly a rough estimate. In any case, it may be possible, under conditions of high heat and low inflow (working in a short lag time for replenishment by local precipitation), for evaporation to exceed inflow. Therefore, the decline in the pool's water level by almost 0.3 m during the past several months could have been due to a simple imbalance between a naturally occurring drop[3] in inflow coupled with high May, June and July evaporative losses.

Obviously, this conjecture is based on "ball-park " figures. The Dripping Springs pool is not entirely comparable to a standard evaporation pan. For one thing, a pan is exposed to surface airflow and turbulence, which reduces the boundary layer over the water and increases evaporation. The pool is protected within a cave and has a completely different shape and surface to volume ratio. Water consumption by wildlife, including swarms of honeybees, and UDAs would have exacerbated evaporative water losses.

Very likely, inflow varies over time, especially if it is highly correlated with local precipitation as Bryan (1925) infers. However, if this is true, there should have been ample water in the local system. The Dripping Springs rain guage recorded above average winter and spring precipitation between October, 2002 and April 2001 and there was an early monsoonal storm in June (16.8 mm). The only dry months were December 2000 when total monthly precipitation was zero and May 2001 when total monthly precipitation was only 0.5 mm (Table E-2). If flow rate responds to local precipitation then it must do so very quickly. Indeed, the lowest pond level was observed on June 19, 2001, after a month of near drought and approximately the same time as the early monsoon cell brought precipitation. By July 16, the water level had risen by ≈ 40 cm. This is by no means conclusive evidence of cause and effect for at least two reasons. The June precipitation filled or partially filled local tinajas and could have attracted water-consuming wildlife elsewhere, thus relieving pressure on Dripping Springs. Second, over the past ten years, long-time OPCNM biological technician Ami Pate has observed a full pool at Dripping Springs, with little variance in level, between repeated visual observations, even after extended dry periods (Pate, personal communication).

Table E-2. Monthly precipitation measurements from the Dripping Springs rain guage, October, 2000 through June, 2001.

Month	Precipitation (mm)
October-00	41.4
November-00	8.6
December-00	0.0
January-01	55.6
February-01	28.7
March-01	24.9
April-01	21.1
May-01	0.5
June-01	16.8

Causes of water withdrawal other than evaporation, such as consumption by wildlife, human consumption by UDA's; increased evapotranspiration from surrounding phreatophytic vegetation (as foliage emerged during the spring and early summer); or, a combination of several or all of these factors cannot be ruled out. The water balance dynamics of Dripping Springs appears to be a complicated interaction of physical and biological variables. Honeybee use is probably not a significant factor, unless a very large number of separate colonies are involved, such as 20 or more within the flight area. For example, 20 colonies could consume water at a rate of about 4 L/day. According to periodic observations by Monument resources management staff, large numbers of bees are always present at the springs during the warm season regardless of the water level.

Since Dripping Springs is only one of two permanent water sources in ORPI and is of great importance as a wildlife-watering site, an extensive bio-hydrological study is recommended. Several questions come to mind as a result of above observations:

1. What are the extremes of fluctuations and the long-term average of inflow into the Dripping

[3] If Kirk (1925) is correct, this could happen simply due to a protracted dry period which, in our climatic region often occurs from mid-April through the beginning of July.

Spings pool?
1.1. What exactly is the source of water; is it an aquifer, local precipitation as inferred by Bryan (1925) or both?
1.2. How does the inflow rate change over annual, seasonal and daily time periods?
1.3. How responsive is the rate of inflow to local and regional precipitation and is there a lag?
1.4. Are the time series stationary or nonstationary over time?

2. What is the water balance maintaining the Dripping Springs pool?
   2.1. Can all sources of outflow or usage be quantified and measured?
   2.2. How do rates of outflow or usage change over annual, seasonal and daily time periods?

3. Could unusually high concentrations of honeybee colonies (10-20 within the fight area during a good year) coupled with water consumption by other wildlife severely deplete a small water source such as Dripping Springs?

4. Could the protracted decomposition of accumulations of dead, non-native honeybees render a small water source with a variable inflow unusable to native wildlife and for how long? The primary cause of the eutrophication of the spring pool appears to be the decomposition of the accumulated bodies of dead honeybees, which, like almost all insects are very high in protein. A search of archived OPCNM files after the site examination and cleanup revealed that this might not have been a singular occurrence. On April 1, 1981, National Park Service hydrologist William Wherrell described the pool as containing "many dead bees (Wherrell 1981)." On June 12, 1958. USGS hydrologist, L. Hiendel described the water quality as being "poor...slightly fetid" and the level "about 1 ft. below lip of sump [i.e, pool]." He recommended that the spring be cleaned out. On June 3-7, 1942, H.V. Peterson, also from the USGS, wrote, "the entire flow was being consumed by birds and insects." Since honeybees are an exotic species, the above question may have significance with respect to NPS natural resources management policy.

5. What is the role of water consumption by UDAs on the hydrology of Dripping Springs?

6. How long would it take Dripping Springs to recover from a eutrophication episode with and without management intervention?

Trash Removal

Nineteen bags of trash were eventually collected (600± kg.) from the vicinity of the seep, some from ridge above Dripping Springs and some from area around and below the spring. I estimate that this is about half the trash, which has been discarded on the spring site and the saddle above it. The trail to the springs from the North Puerto Blanco Drive is well worn, as is the trail up to the springs from the southwest on the other side of the peak. The latter is well illustrated in Figure E-10.

References

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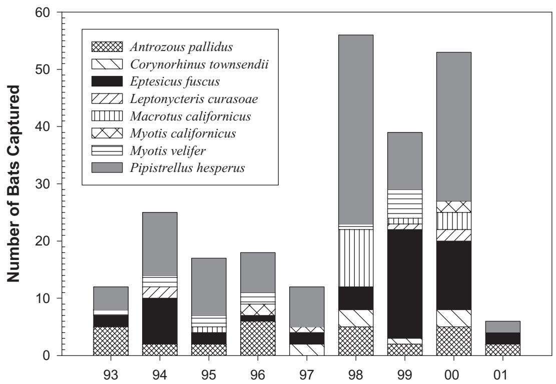

Figure E-1. Bat captures at Dripping Springs (1993-2001).

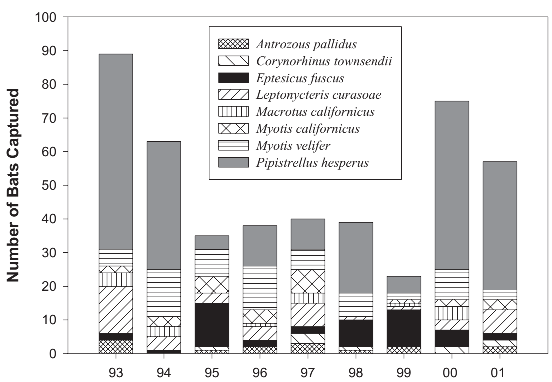

Figure E-2. Bat captures at Wild Horse Tank (1993-2001)

Figure E-3. Dripping Springs pool. Note the floating debris and organic matter, mostly dead bees.

Figure E-4. Nancy Favour measuring total alkalinity by titration**.**

Figure E-5. Decomposing organic matter skimmed from the surface of the Dripping Springs pool. Note the remains of a bird, probably a White-Winged Dove. The bulk of the putrefying material is composed of honeybee bodies, which remains are quite visible

Figure E-6. Mound of all the organic matter removed from the pool. The plastic gallon jug is included for scale.

Figure E-7. Refuse scatter on the saddle above Dripping Springs. View toward the SSW.

Figure E-8. Refuse discarded by undocumented aliens (UDAs) and accumulating under vegetation adjacent to the Dripping Springs pool.

Figure E-9. Telephoto view of UDA trail from the saddle above Dripping Springs. View toward the SSW.

Figure E-10. Nancy Favour removing trash from saddle above Dripping Springs.

Figure E-11.Tim Tibbitts with the final haul of refuse and debris from Dripping Springs and the areas adjacent to it.